Ana Johnson
and
Thérèse Stukel
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Medical Practice Variations in Joint Replacement in Patients with Osteoarthritis

Aparna Ingleshwar[1] and Maria E. Suarez-Almazor[1]
(1)MD Anderson Cancer Center, The University of Texas, Houston, TX 77030, USA

Aparna Ingleshwar (Corresponding author)
Email: aparna.ingleshwar@gmail.com

Maria E. Suarez-Almazor
Email: msalmazor@mdanderson.org

Abstract

Osteoarthritis (OA) is one of the most prevalent of musculoskeletal disorders and the most widespread of all the forms of arthritis, commonly affecting the knee and hip joints. It is a progressive disease causing substantial functional limitation, disability, and morbidity thereby leading to a decreased HRQoL. Moreover, economic costs associated with OA are also substantially high. Total knee/hip arthroplasty (TKA/THA) is widely used for the surgical management of knee and hip OA. The majority of patients who have undergone TKA/THA report substantial improvement in pain and function. Although TKA/THA rates have been exponentially increasing each year, surgery rates vary greatly across the population and are not always consistent with clinical need. Literature documents significant age, gender, and racial/ethnic disparities in joint replacement utilization. Several patient-, provider-, and system-level factors have been identified as potential causes of these disparities. Thus, this chapter aims to provide a descriptive review of the literature on TKA/THA utilization. It examines the current burden of disease in OA, reports on past and present trends in joint replacement utilization, and discusses, in detail, the magnitude, nature, and potential causes of existing disparities in TKA/THA utilization.

Introduction

Osteoarthritis (OA) is a degenerative joint disease resulting in pain, varying degrees of functional limitation, and reduced quality of life (NCC-CC *2008*). It is one of the most prevalent musculoskeletal disorders, the most common of all forms of arthritis (Gelber *2011*), and the primary joint disease affecting elderly individuals (Guilbert *2003*). The most commonly affected joints are those in the hands, knees, hips, and spine (Bijlsma et al. *2011*).

This chapter begins by providing a description of OA pertaining to its prevalence, diagnosis, symptoms, risk factors, impact on quality of life, and associated economic burden. Since there is no

cure for OA, patients with OA of large joints such as hip or knee who do not respond to medical therapy are often offered total joint replacement (TJR) surgery to restore function and mobility. In the next section, the medical and surgical management of OA with particular emphasis on total knee and hip arthroplasty (TKA and THA) is discussed. And in the final section, the chapter provides a detailed description of utilization patterns of TKA and THA, examines disparities in utilization and its underlying causes, and discusses surgical outcomes.

Osteoarthritis

Prevalence and Incidence

The 2008 World Health Organization (WHO) report on the Global Burden of Disease estimated the global prevalence of OA for the year 2004 to be 151.4 million, with the highest prevalence being seen in the Western Pacific regions and the lowest in the Eastern Mediterranean regions (*WHO 2008*). The prevalence of OA varies by age, sex, and ethnicity, as well as by the affected joint. In order to assess variation in surgical rates in OA, it is important to understand the distribution of the disease across demographic groups. Data on prevalence and incidence estimates is presented for three countries: the USA, Canada, and the UK).

The USA: Using prevalence estimates from the Framingham OA Study, the National Arthritis Data Workgroup estimated that in 2005, 9.3 million (4.9 %) US adults aged 26 years or older had symptomatic OA of the knee (Murphy and Helmick *2012*). The prevalence of symptomatic OA of the hip among people aged 45 years or older was 6.7 % in the Framingham OA Study and 9.7 % in the Johnston County Osteoarthritis Project (Lawrence et al. *2008*). In both studies, prevalence was highest among elderly adults (Jordan et al. *2007*). In addition, prevalence was highest among women and Black individuals (Jordan et al. *2007*). Davis and colleagues reported an interaction between gender and age in the prevalence of OA of the knee; among those younger than 45 years, men were affected more frequently than women, whereas among those aged 45 years and older, women were affected both more frequently and more severely than men (Davis et al. *1988*). In another study, increased income and education levels were both associated with a reduced frequency of OA of the knee (Anderson and Felson *1988*), and the age-adjusted prevalence of OA of the knee was nearly three times higher among Black women than among White women (Hartz et al. *1986*).

Because follow-up studies for OA are limited, estimates of the incidence of OA in the US population are also limited (Murphy and Helmick *2012*). A 1995 study showed that among patients aged 20–89, approximately 2 in 1,000 patients developed symptomatic OA of the knee each year; incidence was similar among middle-aged (40–49 years) women and men (1 per 1,000) but slightly higher (10 per 1,000 women and 9 per 1,000 men) among older adults (70–79 years) (Oliveria et al. *1995*). At younger ages (30–39 years), incidence of OA of the hip was higher in men (8 per 100,000) than in women (0 per 100,000), but by ages 70–79 years, the annual incidence was higher among women (6 per 1,000) than men (4 per 1,000) (Murphy and Helmick *2012*). In another study, the age- and sex-adjusted incidence of OA of the hip was 88 per 100,000 person-years, OA of the knee, 240 per 100,000 person-years (Bijlsma et al. *2011*). These differences in prevalence and incidence are important when assessing potential disparities in surgical rates in this disease.

Canada: In the 2011 Canadian Community Health Survey, 17 % of the respondents aged 15 years and older reported having being diagnosed with arthritis, – 12.7 % of males and 21.2 % of females (

