Published in final edited form as:

Arthritis Care Res (Hoboken). 2018 September ; 70(9): 1326–1334. doi:10.1002/acr.23484.

Disparities in total knee replacement: Population losses in quality-adjusted life years due to differential offer, acceptance, and complication rates for Black Americans

Hannah M. Kerman, BA*, Savannah R. Smith, BA*, Karen C. Smith, BA, Jamie E. Collins, PhD, Lisa G. Suter, MD, Jeffrey N. Katz, MD, MSc, and Elena Losina, PhD

Orthopaedic and Arthritis Center for Outcomes Research (OrACORe), Policy and Innovation eValuation in Orthopaedic Treatments (PIVOT) Center, Department of Orthopaedic Surgery (HK, SRS, KCS, JEC, JNK, EL), Division of Rheumatology, Immunology, and Allergy (JNK), Brigham and Women's Hospital, Harvard Medical School (JEC, JNK, EL), Boston, MA, Yale-New Haven Hospital Center for Outcomes Research and Evaluation (LGS) New Haven, CT, Yale School of Medicine (LGS) New Haven, CT

Abstract

Objective—Total knee replacement (TKR) is an effective treatment for end-stage knee osteoarthritis (OA). American racial minorities undergo fewer TKRs than Whites. We estimated quality-adjusted life years (QALYs) lost for Black knee OA patients due to differences in TKR offer, acceptance, and complication rates.

Methods—We used the Osteoarthritis Policy Model, a computer simulation of knee OA, to predict QALY outcomes for Black and White knee OA patients with and without TKR. We estimated per-person QALYs gained from TKR as the difference between QALYs with current TKR use and QALYs when no TKR was performed. We estimated average, per-person QALY losses in Blacks as the difference between QALYs gained with White rates of TKR and QALYs gained with Black rates of TKR. We calculated population-level QALY losses by multiplying per-person QALY losses by the number of persons with advanced knee OA. Finally, we estimated QALYs lost specifically due to lower TKR offer and acceptance and higher complications among Black knee OA patients.

Results—Black men and women gain 64,100 QALYs from current TKR use. With white offer and complications rates, they would gain an additional 72,000 QALYs. Because these additional gains are unrealized, we call this a loss of 72,000 QALYs. Black Americans lose 67,500 QALYs because of lower offer, 15,800 QALYs because of lower acceptance, and 2,600 QALYs because of higher complications.

Conclusion—Black Americans lose 72,000 QALYs due to disparities in TKR offer and complication rates. Programs to decrease disparities in TKR use are urgently needed.

Correspondence: Elena Losina, PhD, Orthopaedic and Arthritis Center for Outcomes Research, Brigham and Women's Hospital, 60 Fenwood Road, BTM 5016, Boston, MA 02115, elosina@partners.org, Tel: 617-732-5338, Fax: 617-525-7900.

*HK and SRS contributed equally to the preparation of this work

Potential conflicts: None

Keywords

Disparities; Race; Arthroplasty; Total Knee Replacement; Osteoarthritis

Knee osteoarthritis (OA) is a painful, disabling condition affecting over 15 million American adults.¹ It is associated with progressive joint deterioration that often leads to substantial pain and functional limitations.² Disease modifying drugs aimed at halting the progression of joint destruction are not currently available. Consequently, over half of all knee OA patients eventually seek total knee replacement (TKR) for restoration of function and symptom relief.³ TKR reduces pain and improves function for about 80% of recipients.⁴

Despite the efficacy of TKR, there are documented racial differences in the use of TKR and in TKR complication rates in the United States.⁵⁻⁷ Black patients with end-stage knee OA are 40% less likely to undergo TKR than their White counterparts,⁷ even though Black patients frequently have more severe disease and greater pain.⁸⁻¹⁰ Analyses of large data sets have shown that the low rates of TKR among minorities are influenced by geographic region and community access to healthcare. However, these factors alone do not fully explain the low rate of TKR use compared to White patients.⁵

TKR utilization is governed by surgeons' "offer" of the procedure as well as patients' willingness to undergo surgical treatment, often called "acceptance" of the surgery.¹¹⁻¹⁴ Acceptance is mediated by personal factors such as familiarity with the procedure, interaction with someone who has had the procedure, social support, and religiosity.^{12,15} Several studies have analyzed the way these factors affect the rate at which racial minorities undergo TKR.¹¹⁻¹⁵ Compared to Whites, Blacks are about half as likely to receive an offer of TKR.¹¹ Sixty-two percent of Blacks accept TKR once offered, compared to 80% of Whites.¹⁴ In conjunction with lower utilization of TKR, Black patients also experience higher complication rates following TKR.^{16,17} A systematic review of complications following TKR suggests that even when controlling for comorbidities, Black patients experience an increased risk of infection, pulmonary embolism, myocardial infarction, pneumonia, and 90 day post-surgery mortality.¹⁶ These increased risks reduce quality of life and contribute to worse TKR outcomes for Black patients.

To our knowledge, the effect on population health of decreased utilization and increased complication rates following TKR has not been quantified. Quality-adjusted life years (QALYs) measure the effects of disease and disability on individuals' lives and can be quantified across a population. Here, we estimate QALYs lost in the Black population due to racial differences in TKR offer, acceptance, and complications.

Methods

Analytic Overview

We used the Osteoarthritis Policy (OAPol) Model, a validated computer simulation model of knee OA natural history and treatment,¹⁸⁻²² to evaluate the effects of differential TKR offer, acceptance, and complication rates in Blacks compared to Whites. We validated model inputs for TKR offer and acceptance rates by comparing OAPol-predicted TKR incidence in

one year against TKR incidence in 2013 as reported by the Healthcare Cost and Utilization Project (HCUP).²³

To determine a baseline level of QALYs gained from TKR, we estimated the QALY increase that Blacks experience from current use of TKR compared to no treatment. Throughout this paper, we will refer to QALY increases from current utilization of TKR as a *gain* in QALYs. To provide context for the QALYs gained by different race/sex populations, we calculated QALY gains from current levels of TKR per 100 persons in each race/sex stratified population.

We describe QALYs that the Black population would gain from increasing TKR offer and acceptance, and lowering TKR complications as a *loss* of QALYs because these are hypothetical gains. We quantified QALYs lost by Black patients by analyzing the same cohort in two situations. First, we simulated a cohort of Black males and females with Black rates of TKR offer, acceptance, and complications. Next we simulated this same Black cohort using White rates of TKR offer, acceptance, and complications. We calculated the average per-person QALYs lost by subtracting the average, individual quality-adjusted life expectancy (QALE) in the Black population using Black TKR rates from the average, individual QALE in the Black population using White TKR rates.

$$\text{QALYs Lost} = [\text{QALE using White rates of TKR}] - [\text{QALE using Black rates of TKR}]$$

We calculated population-level QALY losses by multiplying the QALE differences by the number of persons in each race and sex category with symptomatic, advanced knee OA.¹ We present QALYs lost as both the number of QALYs lost and as the percent lost compared to QALYs gained from current levels of TKR use. We also performed simulations to determine the individual impact of the offer rate, acceptance rate, TKR complication rate, and the combination of offer and complication rates. We focused our analysis on offer and complication rates, as these factors are controlled by the medical system and could theoretically be modified by health care providers.