Statistics Canada). This represented a modest increase from 15.7 % in 2007. Moreover, since 2007, the rate of males diagnosed with arthritis has remained approximately the same, while the rate of females with arthritis has increased substantially (*Statistics Canada*). In a study by Kopec and colleagues, using data from the Medical Services Plan of British Columbia for the years 1991–1992 through 2000–2001, they found that the overall prevalence of OA in 2001 was 10.8 %: 8.9 % in men and 12.6 % in women. In the category of 45–59-year-olds, approximately 10 % of the population had OA, and by 70–74 years about one-third of men and 40 % of women had OA. The overall incidence rate for OA in 2000–2001 was 11.7 per 1,000 person-years, with 10.0 in men and 13.4 in women. Both incidence and prevalence rates were higher in women for all age groups and increased linearly with age after 50 years for both sexes (Kopec et al. *2007*). A later study projected the OA prevalence to increase from 3 million (14 %) in 2010 to 5.8 million (18 %) in 2031 (Sharif et al. *2012*).
The UK: It is estimated that around 8.5 million people in the UK are affected by OA pain (NCC-CC *2008*); at least 0.5 million have radiographic evidence of knee OA, while 210,000 have radiographic evidence of hip OA (NCC-CC *2008*). Peat et al. reviewed findings from UK studies of incidence and prevalence of knee pain, disability, and radiographic OA in the general population. They found that during a 1-year period, 25 % of people above the age of 55 years had a persistent episode of knee pain. Additionally, the prevalence of painful disabling knee OA in those over 55 years was 10 % (Peat et al. *2001*). The prevalence of OA is also higher in women than in men, especially after the age of 50 for knee OA (NCC-CC *2008*). OA of the hip is less common than that of the knee with prevalence estimates ranging from 5 % to 9 % (NCC-CC *2008*). Few data are available on the incidence of osteoarthritis because of the problems of defining it and how to determine its onset. One study reported a 13 % incidence of radiographic knee OA in women aged 45–65 years over a 4-year period (Spector et al. *1991*).

Symptoms

The clinical manifestations of OA are primarily joint pain and stiffness with accompanying loss of function and progressive decrease in range of motion (Bijlsma et al. *2011*). Symptoms at onset are often insidious. Pain can vary greatly in site and nature and present as a dull ache or a sharp, stabbing pain (Manek and Lane *2000*). Stiffness is common, particularly after inactivity. Patients with hip OA may complain of functional difficulties such as putting on shoes or socks, and early physical signs can include restriction of internal rotation and abduction of the affected hip, with pain occurring at the end of the range of motion. Patients with OA of the knee often complain of instability or buckling, especially when they are descending stairs or stepping off curbs.

Diagnosis

OA is diagnosed on the basis of its hallmark radiographic findings, i.e., the presence of joint space narrowing, sclerosis, subchondral cysts, and osteophyte (spur) formation. Radiologic OA can be graded according to specific criteria such as the Kellgren and Lawrence scoring system (Luyten et al. *2012*). The relationship between joint pain and the radiographic features of OA is not constant, in that many joints with pathologic or radiographic evidence of OA may remain asymptomatic. For example, only about 15 % of patients with radiographically demonstrated OA of the knee complain of knee pain (Hannan et al. *2000*). The American College of Rheumatology has developed diagnostic criteria for OA of the knee (Altman et al. *1986*) and hip (Altman et al. *1991*).

Functional Disability and Health-Related Quality of Life (HRQoL)

According to the WHO, OA is the sixth leading cause of moderate to severe disability (*WHO 2008*). OA of the knee and hip generates higher social costs and more disability than OA of all other joints combined (Bergstrom et al. *1985*). Data from the US National Health Interview Survey (NHIS) for the years 2007–2009 showed that one in nine (21 million) adults experienced activity limitations attributable to OA (YJ Cheng et al. *2010*). The three most frequently reported functional limitations among people with OA are bending or stooping, standing, and walking (Centers for Disease Control and Prevention *2009*). State-specific prevalence estimates of arthritis-attributable work limitations demonstrate that OA has a high impact on working-age adults in all US states, with a prevalence ranging from 3.4 % to 15 % in this age group (Centers for Disease Control and Prevention *2009*). People with OA have significantly worse HRQoL than those who do not have OA. Adults with OA report two to four times as many unhealthy days per month as those without OA (Centers for Disease Control and Prevention *2009*). A US "burden of disease" study estimated that in 1996, OA accounted for 6.3 % of all years of life lost to disability, ranking it third behind depression and alcohol abuse (Michaud et al. *2006*). Similarly, a Canadian study estimating the burden of OA in terms of HRQoL and economic costs between persons with OA compared to those without the disease reported that the mean utility value associated with OA group was 0.68 as compared to 0.84 for the non-OA group ($p < 0.0001$) (Tarride et al. *2012*).

Guccione and colleagues (Guccione et al. *1994*) estimated the odds of dependence in seven functional tasks and activities among people with OA. They found that OA of the knee was among the most disabling conditions and was associated with the greatest limitations in walking and climbing stairs. The adjusted percentage of functional disabilities attributable to OA was approximately 16 %, which was equal to or higher than the percentage of functional disabilities attributable to nine other major conditions in four (walking, carrying, climbing stairs, and housekeeping) of the seven functional tasks. A Canadian study by Thomas and colleagues assessed physical activity and performance (walk test, up-and-go test, stair performance measure) in candidates awaiting total knee arthroplasty and a comparison group without OA (Thomas et al. *2003*). They found that all aspects of physical activity were significantly lower in the OA group, with a moderate difference in household score (18 %) and a large difference in leisure activities (63 %).

Using data from 1990, and projecting the effect of OA in 2000, Reginster and colleagues reported that OA had the fourth highest impact on disability, following ischemic heart disease, cerebrovascular disease, and all musculoskeletal diseases (Reginster and Khaltaev *2002*). Using data from a nationwide survey in France, Fautrel and colleagues (Fautrel et al. *2005*) used reported limitation rates to calculate standardized limitation rate ratios for individuals with OA compared with age- and sex-matched controls. They found that individuals with OA reported limitations in mobility 4.5–6 times more frequently than those who did not have OA. Among those with OA, 61 % reported mobility limitations outside the home, compared with 10.2 % of controls; 12.8 % of those with OA also reported mobility limitations inside the home, compared with 2.8 % of controls. Similar patterns with smaller differences were observed for activities of daily living such as shopping and housecleaning. Standardized limitation rate ratios ranged from 1.6 for dressing and sports to 6.0 for mobility outside the home.

Individuals with OA also have significantly lower scores on all health status survey dimensions measured on the SF-36 controls, reflecting decreased HRQoL (Birrell et al. *2000*).

Risk Factors

The risk factor most strongly associated with OA is age (Crowninshield et al. *2006*). Additional risk factors include obesity, joint injuries, and certain occupations resulting in repetitive joint strain. An overweight adult is 38 % more likely to have OA than an adult with a healthy weight (Crowninshield et al. *2006*). Women in the Framingham OA Study who lost 11 pounds reduced their risk of symptomatic OA of the knee by half (Murphy and Helmick *2012*). US and international studies examining the relationship between OA of the hip and increased body weight have demonstrated mixed findings, although obesity is generally associated with symptomatic OA and joint replacement (Murphy and Helmick *2012*). In the Nurses' Health Study, women who were obese, especially at age 18, had an increased risk of undergoing hip replacement later in life (Murphy and Helmick *2012*). Joint injuries, especially in the knee, resulting from sports, work, or other trauma also increase the risk of OA (Murphy and Helmick *2012*). Occupations that involve excessive mechanical stress on the knees, including those requiring hard labor, heavy lifting, knee bending, and repetitive motion, can also increase the risk of OA of the knee. Such jobs include those in construction and agriculture (most often held by men) and cleaning and retail sales (most often held by women) (Davis et al. *1988*).

Health-Care Costs

In 2003, costs attributable to OA and other rheumatic conditions in the USA amounted to $128 billion ($81 billion in medical expenditures and $47 billion in earnings losses), which represented nearly 1 % of that year's US gross domestic product (Yelin et al. *2007*). In 2006 and again in 2007, roughly 12.3 million ambulatory care visits and 85,000 emergency department visits were associated with an OA diagnosis (Schappert and Rechtsteiner *2011*). According to the Agency for Healthcare Research and Quality (AHRQ), discharge data from the Nationwide Inpatient Sample (NIS), Healthcare Cost and Utilization Project (HCUP), demonstrated that OA was the primary diagnosis for an estimated 974,000 hospitalizations in 2010, with a mean cost per stay of $15,100; this is more than double the number of hospital stays associated with a primary diagnosis of OA in 1997 – 418,000 (*Pfuntner et al. 2013*). In 2010, OA was the third most common primary diagnosis associated with a hospital stay (after live born and pneumonia) (*Pfuntner et al. 2013*), whereas it ranked 19th for the same in 1997 (HCUPnet. *1997*). This increase is reflective of the upward trend in OA-related hospitalizations and costs of hospital stays observed between 1993 and 2010 (HCUPnet. *1993*–2010). The number of US adults with OA is projected to rise to 67 million by 2030 (Hootman and Helmick *2006*).

A Canadian study by the Institute for Clinical Evaluative Sciences (ICES) calculated the total cost of arthritis and rheumatism for the year 1994 to be $C4.3 billion and $C7.3 billion, respectively (Stafinski et al. *2001*). The direct costs during the same period varied from $C1.7 to $C2.5 billion dollars, amounting to 2.9 % of the 1994 total health expenditure in Canada or 9.7 % of its GDP. The indirect costs for the same year were $C3.75 billion (Coyte and Axcell *1998*). More recently, a population-based microsimulation model projected the total direct costs of OA in Canada would rise from $1.8 billion in 2010 to $8.1 billion in 2031 (Sharif et al. *2012*).

Likewise, OA has a significant negative impact on the UK economy with OA-related medical costs estimated to be around 1 % of the annual GNP (NCC-CC *2008*). Each year approximately two million people visit their general practitioner (GP) due to OA. Between 1999 and 2000 there were 114,500 OA-related hospitalizations in the UK and 36 million working days lost due to OA alone, incurring a cost of around £3.2 billion in lost production (NCC-CC *2008*). Moreover, only very few people who

receive disability benefits return to work later (NCC-CC *2008*). An additional £43 million and £215 million were spent on community services and social services for OA (NCC-CC *2008*). Most recent estimates from the Hospital Episode Statistics (HES) for the years 2010–2011 depict a significant increase in hospital admissions for hip and knee arthritis, with a collective figure of 181,350 admissions (Chen et al. *2012*).

Treatment Options

Because OA is currently an incurable disease, treatment mostly involves managing symptoms and slowing the progression of the disease through lifestyle changes such as weight reduction. In 1995, the American College of Rheumatology published recommendations for the medical management of OA of the knee and hip (Hochberg et al. *1995*). These guidelines outlined the use of nonpharmacologic modalities including patient education and physical and occupational therapy, as well as the use of selected pharmacologic agents. Specific recommendations for surgical management of OA, however, were not included.

Treatment for OA of the hip is generally similar to treatment for OA of the knee, with a few minor differences (Altman et al. *2000*). Intra-articular hyaluronan therapy is not approved for OA of the hip; no published studies have examined its efficacy in patients with OA of the hip (Altman et al. *2000*). The efficacy of intra-articular glucocorticoid injections has not been studied in patients with OA of the hip, but such injections are used occasionally and may be efficacious (Altman et al. *2000*). Modalities of physical therapy for patients with OA of the hip differ from those used in patients with OA of the knee, and consultation with a physical therapist should be considered as part of the overall management of OA (Altman et al. *2000*).

Patients with severe symptomatic OA who have pain that is unresponsive to medical therapy and/or who have progressive physical limitations should be referred to an orthopedic surgeon for surgical evaluation (Altman et al. *2000*). Osteotomy and joint-preserving surgical procedures are advocated in young adults with symptomatic hip OA with dysplasia and in physically active young adults with unicompartmental knee OA. High tibial osteotomy for knee OA is shown to be an effective procedure yielding optimal clinical results, thereby delaying the need for joint replacement by some 10 years. The use of joint lavage and arthroscopic debridement in knee OA are controversial, with some studies showing short-term symptom relief, while others attribute these improvements to a placebo effect (Zhang et al. *2008*).

In cases in which all treatments fail, joint replacement surgery is advocated. A knee replacement can be partial (one or two compartments) or total (three compartments) (Michael et al. *2010*). Total joint replacement provides marked pain relief and functional improvement in the vast majority of patients with OA (Lopez-Olivo et al. *2011*) and has been shown to be cost-effective (Altman et al. *2000*). Indications for THA, developed at a National Institutes of Health Consensus Conference, include “radiographic evidence of joint damage and moderate to severe persistent pain or disability, or both, that is not substantially relieved by an extended course of nonsurgical management” (Altman et al. *2000*). Although no evidence-based indications for TKA have been published, Dieppe and colleagues summarized indications derived from three consensus groups of orthopedic surgeons (Altman et al. *2000*; Dieppe et al. *1999*).