The OAPol Model

The OAPol Model is a validated, state transition, Monte Carlo simulation model of the natural history and treatment of knee OA.¹⁸⁻²² The model generates cohorts of hypothetical patients based on pre-specified distributions of demographic and clinical characteristics, including age, sex, race/ethnicity, comorbidities, body mass index (BMI), and the structural and symptomatic severity of knee OA. Subjects transition through health states that are defined by knee OA structural and symptomatic severity, obesity, and comorbidities. Each state is associated with a quality of life (QoL) utility. Subjects can undergo knee OA treatments that reduce pain severity and improve QoL. QoL utilities were derived from the Osteoarthritis Initiative (OAI) and stratified by age, obesity, comorbidities, and knee OA pain (Table 1).²⁴ Pain reductions from TKR were derived from the Study of Knee Arthroplasty Responses (STARs) and the Adding Value in Knee Arthroplasty (AViKA) study, two longitudinal studies of knee arthroplasty patients.^{25,26}

To begin a treatment, a subject must be eligible for the treatment. Probability of eligibility is stratified by OA pain, OA severity, and age. If a subject is eligible, the model then assesses whether a subject is offered the treatment. If offered, the model assesses whether the subject accepts the offer. Offer and acceptance rates are stratified by age, race, and sex.

Treatments carry probabilities of complications that cause QoL decrements. The model tracks each subject until death and aggregates QoL decrements due to knee OA structural and symptomatic progression, development of comorbidities, increase in BMI, and treatment complications. Additional details on the OAPol Model have been previously published.¹⁸⁻²²

Model Inputs

Key model inputs are presented in Table 1.

Cohort Characteristics—We simulated four cohorts: Black females, Black males, White females, and White males. We derived demographic parameters for populations with advanced knee OA from published data and national surveys. Mean age was 66 years, the average age of patients scheduled to undergo a TKR in the AViKA study.²⁵ The cohort's Kellgren-Lawrence (KL) grade, a measure of OA severity,²⁷ was 50% grade 3 and 50% grade 4 at initialization, representing an advanced disease population.

We derived BMI distributions, stratified by race/ethnicity and sex, from the 2012 National Health Interview Survey.²⁸ We measured knee OA pain with the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)²⁹ Pain subscale (0 – 100, 100 worst). Variations in WOMAC Pain due to race/ethnicity, age, sex, KL grade, and number of comorbidities were derived using data from the OAI.²⁴ Cohort-level baseline pain of those receiving TKR was matched to published values of sex, and race-specific WOMAC pain of patients scheduled to undergo TKR.²⁵

Total Knee Replacement Characteristics

Eligibility: We assumed that subjects had previously failed conservative, nonsurgical treatments for knee OA, including non-steroidal anti-inflammatory drugs (NSAIDs), physical therapy, and corticosteroid injections. We calibrated subjects' eligibility for TKR so that the total number of TKRs projected in the model would be consistent with national HCUP data: 50% of Black subjects with WOMAC Pain 15-40 were eligible for TKR, and 75% percent of White subjects with WOMAC Pain 15-40 were eligible for TKR. All subjects with WOMAC Pain greater than 40 were eligible. We used different eligibility for Black and White patients to capture the fact that Black patients are likely offered TKR at higher pain levels.¹¹ These differences in pain facilitated calibration of model-based estimates to the number of TKRs in the United States in 2013 as estimated by HCUP.

TKR Utilization: We defined TKR utilization as the probability that TKR was offered multiplied by the probability that TKR was accepted by the patient. Offer rates were stratified by race, and acceptance rates were stratified by race and sex. We derived TKR offer rates for Black and White subjects from a 2010 study by Hausmann and colleagues,¹¹ which measured the rate at which orthopedic surgeons recommended TKR to 457 patients in

the Veterans Affairs (VA) health care system. The offer rate was 22.7% for Whites compared to 10.5% for Blacks. All enrolled patients had a WOMAC Pain score of 39 or higher, and in descriptions of the cohort at baseline, Black patients were more likely to have severe pain from OA.¹¹ We derived the probability of TKR acceptance for patients who had already been offered a TKR from a study by Vina and colleagues.¹⁴ TKR was accepted by 83% and 59% of White and Black men and 78% and 64% of White and Black women, respectively.

We conducted sensitivity analyses using 95% confidence intervals (CIs) around our base case offer and acceptance rates. Additionally, we repeated the full analysis with two acceptance rates derived from a study of willingness to undergo TKR in the Johnston Country Osteoarthritis Project (JoCo OA).¹³ In the JoCo study, the first (narrow) acceptance rate defined acceptance as “definite” willingness to undergo TKR, and the second (broad) acceptance rate defined acceptance as “definite” or “probable” willingness to undergo TKR. For full derivations of all offer and acceptance rates, see the Appendix.

TKR Complications: We derived the probabilities of TKR-related complications for myocardial infarction, pulmonary embolism, pneumonia, deep infection, and death. Complications could occur during the first year following surgery, and each complication carried a unique QoL decrement (Table 1). We applied a QoL decrement of 9.3% during the year of surgery for subjects without a specific TKR complication, representing the pain and disability associated with recovery. White complication rates were derived from an analysis of over 80,000 Medicare patients who underwent TKR.³⁰ We calculated complications for Black patients by multiplying relative risks of each complication for Blacks by the rate of each complication for the White population. Relative risks were identified using a systematic review that evaluated postoperative TKR outcomes in racial and ethnic minorities.¹⁶

TKR Subsequent Year Utilization: Subjects who were eligible but not offered a TKR within the first year of eligibility had a reduced probability of TKR offer in subsequent years. Similarly, those offered a TKR who did not accept within a year had a reduced probability of accepting a TKR in subsequent years. In the base case, we assumed that subsequent year offer for eligible White males who had previously not been offered TKR was 1%. We also set subsequent year acceptance values for White males to 1%. We set subsequent year values for White females, Black males, and Black females based on the ratio of each group's acceptance/offer values compared to White males. In this way, disparity was propagated in the subsequent years. We performed sensitivity analyses examining White male offer and acceptance rates of 2% and 5%.