Total Joint Replacement

The number of hip and knee replacements has increased rapidly over the past decade in most countries, with an increase in the ratio of TKA performed relative to THA (Crowninshield et al. *2006*). THA was the first total joint replacement procedure to have widespread use. TKA was developed later. In the mid-1980s, twice as many THAs were performed in the USA as TKAs (Crowninshield et al. *2006*). During the next 17 years, a rapid increase in the number of TKAs performed resulted in a reversal of this ratio, with twice as many TKAs as THAs performed in 2002 (Crowninshield et al. *2006*). More recently, in 2010, a total of 658,340 TKAs and 302,839 THAs were performed (*AHRQ. 2010*), representing compared to 1993 an increase of more than 220 % for TKA and 120 % for THA (Figs. 1 and 2). The number of revision TKAs and THAs (procedure in which previously implanted knee or hip prosthesis is removed and replaced with a new one) has also increased significantly. Kurtz and colleagues found that the total number of revision THAs almost doubled and the total number of revision TKAs tripled between 1990 and 2002 (Kurtz et al. *2005*).

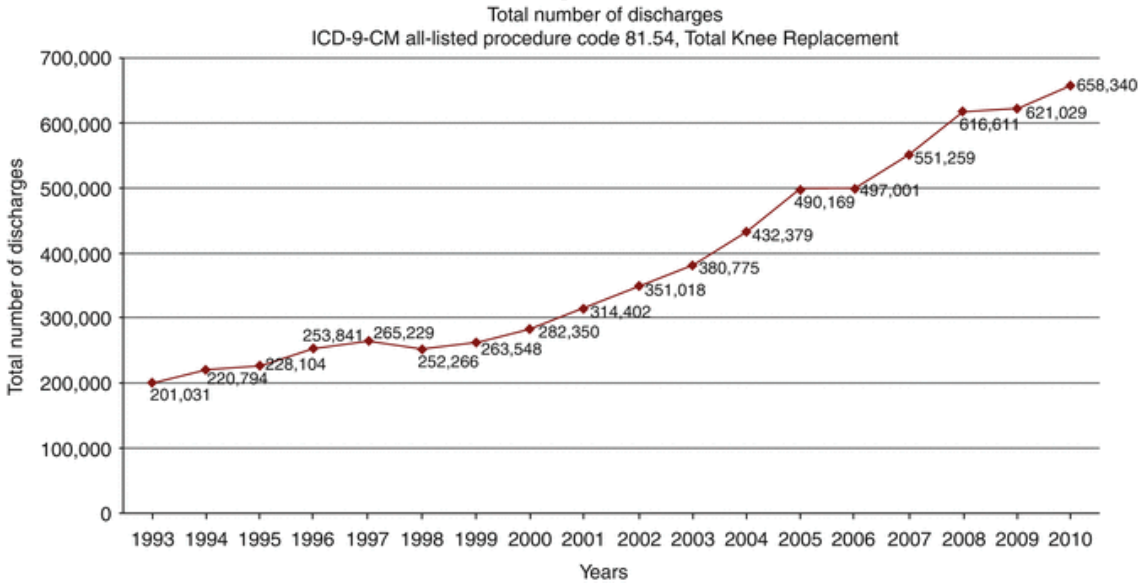

Fig. 1
Number of hospital discharges per year associated with hospital stays for total knee replacement (ICD-9-CM procedure code 81.54) (*Source*: Weighted national estimates from the Healthcare Cost and Utilization Project Nationwide Inpatient Sample, based on data collected by individual states and provided to the Agency for Healthcare Research and Quality)

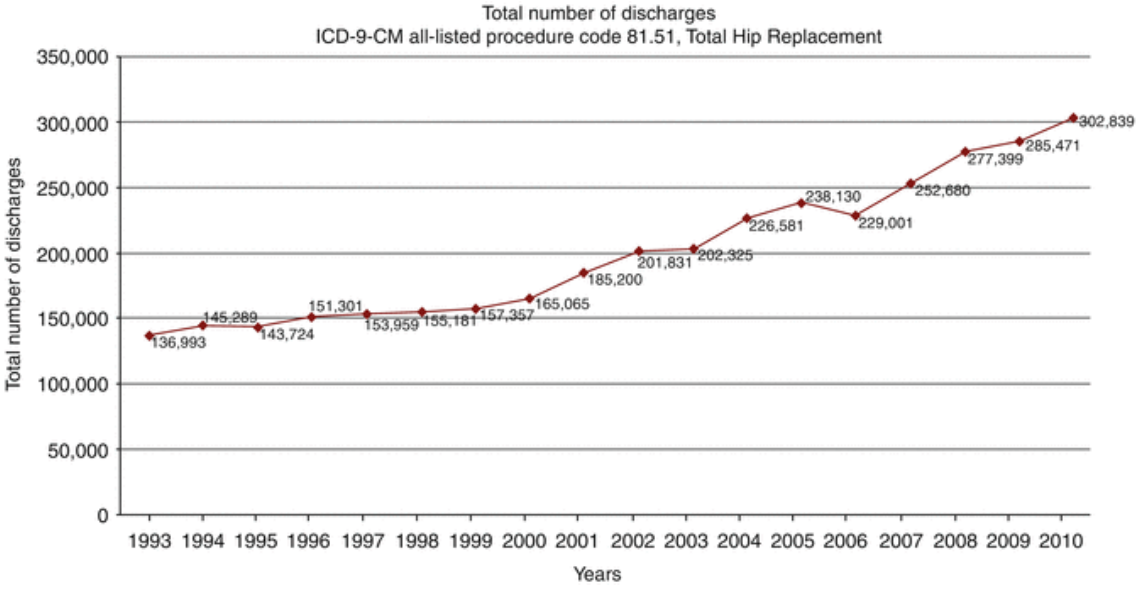

Fig. 2
Number of hospital discharges per year associated with hospital stays for total hip replacement (ICD-9-CM procedure code 81.51) (*Source*: Weighted national estimates from the Healthcare Cost and Utilization Project Nationwide Inpatient Sample, based on data collected by individual states and provided to the Agency for Healthcare Research and Quality)