Age-Adjusted Sensitivity Analyses: We conducted a sensitivity analysis using published differences in the rate of TKR for those above and below 65 years of age, as older patients are more likely to receive TKRs.³¹ Relative rates of TKR for those above and below 65 were taken from age-, race-, and sex-stratified OAI utilization rates.³¹ Using these values, we stratified offer and acceptance by age, race, and sex (see Appendix Table 1).

Results

Model Input Validation

OAPol TKR estimates for a single year were within 5% of HCUP results for 2013. HCUP reported 626,567 TKR procedures in 2013 for American Whites, Blacks, and Hispanics. The OAPol Model estimated 633,217 TKR procedures in a year for Whites, Blacks, and Hispanics, or approximately 101% of TKR procedures documented in the HCUP data set (Table 2).

Primary Analysis

Quality-Adjusted Life Years Gained from TKR—For the Black population, current levels of TKR utilization led to a gain of 64,100 QALYs (Table 3). This represents a lifetime estimate of QALYs gained for the 600,000 Black women and 310,000 Black men with severe OA.¹ For the White population, current levels of TKR utilization led to a gain of 872,500 QALYs. This represents a lifetime estimate of QALYs gained for the 3.6 million White women and 2.5 million White men with severe OA. Assessing QALY gains from current TKR utilization per 100 persons, Black males gained 4.8 QALYs, Black females gained 8.2 QALYs, White males gained 12.6 QALYs, and White females gained 15.7 QALYs (Figure 1).

Quality-Adjusted Life Years Lost from Disparities in TKR Use—Analyzing the Black cohort with White offer levels led to an additional 67,500 QALYs gained for a total of 131,600 QALYs, a 105% increase compared to QALYs gained from current levels of TKR use. Because these 67,500 QALYs go unrealized due to the lower offer rate experienced by Black patients, we call this a 67,500 QALY loss (a loss of 105% of the QALYs gained from current use). The lower rate of TKR acceptance in the Black population led to a loss of 15,800 QALYs (25%), and the increased complication rates led to a loss of 2,600 QALYs (4%). The combined effect of lower offer rate and higher complications for the Black population resulted in a QALY loss of 72,000 QALYs (112%): 54,900 QALYs for Black women and 17,100 QALYs for Black men (Table 3).

Sensitivity Analyses

Offer and Acceptance Rates—When Black TKR offer was varied across the 95% CI, QALYs gained by Black men and women from current TKR use ranged from 36,900 to 111,500 QALYs. QALY losses due to low offer ranged from 94,300 QALYs (L95CI) to 19,700 QALYs (U95CI). These QALY losses translate into between 256% and 18% of QALYs gained from current TKR use.

When Black TKR acceptance was varied across the 95% CI, QALYs gained by Black men and women from current TKR use ranged from 56,900 to 71,400 QALYs. QALYs losses due to low acceptance ranged from 23,600 QALYs (L95CI) to 9,100 QALYs (U95CI). These QALY losses translate into between 41% and 13% of QALYs gained from current TKR use.

Using the acceptance rate estimates from the JoCo OA cohort, QALYs gained by Black men and women from current TKR use ranged from 21,400 QALYs (using the narrower

definition of acceptance) to 43,100 QALYs (using the broader definition of acceptance). QALY losses due to low acceptance ranged from 13,800 QALYs (narrow) to 26,600 QALYs (broad). The combined effect of lower offer and higher complications with JoCo acceptance rates resulted in QALY losses ranging from 25,700 QALYs (narrow) to 48,900 QALYs (broad) (Appendix Table 2). QALY losses due to low offer and high complications translate into between 120% and 113% of QALYs gained from current TKR use.

Rates of Subsequent TKR Offer and Acceptance

2% Subsequent Offer and Acceptance: With White male subsequent year offer/acceptance increased from 1% (base case) to 2%, and all other groups adjusted accordingly, TKR utilization for all races increased by 18% compared to the base case. The increase in TKRs across the entire population magnified the QALY disparity between Black and White populations. Black women gained 60,600 QALYs and Black men gained 17,600 QALYs from their current use of TKR. Analyzing the Black female cohort with White offer rates, Black Women gained 59,100 QALYs, for a total of 119,700 QALYs, a 98% increase over QALYs gained from current TKR use. Because these gains go unrealized, we call this a loss of 59,100 QALYs (a loss of 98% of the QALYs gained from current use). Black men lost 17,900 QALYs (102%) to low offer rates. Due to increased complications, Black women lost 2,500 QALYs (4%) and Black men lost 1,100 QALYs (6%). The combination of lower offer and higher complication rates led to a QALY loss of 62,800 QALYs (104%) for Black women and 19,400 QALYs (111%) for Black men (Table 4).

5% Subsequent Offer and Acceptance: With White male subsequent year offer/acceptance rates increased to 5%, TKR utilization for all races increased by 62% compared to the base case. Black women gained 93,700 QALYs and Black men gained 25,800 QALYs from their current use of TKR. Black Women lost 74,000 QALYs (79%) and Black men lost 21,800 QALYs (84%) to low offer rates. Due to increased complications, Black women lost 3,500 QALYs (4%) and Black men lost 1,300 QALYs (5%). The combination of lower offer and higher complication rates led to a QALY loss of 79,700 QALYs (85%) for Black women and 24,400 QALYs (94%) for Black men (Table 4).

Differentiated Offer & Acceptance Rates for those Above and Below Age 65—

With age-stratified rates of offer and acceptance, current levels of TKR utilization led to a gain of 51,400 QALYs for Black women and 14,700 QALYs for Black men. Due to lower offer rates, Black women lost 50,300 QALYs (98%) and Black men lost 15,400 QALYs (105%). Due to lower acceptance rates, Black women lost 9,200 QALYs (18%) and Black men lost 5,300 QALYs (36%). Due to higher complication rates, Black women lost 1,600 QALYs (3%) and Black men lost 400 QALYs (3%). Due to the combination of lower offer and higher complications, Black women lost 54,000 QALYs (105%) and Black men lost 16,700 QALYs (114%) (Table 5).

Discussion

Using current, published estimates of TKR offer, acceptance, complication levels, and symptomatic knee OA burden in the United States, we calculated the population QALYs for

Black knee OA patients. Black patients lost 72,000 QALYs from lower rates of TKR offer and increased rates of TKR complications. The higher rate of complications alone accounted for a loss of 2,600 QALYs, and lower offer rate alone accounted for a loss of 67,500 QALYs.

Differential uptake of TKR in United States minority populations is well documented.^{5-7,11,13,14,32} Studies range from reviews of large Medicare data sets to cohort studies examining patient preferences and physician bias. A recent systematic review by Shahid and Singh investigated twenty years of disparities in arthroplasty procedures.³³ One of the reviewed papers suggests that the difference in TKR rates for Blacks as compared to Whites increased from 36% in 1991 to 40% in 2008.⁷ Even after adjusting for variation in hospital referral regions, disparities persist for Black women and men.⁵ This may be explained by surgery outcome expectations; Black patients tend to expect longer hospital stays, more complications, and more pain after surgery.³⁴ In addition, personal and community knowledge of TKR may significantly influence procedure uptake for American minority patients with OA.^{12,15}

Dramatic QALY losses arise from the lower offer rate for Black patients. Offer rate is controlled by surgeons; it is a metric over which the professional, medical community has some control. Thus far, interventions to reduce TKR disparity have been focused on educational tools and decision aid interventions, and trials involving these tools have met with limited success.^{35,36} The mixed results of educational interventions may be due to reticence of Black patients to accept surgery, influenced by a history of unequal treatment in the American medical establishment.^{37,38} Given the outsize impact of physician offer, it seems that a focus on the physician's role may help bolster TKR utilization. Our results suggest that focusing on offer rates and physician training could have a meaningful impact on patients' QALYs. Patient-oriented interventions may still be needed, however, as healthcare communications are also influenced by patients' community and life-experiences.

In our sensitivity analysis, increasing subsequent offer and acceptance rates across all patient groups increased the number of QALYs lost. This occurs because more TKRs in the population magnify the difference in the rates of offer and acceptance between minority and White patients, creating a greater loss of QALYs for the Black population. Adjusting offer and acceptance rates for age made little difference in QALYs lost. With the age-adjusted rates, Black women and Black men experienced a loss of over 50,000 and 10,000 QALYs, respectively, due to lower TKR utilization.

There are limitations to our analyses. While many studies have quantified a significant difference in rates of TKR for White and Black patients, most of these studies used national datasets that track utilization without breaking down the rate of surgery into the component factors of offer and acceptance. In contrast, there are relatively few cohort studies that specifically focus on quantifying race-stratified rates of TKR offer among patients with knee OA. We derived offer rates from a study of VA patients, all of whom are seen in a single payer system and the majority of whom are male.¹¹ For these reason, VA hospitals are not always representative of the environments in which most Americans with symptomatic knee OA seek care. Additionally, the authors of this study found that there was no statistically

significant difference between Black and White offer rates after controlling for patient preference. To address these concerns, we conducted sensitivity analyses around the 95% CI reported in this study. We also validated our TKR utilization for each race/sex category against national HCUP data. While this validation supports our TKR estimates, future studies assessing the offer rate of TKR in a private system are crucial for understanding the full impact of QALY losses for racial minorities.

Our ideal utilization rates and subsequent QALY losses were based on White values as the referent rates. Black patients have higher rates of severe OA and OA risk factors, and increased OA pain compared to their White counterparts.^{8,9,39} Therefore, increasing Black rates of TKR to match White rates may still be insufficient to address the levels of OA pain and disability experienced by the Black population. To appropriately address the burden of OA among Black patients, it is possible that TKR utilization should surpass White utilization estimates. This would lead to QALY losses greater than the estimates we present.

Racial differences in TKR utilization and complications lead to a significant loss of QALYs for Black patients in the United States. Studies addressing physician knowledge of disparities would provide further information to help disparity researchers understand how to increase the rate of TKR. To improve offer rates, physicians must be educated on racial disparities in TKR and the factors that may influence minority patients' beliefs and attitudes towards surgery. To improve acceptance rates, we must adopt patient-centered care that promotes fully informed consent and shared decision making for all patients. Reducing the difference in utilization and complications of TKR could increase the quality of life for individual minority patients and have a significant positive effect on the larger population.

Acknowledgments

Supported by: NIH/NIAMS R01AR064320, K24AR057827

Technical Appendix Part 1: Methods

Healthcare Cost and Utilization Project (HCUP) Validation

We compared the number of OAPol predicted TKRs in one year to the number of TKRs reported by HCUP in 2013. HCUP does not report the national number of TKRs stratified by race; however, TKRs stratified by race are reported by 29 states. We used the racial distributions reported in the state data to estimate that of the 640,695 TKRs in 2013, 626,567 were in White, Black, or Hispanic patients.

Offer and Acceptance Derivations

1. TKR Offer

Base Case—In a study of 120 Black and 337 White patients, Haussmann and colleagues reported an odds ratio of 0.46 for Black TKR offer compared to White TKR offer.¹ The overall probability of being offered a TKR in their study was 19.5%. From this data, we calculated the probability of TKR offer as 22.7% for white patients and multiplied by the

odds ratio to find a 10.5% probability of TKR offer for Black patients. As TKR offer rate was low, we assumed that the odds ratio was a reasonable approximation of the relative risk.

Sensitivity Analysis—The 95% confidence interval (CI) for the Black TKR offer odds ratio was 0.26 – 0.83. Assuming White offer remains constant at 22.7%, this corresponds to Black offer rates of 5.91% and 18.86%.

2. TKR Acceptance

Base Case—Vina and colleagues reported that 177/212 of White men, 232/299 of White women, 45/76 of Black men, and 131/206 of Black women were willing to receive a TKR when offered.² We used these values to calculate the mean probabilities of acceptance: 83.5%, 77.6%, 59.2%, and 63.6% for White men, White women, Black men, and Black women, respectively.

Sensitivity Analysis—For Black acceptance, we calculated the surrounding binomial 95% confidence interval (CI). For Black men, the 95% CI was 48.2 – 70.3%, and for Black women, the 95% CI was 57.0 – 70.2%.

We conducted an additional sensitivity analysis using acceptance values from the Johnston Country Osteoarthritis Project (JoCo OA).³ In this cohort, willingness to accept TKR was measured with a five point Likert scale. We calculated two acceptance rates using the responses from the cohort with symptomatic knee OA: in the more conservative estimate (narrow), we defined acceptance as definite willingness to have surgery, and in the less conservative estimate (broad), we defined acceptance as definite or probable willingness to have surgery. With the more conservative estimate, White acceptance was 32.8% while Black acceptance was 20.1%. With the less conservative estimate, White acceptance was 68.3% and Black acceptance was 40.9%.

Age Adjusted Sensitivity Analysis

Rates of total knee replacement (TKR) are influenced by patient age, with knee OA patients over age 65 experiencing over 60% of surgeries.⁴ This technical appendix details the derivations for a sensitivity analysis that accounts for different rates of TKR based on age.

1. TKR Usage by Race, Sex, and Age

Collins and colleagues stratified utilization rates from the OAI database by race, age, and sex.⁴ We used the ratio of TKR incidence in those over age 65 (65+) to those under age 65 (65-) to transform the TKR offer and acceptance rates used in the primary analysis. This resulted in sixteen new rates: a new offer and acceptance value for each race/sex/age group.