In Canada, the rate of joint replacements has also increased steadily since 1981 although the increase in hip replacements seems to have leveled off (Williams et al. *2004*). Data from the Canadian Joint Replacement Registry (CJRR) show that combined knee and hip replacement utilization in Canada increased by 101 %, from 31,043 procedures in 1996–1997 to 62,196 procedures in 2006–2007 (*Canadian Institute for Health Information 2009*). More specifically, in 2006–2007, there were 37,943 hospitalizations for knee replacements and 24,253 hospitalizations for hip replacements, with the number of knee replacements increasing by 140 % since 1996–1997 and the number of hip replacements by 59 % (*Canadian Institute for Health Information 2009*). TKA utilization surpassed THA rates in the mid-1990s, and this difference continues to increase (*Canadian Institute for Health Information 2009*). TKA and THA utilization estimates show that in 2009–2010, 22,545 TKAs were reported, of which 93.8 % were primary procedures. In the same year, 15,953 THAs were reported, of which 89.2 % were primary replacements. These figures depict a 36 % increase in the number of TKAs and a 26 % increase in the number of THAs since 2003–2004. A more recent study comparing TKA and THA utilization rates in Ontario, Canada, and the USA was conducted by Ravi et al. The authors utilized administrative databases, HCUP and ICES, to assess utilization rates for the USA and Ontario for the years 2001, 2003, 2005, and 2007. They found that compared to Ontario, the USA had consistently higher crude rates of TKA for all time periods. Although, THA rates were higher in the USA in 2001 and 2003, they did not significantly differ from Ontario in 2005 and 2007. Additionally, recipients of THA and TKA in the USA were consistently younger (<60 years of age) compared to those in Ontario. Comparison of age- and sex-standardized rates of TKA revealed greater rates in the USA for all time periods, but the relative increase in rates from 2001 to 2007 was greater in Ontario (the USA, 59 %; Ontario, 73 %) (Ravi et al. *2012a*).

The UK: In its ninth annual report, the National Joint Registry reported that in 2011, 84,653 TKAs were conducted in the UK, an increase of 3 % over 2010 (*NJR 2012*). Likewise, 80,314 THAs were performed, an increase of 5 % over 2010. Dixon and colleagues examined trends in primary and revision TKA and THA in England between 1991 and 2000 using data from the Hospital Episode

Statistics (HES) database (Dixon et al. *2004*). They found that between 1991 and 2000, the rates of primary THA increased by 18 %, while the incidence of revision THA more than doubled. The rates of primary TKA doubled, with revision TKA increasing by 300 %. Over the 10-year period, the proportion of THA that required revision rose from 8 % to 20 % (Dixon et al. *2004*). Another study examining TKA and THA utilization trends in the UK using data from the General Practice Research Database for the years 1991–2006 found that during this 16-year period, THA and TKA rates increased significantly mostly for TKR (Culliford et al. *2010*).

Outcomes of Total Joint Replacement

Most patients who have undergone TKA and THA report improvement in pain and function (Hawker et al. *1998*). Specifically, 85–90 % of patients report pain relief after total joint replacement surgery, and 70–80 % report functional improvement and are satisfied with the surgery (Kane et al. *2005*). The greatest improvement is seen within 3–6 months after surgery, with more gradual improvements occurring up to 2 years after surgery (Jones et al. *2000*).

A meta-analysis of 130 studies on TKA (Callahan et al. *1994*) indicated that these favorable results continue over time, with 89 % of patients reporting good to excellent results after an average follow-up period of 4.1 years (Callahan et al. *1994*). Another meta-analysis showed similar results: TKA was found to lead to substantial functional improvement, with large effect sizes even in studies in which the duration of follow-up was more than 5 years (Kane et al. *2005*). Although improvements following TKA can be dramatic, the gains are typically less than those reported by patients who have undergone THA (Salmon et al. *2001*). Approximately 15–30 % of patients who undergo TKA and THA report little or no improvement after surgery or are unsatisfied with the results after a few months (Jones et al. *2000*).

Several studies have reported positive effects of TKA and THA on HRQoL (Jones et al. *2000*). In a cross-sectional community-based study, patients reported significant and persistent relief of pain, improved physical function, and satisfaction with the result 2–7 years after the surgery (Hawker et al. *1998*). A review article by Towheed and Hochberg in 1996 identified 20 studies published between 1978 and 1995 that evaluated changes in HRQoL after THA. Results of all studies consistently showed beneficial and often dramatic improvements in HRQoL which were most likely to occur within the first 3–6 months after the surgery (Towheed and Hochberg *1996*). Several other studies have reconfirmed these findings, with greatest improvements within the first 3–6 months after surgery and long-lasting improvement in studies with long-term follow-up (Ethgen et al. *2004*; Cushner et al. *2010*; Cushnaghan et al. *2007*; Shan et al. *2014*). Moreover, it has been shown that patients who undergo THA have better and earlier gains than do those who undergo TKA in terms of HRQoL (March et al. *2002*; Cushner et al. *2010*).

The major concern in long-term outcomes of TKA and THA is survival of the prosthesis. Prostheses can fail for a variety of reasons, such as aseptic loosening, deep joint infection, dislocation, fracture, technical error, or implant fracture (Callahan et al. *1994*). In general, aseptic loosening arises from osteolysis (Katz *2006*), when polyethylene wear debris collects in the joint and elicits an inflammatory reaction that erodes the bone. Data from referral centers suggest that hip and knee replacements may last more than 20 years in most patients (Katz *2006*). The only population-based data available suggest that over short-term follow-up (4 years or less), the rate of THA failure leading to revision is between 1 % and 4 % per year (Losina et al. *2004*). Data from the Swiss registry suggest that failure rates following THA are approximately 1 % per year for procedures done in the 1980s and early 1990s. However, for procedures done more recently, the failure rates appear to be lower (Katz

2006). Thus, one can reasonably anticipate 90 % revision-free survival after 10 years of follow-up for patients who have undergone primary TKA and THA (Katz 2006). More recently, Ravi et al. conducted a systematic review comparing complications of TJR in rheumatoid arthritis (RA) versus OA. The results indicated that patients with RA are at increased risk of dislocation following THA (adjusted odds ratio 2.16 [95 % confidence interval 1.52–3.07]). In addition, risk of infection and risk of early revision following TKA were greater in RA versus OA. No significant differences between RA and OA were observed for: rates of revision at later time points, 90-day mortality, or rates of venous thromboembolic events following THA or TKA (Ravi et al. 2012b).