2. Primary Analysis

In the primary analysis, offer and acceptance rates were derived from Haussman and colleagues¹ and Vina and colleagues,² respectively. Offer rates were stratified by race, and acceptance rates were stratified by race and sex. Multiplying the offer rate by the acceptance rate for each race/sex group (White Males, White Females, Black Females, Black Males)

gives us the Incidence of Participation (IoP). We call the primary analysis Incidence of Participation the $\text{IoP}_{\text{unadjusted}}$.

$$\text{IoP}_{\text{unadjusted}} = \text{Offer} \times \text{Acceptance}$$

3. Derivation of Age Adjusted IoPs

Age adjusted IoPs were derived from the Collins and colleagues cohort using an equation relating overall incidence of TKR to age stratified TKR incidence rates. Our first equation draws on the fact that the total number of TKRs in the study is equal to the sum of the number of people over 65 who received TKRs and the number of people under 65 who received TKRs. The total number of TKRs for a given group can be calculated by multiplying the IoP by the number of subjects in a given category. With this relationship in mind, we constructed an equation relating $\text{IoP}_{\text{unadjusted}}$, IoP_{65+} , and IoP_{65-} . We assumed that the unadjusted IoP multiplied by the total number of subjects would equal the sum of the age-adjusted IoPs multiplied by the number of subjects in each age category (Equation 1). We also assumed that the ratio between the IoP_{65-} and the IoP_{65+} would be equal to the ratio between the incidence rate (IR) of TKR in those under age 65 and those over age 65 from Collins and colleagues (Equation 2).

$$\text{IoP}_{\text{unadjusted}} \times \text{total \# subjects} = [\text{IoP}_{65-} \times \# \text{ subjects} < 65] + [\text{IoP}_{65+} \times \# \text{ subjects} \geq 65]$$

Equation 1

$$\frac{\text{IoP}_{65-}}{\text{IoP}_{65+}} = \frac{\text{IR}_{65-}}{\text{IR}_{65+}} \quad \text{Equation 2}$$

Using Equation 2, we can define IoP_{65-} in terms of IoP_{65+} .

$$\text{IoP}_{65-} = \frac{\text{IR}_{65-}}{\text{IR}_{65+}} \times \text{IoP}_{65+}$$

With this new definition of IoP_{65-} , we can now write Equation 1 with a single variable, IoP_{65+} .

$$\text{IoP}_{\text{unadjusted}} \times \text{total \# subjects} = \text{IoP}_{65+} \times \frac{\text{IR}_{65-}}{\text{IR}_{65+}} \times \# \text{ subjects} < 65 + [\text{IoP}_{65+} \times \# \text{ subjects} \geq 65]$$

Using this equation, we solved for IoP_{65+} for each race/sex group: White Males, White Females, Black Males, Black Females.

4. Derivation of Age Adjusted Offer and Acceptance Rates

We split the IoP_{65+} into component offer and acceptance rates using the relationship between the offer and acceptance values from Hausmann and Vina. We derived an equation relating the age adjusted $IoPs$ to the original ratio of offer rate to acceptance rate. From this relationship, we derived age adjusted acceptance values and age adjusted offer values.

We began with the assumption that the ratio of the age adjusted offer and acceptance should be the same as the original ratio of offer and acceptance from Hausmann and Vina.

$$\frac{\text{Offer}_{\text{age adjusted}}}{\text{Acceptance}_{\text{age adjusted}}} = \frac{\text{Offer}_{\text{Hausmann}}}{\text{Acceptance}_{\text{Vina}}}$$

We multiplied both sides by $\text{Acceptance}_{\text{age adjusted}}$.

$$\text{Offer}_{\text{age adjusted}} = \frac{\text{Offer}_{\text{Hausmann}}}{\text{Acceptance}_{\text{Vina}}} \times \text{Acceptance}_{\text{age adjusted}}$$

We multiplied both sides by $\text{Acceptance}_{\text{age adjusted}}$ a second time, so that on the left we would have $IoP_{\text{age adjusted}}$, a value we had previously derived.

$$= \frac{\text{Offer}_{\text{Hausmann}}}{\text{Acceptance}_{\text{Vina}}} \times \text{Acceptance}_{\text{age adjusted}} \times \text{Acceptance}_{\text{age adjusted}}$$

Simplified, the equation becomes:

$$IoP_{\text{age adjusted}} = \frac{\text{Offer}_{\text{Hausmann}}}{\text{Acceptance}_{\text{Vina}}} \times [\text{Acceptance}_{\text{age adjusted}}]^2$$

We isolated and solved for the value of $\text{Acceptance}_{\text{age adjusted}}$.

$$\sqrt{IoP_{\text{age adjusted}} \div \frac{\text{Offer}_{\text{Hausmann}}}{\text{Acceptance}_{\text{Vina}}}} = \text{Acceptance}_{\text{age adjusted}}$$

1. Hausmann LR, Mor M, Hanusa BH, Zickmund S, Cohen PZ, Grant R, et al. The effect of patient race on total joint replacement recommendations and utilization in the orthopedic setting. *J Gen Intern Med* 2010; 25: 982-988.

2. Vina ER, Cloonan YK, Ibrahim SA, Hannon MJ, Boudreau RM, Kwoh CK. Race, sex, and total knee replacement consideration: role of social support. *Arthritis Care Res (Hoboken)* 2013; 65: 1103-1111.
3. Allen KD, Golightly YM, Callahan LF, Helmick CG, Ibrahim SA, Kwoh CK, et al. Race and sex differences in willingness to undergo total joint replacement: the Johnston County Osteoarthritis Project. *Arthritis Care Res (Hoboken)* 2014; 66: 1193-1202.
4. Collins JE, Deshpande BR, Katz JN, Losina E. Race- and sex-specific incidence rates and predictors of total knee arthroplasty: Seven-year data from the Osteoarthritis Initiative. *Arthritis Care Res (Hoboken)* 2016; 68: 965-973.

Appendix Table 1: Age Adjusted Offer and Acceptance

		Black Male	Black Female	White Male	White Female
65-	Offer	11.1%	9.3%	16.9%	20.9%
	Acceptance	62.8%	56.8%	62.2%	71.4%
65+	Offer	9.9%	11.2%	25.4%	23.4%
	Acceptance	56.2%	68.2%	93.4%	79.9%

The process of deriving these new rates is described below.

Technical Appendix Part 2: Acceptance Rate Sensitivity Analysis Results

Appendix Table 2. shows sex-stratified QALYs lost using acceptance rates derived from the JoCo OA cohort.

Appendix Table 2. Sensitivity Analysis using Johnston Country Osteoarthritis Project TKR Acceptance Rates *

Population QALYs Gains		Population QALY Losses			
Cohort	Current TKR Use Compared to No Treatment (SE)	Due to Low Offer (SE)	Due to Low Accept (SE)	Due to High Comp. (SE)	Due to Low Offer and High Comp. (SE)
Black-F	16,200 (1,400) – 32,500 (1,600)	17,700 (1,000) – 34,700 (1,300)	10,600 (1,000) – 20,100 (1,300)	700 (1,400) – 1,100 (1,100)	19,400 (1,000) – 36,900 (1,200)
Black-M	5,300 (1,000) – 10,600 (1,000)	5,900 (700) – 11,200 (500)	3,200 (500) – 6,500 (500)	400 (500) – 500 (500)	6,300 (600) – 12,100 (600)

* The low estimate of QALYs lost used a “narrow” acceptance rate with acceptance defined as definite willingness to undergo TKR. The high estimate of QALYs lost used a “broad” acceptance rate with acceptance defined as both definite and probable willingness to undergo TKR.

References

1. Deshpande BR, Katz JN, Solomon DH, Yelin EH, Hunter DJ, Messier SP, et al. Number of persons with symptomatic knee osteoarthritis in the US: Impact of race and ethnicity, age, sex, and obesity. *Arthritis Care Res (Hoboken)*. 2016; 68:1743–1750. [PubMed: 27014966]
2. Hunter DJ, Felson DT. Osteoarthritis. *BMJ: British Medical Journal*. 2006; 332:639–642. [PubMed: 16543327]

3. Losina E, Paltiel AD, Weinstein AM, Yelin E, Hunter DJ, Chen SP, et al. Lifetime medical costs of knee osteoarthritis management in the United States: impact of extending indications for total knee arthroplasty. *Arthritis Care Res (Hoboken)*. 2015; 67:203–215. [PubMed: 25048053]
4. Beswick AD, Wylde V, Gooberman-Hill R, Blom A, Dieppe P. What proportion of patients report long-term pain after total hip or knee replacement for osteoarthritis? A systematic review of prospective studies in unselected patients *BMJ Open*. 2012; 2:e000435.
5. Skinner J, Weinstein JN, Sporer SM, Wennberg JE. Racial, ethnic, and geographic disparities in rates of knee arthroplasty among Medicare patients. *N Engl J Med*. 2003; 349:1350–1359. [PubMed: 14523144]
6. Bang H, Chiu YL, Memtsoudis SG, Mandl LA, Della Valle AG, Mushlin AI, et al. Total hip and total knee arthroplasties: trends and disparities revisited. *Am J Orthop (Belle Mead NJ)*. 2010; 39:E95–102. [PubMed: 21290031]
7. Singh JA, Lu X, Rosenthal GE, Ibrahim S, Cram P. Racial disparities in knee and hip total joint arthroplasty: an 18-year analysis of national Medicare data. *Ann Rheum Dis*. 2014; 73:2107–2115. [PubMed: 24047869]
8. Jordan JM. An ongoing assessment of osteoarthritis in African Americans and Caucasians in North Carolina: The Johnston County Osteoarthritis Project. *Trans Am Clin Climatol Assoc*. 2015; 126:77–86. [PubMed: 26330661]
9. Allen KD, Helmick CG, Schwartz TA, DeVellis RF, Renner JB, Jordan JM. Racial differences in self-reported pain and function among individuals with radiographic hip and knee osteoarthritis: the Johnston County Osteoarthritis Project. *Osteoarthritis Cartilage*. 2009; 17:1132–1136. [PubMed: 19327733]
10. Allen KD, Chen JC, Callahan LF, Golightly YM, Helmick CG, Renner JB, et al. Racial differences in knee osteoarthritis pain: potential contribution of occupational and household tasks. *J Rheumatol*. 2012; 39:337–344. [PubMed: 22133621]
11. Hausmann LR, Mor M, Hanusa BH, Zickmund S, Cohen PZ, Grant R, et al. The effect of patient race on total joint replacement recommendations and utilization in the orthopedic setting. *J Gen Intern Med*. 2010; 25:982–988. [PubMed: 20509053]
12. Kwoh CK, Vina ER, Cloonan YK, Hannon MJ, Boudreau RM, Ibrahim SA. Determinants of patient preferences for total knee replacement: African-Americans and whites. *Arthritis Res Ther*. 2015; 17:348. [PubMed: 26635132]
13. Allen KD, Golightly YM, Callahan LF, Helmick CG, Ibrahim SA, Kwoh CK, et al. Race and sex differences in willingness to undergo total joint replacement: the Johnston County Osteoarthritis Project. *Arthritis Care Res (Hoboken)*. 2014; 66:1193–1202. [PubMed: 24470235]
14. Vina ER, Cloonan YK, Ibrahim SA, Hannon MJ, Boudreau RM, Kwoh CK. Race, sex, and total knee replacement consideration: role of social support. *Arthritis Care Res (Hoboken)*. 2013; 65:1103–1111. [PubMed: 23281259]
15. Ibrahim SA, Siminoff LA, Burant CJ, Kwoh CK. Understanding ethnic differences in the utilization of joint replacement for osteoarthritis: the role of patient-level factors. *Med Care*. 2002; 40:I44–51. [PubMed: 11789631]
16. Nwachukwu BU, Kenny AD, Losina E, Chibnik LB, Katz JN. Complications for racial and ethnic minority groups after total hip and knee replacement: a review of the literature. *J Bone Joint Surg Am*. 2010; 92:338–345. [PubMed: 20124060]
17. Ibrahim SA, Stone RA, Han X, Cohen P, Fine MJ, Henderson WG, et al. Racial/ethnic differences in surgical outcomes in veterans following knee or hip arthroplasty. *Arthritis Rheum*. 2005; 52:3143–3151. [PubMed: 16200594]
18. Losina E, Walensky RP, Kessler CL, Emrani PS, Reichmann WM, Wright EA, et al. Cost-effectiveness of total knee arthroplasty in the United States: patient risk and hospital volume. *Arch Intern Med*. 2009; 169:1113–1121. discussion 1121–1112. [PubMed: 19546411]
19. Losina E, Walensky RP, Reichmann WM, Holt HL, Gerlovin H, Solomon DH, et al. Impact of obesity and knee osteoarthritis on morbidity and mortality in older Americans. *Ann Intern Med*. 2011; 154:217–226. [PubMed: 21320937]
20. Losina E, Thornhill TS, Rome BN, Wright J, Katz JN. The dramatic increase in total knee replacement utilization rates in the United States cannot be fully explained by growth in