Costs and Length of Stay

Hospital costs and charges for TKA and THA have been steadily rising in the USA (Figs. 3 and 4). As of 2010, the average hospital costs for TKA and THA in the USA were $15,924 and $16,596, respectively (HCUPnet. 2010), with average hospital charges for TKA of $48,111 and for THA, $51,072 (HCUPnet. 2010). The average length of stay for both procedures has decreased from around 7 days in 1993 to approximately 3 days in 2010 (HCUPnet. 1993–2010). Although TKA and THA attributable hospital costs have been steadily rising, the benefits of these procedures in terms of long-term cost savings have been underestimated. In order to demonstrate these potential cost savings, Hawker et al. conducted a population-based nested case–control study of the costs of hip and knee replacement surgery in Ontario, Canada. They examined changes in direct health-care costs and arthritis severity after TJR for hip/knee arthritis compared with contemporaneous changes in matched controls. The results showed that, on average, cases experienced significant decreases in arthritis attributable costs (mean decrease $278 including prescription drugs) and pain and disability (P = 0.0001 for all). Over the same time period, controls experienced a significant increase in total health-care costs (mean increase $1978 including prescription drugs, P = 0.04) and no change or worsening of their arthritis status (Hawker et al. 2009).

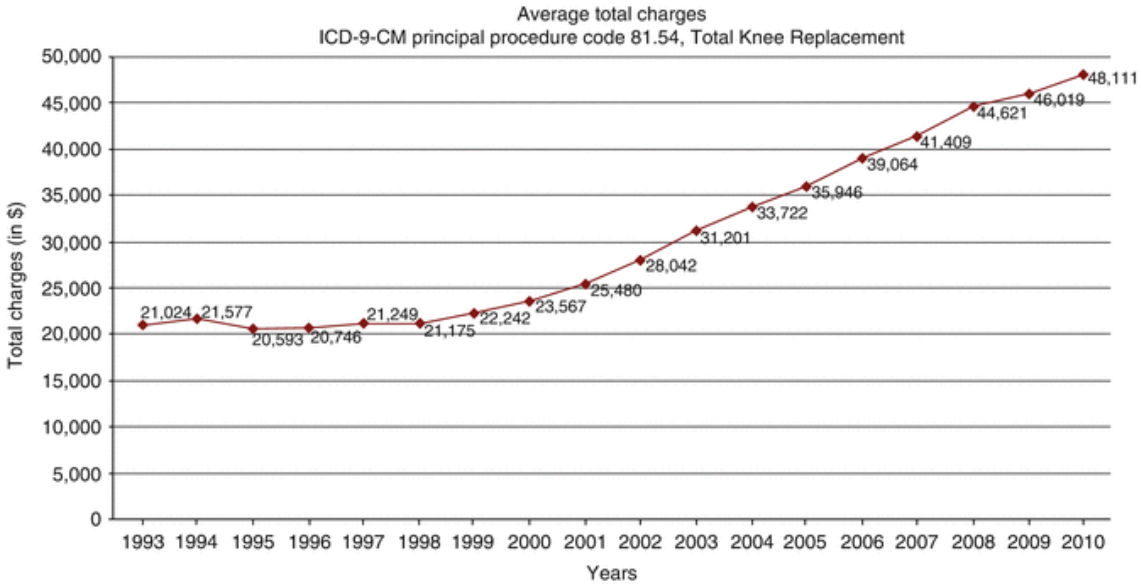

Fig. 3
Average total hospital charges, by year, for a total knee arthroplasty in the USA (ICD-9-CM principal procedure code 81.54) (*Source*: Weighted national estimates from the Healthcare Cost and Utilization Project Nationwide Inpatient Sample, based on data collected by individual states and provided to the Agency for Healthcare Research and Quality)

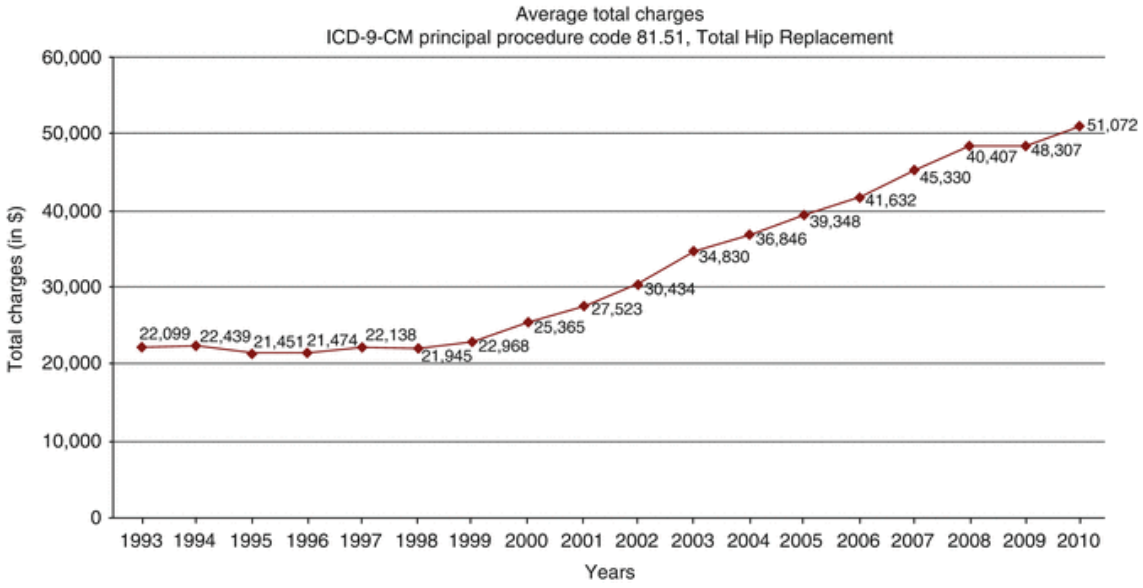

Fig. 4

Average total hospital charges, by year, for a total hip arthroplasty in the USA (ICD-9-CM principal procedure code 81.51) (*Source*: Weighted national estimates from the Healthcare Cost and Utilization Project Nationwide Inpatient Sample, based on data collected by individual states and provided to the Agency for Healthcare Research and Quality)

Variation in the Use of TKA and THA

Many studies have reported significant variation in the rates of TKA and THA utilization.