- population size and the obesity epidemic. *J Bone Joint Surg Am.* 2012; 94:201–207. [PubMed: 22298051]
21. Losina E, Michl G, Collins JE, Hunter DJ, Jordan JM, Yelin E, et al. Model-based evaluation of cost-effectiveness of nerve growth factor inhibitors in knee osteoarthritis: impact of drug cost, toxicity, and means of administration. *Osteoarthritis Cartilage.* 2016; 24:776–785. [PubMed: 26746146]
 22. Katz JN, Smith SR, Collins JE, Solomon DH, Jordan JM, Hunter DJ, et al. Cost-effectiveness of nonsteroidal anti-inflammatory drugs and opioids in the treatment of knee osteoarthritis in older patients with multiple comorbidities. *Osteoarthritis Cartilage.* 2016; 24:409–418. [PubMed: 26525846]
 23. HCUPnet. Healthcare Cost and Utilization Project (HCUP). Agency for Healthcare Research and Quality; Rockville, MD: 2013. <http://hcupnet.ahrq.gov/> [Accessed March 2016]
 24. Osteoarthritis Initiative (OAI). San Francisco: University of California; 2013.
 25. Losina E, Collins JE, Wright J, Daigle ME, Donnell-Fink LA, Strnad D, et al. Postoperative care navigation for total knee arthroplasty patients: A randomized controlled trial. *Arthritis Care Res (Hoboken).* 2016; 68:1252–1259. [PubMed: 26714179]
 26. Dave AJ, Selzer F, Losina E, Klara KM, Collins JE, Usiskin I, et al. Is there an association between whole-body pain with osteoarthritis-related knee pain, pain catastrophizing, and mental health? *Clin Orthop Relat Res.* 2015; 473:3894–3902. [PubMed: 26443774]
 27. Kellgren JH, Lawrence JS. Radiological assessment of osteo-arthritis. *Ann Rheum Dis.* 1957; 16:494–502. [PubMed: 13498604]
 28. National Health Interview Survey. Hyattsville (MD): National Center for Health Statistics, Centers for Disease Control and Prevention, US Department of Health and Human Services; 2012.
 29. McConnell S, Kolopack P, Davis AM. The Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC): a review of its utility and measurement properties. *Arthritis Rheum.* 2001; 45:453–461. [PubMed: 11642645]
 30. Katz JN, Barrett J, Mahomed NN, Baron JA, Wright RJ, Losina E. Association between hospital and surgeon procedure volume and the outcomes of total knee replacement. *J Bone Joint Surg Am.* 2004; 86-A:1909–1916. [PubMed: 15342752]
 31. Collins JE, Deshpande BR, Katz JN, Losina E. Race- and sex-specific incidence rates and predictors of total knee arthroplasty: Seven-year data from the Osteoarthritis Initiative. *Arthritis Care Res (Hoboken).* 2016; 68:965–973. [PubMed: 26554629]
 32. Zhang W, Lyman S, Boutin-Foster C, Parks ML, Pan TJ, Lan A, et al. Racial and ethnic disparities in utilization rate, hospital volume, and perioperative outcomes after total knee arthroplasty. *J Bone Joint Surg Am.* 2016; 98:1243–1252. [PubMed: 27489314]
 33. Shahid H, Singh JA. Racial/ethnic disparity in rates and outcomes of total joint arthroplasty. *Curr Rheumatol Rep.* 2016; 18:20. [PubMed: 26984804]
 34. Ibrahim SA, Siminoff LA, Burant CJ, Kwok CK. Differences in expectations of outcome mediate African American/white patient differences in “willingness” to consider joint replacement. *Arthritis Rheum.* 2002; 46:2429–2435. [PubMed: 12355491]
 35. Ibrahim SA, Hanusa BH, Hannon MJ, Kresevic D, Long J, Kent Kwok C. Willingness and access to joint replacement among African American patients with knee osteoarthritis: a randomized, controlled intervention. *Arthritis Rheum.* 2013; 65:1253–1261. [PubMed: 23613362]
 36. Ibrahim SA, Blum M, Lee GC, Moar P, Medvedeva E, Collier A, et al. Effect of a decision aid on access to total knee replacement for Black patients with osteoarthritis of the knee: A randomized clinical trial. *JAMA Surg.* 2017; 152:e164225. [PubMed: 27893033]
 37. Katz JN. Patient preferences and health disparities. *JAMA.* 2001; 286:1506–1509. [PubMed: 11572745]
 38. Katz RV, Kegeles SS, Kressin NR, Green BL, James SA, Wang MQ, et al. Awareness of the Tuskegee Syphilis Study and the US presidential apology and their influence on minority participation in biomedical research. *Am J Public Health.* 2008; 98:1137–1142. [PubMed: 17901437]
 39. Ogden CL, Carroll MD, Kit BK, Flegal KM. Prevalence of childhood and adult obesity in the United States, 2011–2012. *JAMA.* 2014; 311:806–814. [PubMed: 24570244]

40. Taylor DC, Pandya A, Thompson D, Chu P, Graff J, Shepherd J, et al. Cost-effectiveness of intensive atorvastatin therapy in secondary cardiovascular prevention in the United Kingdom, Spain, and Germany, based on the Treating to New Targets study. *Eur J Health Econ*. 2009; 10:255–265. [PubMed: 18800232]
41. Melnikow J, Birch S, Slee C, McCarthy TJ, Helms LJ, Kuppermann M. Tamoxifen for breast cancer risk reduction: impact of alternative approaches to quality-of-life adjustment on cost-effectiveness analysis. *Med Care*. 2008; 46:946–953. [PubMed: 18725849]
42. Weaver M, Krieger J, Castorina J, Walls M, Ciske S. Cost-effectiveness of combined outreach for the pneumococcal and influenza vaccines. *Arch Intern Med*. 2001; 161:111–120. [PubMed: 11146707]
43. Fisman DN, Reilly DT, Karchmer AW, Goldie SJ. Clinical effectiveness and cost-effectiveness of 2 management strategies for infected total hip arthroplasty in the elderly. *Clin Infect Dis*. 2001; 32:419–430. [PubMed: 11170950]
44. SooHoo NF, Lieberman JR, Ko CY, Zingmond DS. Factors predicting complication rates following total knee replacement. *J Bone Joint Surg Am*. 2006; 88:480–485. [PubMed: 16510811]
45. Paxton EW, Namba RS, Maletis GB, Khatod M, Yue EJ, Davies M, et al. A prospective study of 80,000 total joint and 5000 anterior cruciate ligament reconstruction procedures in a community-based registry in the United States. *J Bone Joint Surg Am*. 2010; 92(2):117–132. [PubMed: 21123596]
46. Mahomed NN, Barrett J, Katz JN, Baron JA, Wright J, Losina E. Epidemiology of total knee replacement in the United States Medicare population. *J Bone Joint Surg Am*. 2005; 87:1222–1228. [PubMed: 15930530]

Significance and Innovation

- Many studies have described lower rates of TKR use for racial minorities in the United States, but to our knowledge, no study has investigated the effect of lower TKR utilization and higher associated complications on population-level health.
- Quality-adjusted life years (QALYs) measure the effects of disease and disability on individual's lives and can be quantified across a population.
- We estimated the QALYs lost in the Black population due to racial differences in the rate of TKR offer, acceptance, and complications.