Variation by Socioeconomic Status (SES)

Several studies have documented reduced TKR utilization in persons of lower SES (Agabiti et al. *2007*). Authors Dixon and colleagues examined trends in primary and revision joint (hip and knee) replacement in England between 1991 and 2000. They observed a significant deprivation-based gradient in rates, with the most deprived fifth of the population experiencing significantly lower rates (Dixon et al. *2004*). Another study by Mahomed and colleagues examining the rates and outcomes of primary and revision THA in the US Medicare population also found similar results. Those with lower incomes (receiving Medicaid supplement) were found to have significantly lower rate ratios for both primary THA (rate ratio, 0.66; 95 % confidence interval 0.63–0.70) and revision THA (rate ratio, 0.90; 95 % confidence interval 0.83–0.97) (Mahomed et al. *2003*).

Geographic Variation

Use of TKA and THA in the USA differs by geographic region and is highest in the western, north central, and Rocky Mountain regions and lowest in New England and the mid-Atlantic states (Katz *2006*). A study which examined use of TKA and THA in Medicare beneficiaries across all 50 states and the District of Columbia for the years 1995–1996 (Peterson et al. *1992a*) found that age-adjusted utilization rates of TKA and THA were significantly higher in the midwestern and western states

compared with southern and eastern states. Their results showed no significant association between the use of THA/TKA and the number of orthopedic surgeons in each state, but use of THA/TKA was inversely related to population density. Thus, they concluded that variation was likely the result of patients' lifestyles or other factors rather than the practice patterns of the physicians (Peterson et al. *1992a*). However, subsequent estimates from the HCUP database showed an apparent increase in TKA procedures in the southern states, such that in 2010, TKA rates were the highest in the southern and midwestern states (37.8 % and 28.6 %, respectively) compared to the western (17.0 %) and northeastern states (16.6 %) (HCUPnet. *2010*). A similar trend was observed for THA with higher numbers reported in southern (34.5 %) and midwestern (26.5 %) states and similar number of procedures in the western (19.2 %) and northeastern states (19.8 %) (HCUPnet. *2010*).

Fisher and colleagues studied regional variations in the use of TKA and THA in Medicare patients for the years 2000–2001 and 2005–2006. They found that the age–sex-adjusted TKA and THA rates varied widely in both periods (Table 1). Variation also existed within the individual states for both procedures (*Fisher et al. 2010*).**Table 1**

Age–sex-adjusted TKA and THA rates across US states

	2000–2001 (per 1,000 beneficiaries)	**2005–2006 (per 1,000 beneficiaries)**
TKA Highest rate Lowest rate	 Elyria, Ohio (10.5) Honolulu (2.5)	 Lincoln, Nebraska (15.7) Manhattan (4.0)
Other regions with TKA rates consistently lower than the national average		
Paterson, New Jersey Kingsport, Tennessee Oxford, Mississippi	3.1 3.1 4.5	4.4 4.9 5.5
Other regions with TKA rates consistently higher than the national average		
Sioux Falls, South Dakota Topeka, Kansas Casper, Wyoming	9.1 9.9 7.4	14.3 13.4 12.9
THA Highest rate Lowest rate	 Boulder, Colorado (6.7) Alexandria, Louisiana (1.2)	 Bryan, Texas (1.8) Ogden, Utah (7.2)
Other regions with THA rates consistently lower than the national average		
Honolulu Fort Smith, Arkansas	1.5 1.6	1.9 2.6

Wilkes-Barre, Pennsylvania	2.2	1.9
Regions with THA rates consistently higher than the national average		
Grand Forks, North Dakota	5.9	6.3
Lansing, Michigan	5.8	6.2
Fort Myers, Florida	5.3	6.1

TKA total knee arthroplasty

THA total hip arthroplasty

Rates include both primary and revision replacements

Source: *Fisher et al. (2010)*

The authors discussed potential reasons for these observed geographical variations in TKA and THA rates and felt they were related to differences in physician recommendations and physician preferences for joint replacement surgery and possibly differences in the supply of surgeons who could perform the procedures (*Fisher et al. 2010*).

Population density also appears to have an effect on variation. In Olmsted County, Minnesota, between 1969 and 1980 rural residents were less likely than urban residents to undergo THA (29/100,000 vs. 49/100,000) (Melton et al. *1982*). More recently, in 2009, Francis and colleagues reported use of TKA/THA in rural and urban Medicare beneficiaries in 2005 and observed the opposite. They found that, compared to urban beneficiaries, rural beneficiaries were 30 % more likely to undergo TKA (odds ratio (OR) 1.30 [95 % confidence interval (CI) 1.29–1.32]) and 19 % more likely to undergo THA (OR 1.19 [95 % CI 1.17–1.21]). Moreover, even after adjusting for age, sex, race/ethnicity, median household income, average house value, mean poverty ratio, and state of residence, rural beneficiaries were still 14 % and 15 % more likely to have TKA (OR 1.14 [95 % CI 1.13–1.15]) and THA (OR 1.15 [95 % CI 1.13–1.18]) procedures, respectively. The authors attributed this increased frequency of TKA/THA procedures in rural residents to: rising trends in commuting from rural to urban setting for elective surgery thereby eliminating access barriers, increase in orthopedic surgery workforce, greater specialist care in rural areas (through permanent and outreach clinics), and an upsurge in hospital marketing of profitable product lines, such as total joint replacement surgeries. However, the authors also recognized that while these factors may account for similar rates between rural and urban populations, they fall short of explaining the increased frequency of TKA/THA procedures among individuals in rural settings (Francis et al. *2009*).

Significant sex, racial, and ethnic disparities were noted in both rural and urban areas. Interestingly, they were less pronounced in rural compared to urban areas for Hispanic and Asian or Pacific Island beneficiaries. There was no rural–urban difference in rates among Black beneficiaries, but a disparity was observed for rural compared with urban Native American beneficiaries, which the authors speculated could be due to differences in referral patterns for total joint replacement surgeries within the Indian Health Service. Other noteworthy findings included: Black beneficiaries had lower odds than White beneficiaries of undergoing TKA or THA in rural areas (OR 0.68, 95 % CI 0.65–0.71); no disparity in TKA/THA use was detected for Hispanic beneficiaries compared with White beneficiaries in rural areas, but differences were observed in urban areas such that Hispanics had lower odds than Whites for receipt of TKA/THA (OR 0.62, 95 % CI 0.50–0.70) (Francis et al. *2009*).