Figure 1. QALYs Gained from Current TKR Utilization

Bar height represents the number of QALYs gained for each race/sex cohort per 100 persons.

Abbreviations: QALY: Quality-Adjusted Life Year

Model Inputs

Model inputs were taken from scientific literature assessing cohorts that undergo total knee replacement and the rate of TKR utilization stratified by race and sex.

Table 1

Parameter	Estimate	Data Source
Age: Mean (SD)	66 (8)	Cohort Characteristics Losina et al., 2016 ²⁵
Race	WOMAC Pain (0-100)	
White	Female 23	Male 21
Black	42	33
Adverse Events	Quality of Life Decrement	Derived from
<i>Post-Op Recovery</i>	9.3%	Losina et al., 2009 ¹⁸
<i>Myocardial Infarction</i>	9.7%	Taylor et al., 2009 ⁴⁰
<i>Pulmonary Embolism</i>	11.2%	Melnikow et al. 2008 ⁴¹
<i>Pneumonia</i>	10.2%	Weaver et al., 2001 ⁴²
<i>Joint Infection</i>	14.6%	Fisman et al., 2001 ⁴³
Quality of Life Utility: Nonobese/Obese		
WOMAC Pain (0-100)		
Age Group	1 - 15	16 - 40
55-64	0.822/0.812	0.786/0.775
65-74	0.846/0.835	0.810/0.799
75+	0.829/0.818	0.793/0.782
		0 Comorbidity
		1 Comorbidity
55-64	0.797/0.786	0.761/0.750
65-74	0.821/0.810	0.785/0.774
75+	0.804/0.793	0.768/0.757

Parameter	Estimate			Data Source
	2+ Comorbidities			
55-64	0.800/0.789	0.738/0.727	0.641/0.630	0.506/0.495
65-74	0.824/0.813	0.762/0.751	0.665/0.654	0.530/0.519
75+	0.807/0.796	0.745/0.734	0.648/0.637	0.513/0.502
Population with Advanced Symptomatic Knee OA, Age >45				
	Female	Male	Total	Deshpande et al., 2016 ¹
White	3,550,000	2,510,000	6,060,000	
Black	600,000	310,000	910,000	
Total Knee Replacement Characteristics				
	Male		Female	Data Source Used in Derivations
	Black	White	Black	White
TKR Utilization	6%	19%	7%	18%
Offer Rate	10%	23%	10%	23%
Acceptance Rate	59%	83%	64%	78%
Offer Rate 65+	10%	25%	11%	23%
Acceptance Rate 65+	56%	93%	68%	80%
Offer Rate 65-	11%	17%	9%	21%
Acceptance Rate 65-	63%	62%	57%	71%
Probability of Adverse Events				
Myocardial Infarction	1.20%	0.80%	1.20%	0.80%
Pulmonary Embolism	1.36%	0.79%	1.36%	0.79%
Joint Infection	1.05%	0.70%	1.05%	0.70%
Pneumonia	2.03%	1.36%	2.03%	1.36%
				Katz et al., 2004 ³⁰

Parameter	Estimate			Data Source
90-Day Mortality	0.88%	0.63%	0.88%	Ibrahim et al., 2005 ¹⁷
			0.63%	Katz et al., 2004 ³⁰ Mahomed et al., 2005 ⁴⁶

Abbreviations: WOMAC: Western Ontario and McMaster Universities Arthritis Index

Table 2
Validation of TKR Utilization Predicted by the OAPol Model

Race/Ethnicity	Total Number of TKRs from HCUP, 2013	Total Number of TKRs from OAPol	% of HCUP
White	536,556	544,752	102%
Black	42,871	40,730	95%
Hispanic	47,141	47,735	101%
Total	626,567	633,217	101%

Abbreviations: OAPol: Osteoarthritis Policy Model; TKR: Total Knee Replacement; HCUP: Healthcare Cost and Utilization Project

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Table 3
QALYs Lost Due to Lower Rates of TKR Offer and Acceptance and Higher Rates of Complications Among Black Men and Women

Population QALYs Gains						Population QALY Losses				
Cohort	Current TKR Use Compared to No Treatment (SE)		Due to Low Offer (SE)		Due to Low Accept (SE)		Due to High Comp. (SE)		Due to Low Offer and High Comp. (SE)	
Black-F	49,300 (1,200)		51,600 (900)		10,200 (1,100)		1,700 (1,000)		54,900 (900)	
Black-M	14,900 (1,100)		15,900 (600)		5,600 (600)		900 (600)		17,100 (700)	

Abbreviations: QALY: Quality-Adjusted Life Year; Black-F: Black Female; Black-M: Black Male; Comp.: Complications; SE: Standard Error

Table 4

QALYs Lost with Varied Subsequent Year Offer and Acceptance

Population QALYs Gains		Population QALY Losses			
		2% Subsequent Offer and Acceptance			
Cohort	Current TKR Use Compared to No Treatment (SE)	Lost to Low Offer (SE)	Lost to Low Accept (SE)	Lost to High Comp. (SE)	Lost to Low Offer and High Comp. (SE)
Black-F	60,600 (1,400)	59,100 (1,300)	11,800 (1,000)	2,500 (1,100)	62,800 (1,200)
Black-M	17,600 (1,100)	17,900 (700)	6,300 (600)	1,100 (600)	19,400 (600)
		5% Subsequent Offer and Acceptance			
Black-F	93,700 (1,300)	74,000 (1,100)	15,000 (1,000)	3,500 (1,400)	79,700 (1,000)
Black-M	25,800 (1,100)	21,800 (700)	8,200 (700)	1,300 (600)	24,400 (700)

Abbreviations: QALY: Quality-Adjusted Life Year; Black-F: Black Female; Black-M: Black Male; Comp.: Complications; SE: Standard Error

Table 5

QALYs Lost with Offer and Acceptance Rates Adjusted for Age

Population QALY Gains		Population QALY Losses			
Cohort	Current TKR Use Compared to No Treatment (SE)	Lost to Low Offer (SE)	Lost to Low Accept (SE)	Lost to High Comp. (SE)	Lost to Low Offer and High Comp. (SE)
Black-F	51,400 (1,300)	50,300 (1,300)	9,200 (1,100)	1,600 (1,100)	54,000 (900)
Black-M	14,700 (1,000)	15,400 (400)	5,300 (500)	400 (400)	16,700 (400)

* Subsequent year offer rate 1%, accept rate 1%

Abbreviations: QALY: Quality-Adjusted Life Year; Black-F: Black Female; Black-M: Black Male; Comp.: Complications; SE: Standard Error