In their 2008–2009 annual report, the CJRR described profound provincial variations in the rates of hip and knee replacement for the years 2006–2007 in Canada (*Canadian Institute for Health*

Information 2009). The highest age-standardized rate of knee replacement occurred in Manitoba (157.4), whereas that for hip replacement occurred in Saskatchewan and Manitoba (slightly above 90). Newfoundland and Labrador had the lowest rates for both knee (77.9) and hip (50.5) replacements. Compared to 1996–1997, the age-standardized rates of hip and knee replacements increased in most of the jurisdictions with the greatest percent increase seen in Manitoba. Both Nova Scotia and Alberta recorded slight decreases for hip replacement rates (6 % and 3 %, respectively), while Nova Scotia alone recorded a very small increase in knee replacement rates (3 %), over the time period (*Canadian Institute for Health Information 2009*). Considerable regional variation in TKA and THA rates occurred within the province of Ontario itself. According to the 2004 I.E. atlas on Arthritis and Related Conditions, variations in TKA by District Health Council (DHC) showed a twofold difference between the highest and lowest rates for TKA (180.2 per 100,000 for Northwestern Ontario and 90.9 per 100,000 for Toronto) (Williams et al. *2004*). The DHC with lowest age-standardized THA rates in 2001–2002 were Toronto, Simcoe-York, and Algoma-Cochrane-Manitoulin-Sudbury, whereas those with higher rates were Grey-Bruce-Huron-Perth, Essex-Kent-Lambton, and Southeastern Ontario (Williams et al. *2004*). The rankings of THA rates by districts have remained relatively consistent in the past four study periods as reported by the ICES practice atlases. However, compared to 1996–1997, changes in ranking occurred in the Grand River and Thames Valley districts where the rankings dropped and Niagara and Northwestern Ontario where they increased (Williams et al. *2004*), primarily due to increases in rates in districts moving up in the ranking, and not because of declines in those ranked lower.

One of the earliest estimates of regional variation in joint replacement in the UK was reported by Frankel and colleagues in 1990 (Frankel et al. *1990*). Using HES data, they demonstrated variations in TKA rates by regional health authority for the time period 1980–1988/1989. TKA rates varied between 25 per 100,000 in southwestern regions to 13 per 100,000 in the northwestern Thames region (Frankel et al. *1990*). For the year 2000, HES data showed that TKA and THA rates were highest in the southwest and midland regions, with TKA rates also high in Trent, whereas the lowest rates for both the procedures were observed in the northwest, southeast, and London regions (Dixon et al. *2006*). The authors also found marked regional variation by gender for TKA procedures, such that for men, Trent had the highest TKA rate and London had the lowest, while for women, rates were highest in the West Midlands and lowest in the northwest. While regional variation decreased overall, in 2000, regions with the highest rates were still around 25–30 % greater than those with the lowest rates (Dixon et al. *2006*). UK studies exploring urban–rural differences and effect of deprivation on joint replacement rates have consistently found that THA utilization is higher in rural areas compared to urban areas (Judge et al. *2009*) and that people living in areas with least deprivation receive a greater number of THA procedures (Judge et al. *2009*). However, a study by Cookson and colleagues found that although the effect of deprivation on THA utilization was still evident, these inequalities had significantly narrowed over time, with the proportionate increase in use in those in the least deprived areas falling from 41 % in 1991 to 27 % in 2001 (Cookson et al. *2007*). The authors reasoned that increased hip replacement rates in the 1990s might have lowered barriers to access, thereby allowing greater dispersion of this surgical procedure among lower socioeconomic groups (Cookson et al. *2007*). With respect to TKA one study reported no association between urbanity and utilization (Judge et al. *2009*), whereas two others reported conflicting findings for the effect of deprivation on TKA rates. Dixon and colleagues found that those in the least deprived areas had significantly higher TKA rates (Dixon et al. *2004*), while Judge et al. found that those in most deprived areas receive greater number of TKA procedures (Judge et al. *2009*). Judge et al. attributed the observed difference in the direction of the effects to their failure in controlling for clustering in the data, which caused the association to change direction (Judge et al. *2009*).

Gender, Age, and Ethnicity

Although the number of TKAs and THAs performed over the past two decades has increased for patients of all ages, it has been much more substantial in women of all ages, in patients younger than 65, and in Whites.

Overall, in 2009 in the USA, the hospitalization rates for TKA were 57 % higher for women than for men, and for THA, 38 % higher for women than for men (Wier et al. *2011*). Data from the National Hospital Discharge Survey between 1990 and 2002 also showed significant higher rates for primary and revision TKAs and THAs in women compared to men (Kurtz et al. *2005*). Likewise, higher rates of TKA and THA in women compared to men have been documented in Canada and the UK. For 2006–2007 CJRR reported that females were more likely to undergo hip replacement than males the age-standardized rate for females was 85.5 per 100,000 compared to 75.6 per 100,000 for males (*Canadian Institute for Health Information 2009*). Females also had an increased rate of knee replacement (148.0 per 100,000) than males (109.6 per 100,000). In the UK, the NJR reported that in 2011, approximately 60 % of those who had undergone hip replacements and 56 % of those who had undergone knee replacements were female (*NJR 2012*), with a gender ratio that has remained relatively constant over the past 8 years (*NJR 2012*). A systematic review examining disparities in TKA identified seven studies addressing this topic, six of which reported that women were more likely to undergo total joint replacement procedures than men (Kane et al. *2007*). However, it has been documented that women altogether are more likely to suffer from knee OA, have worse symptoms and greater disability at the time of joint replacement (Hawker et al. *2000*), and have a greater need for joint replacement (Hawker et al. *2000*). Thus, after adjusting for prevalence, need, and severity of symptoms, an opposite trend is observed wherein women are less likely to receive total joint replacement than men (Hawker et al. *2000*). Hence, although the absolute numbers and increases in rates of knee and hip replacement procedures might be greater in women, they belie the fact that there is a disparity in the use of joint replacement procedures by women according to need which might be the result of certain barriers, perceived or actual, that is unique to women.

Wier and colleagues reviewed TKA and THA hospitalization rates in the USA between 1997 and 2009, categorizing the data by sex and four age brackets (18–44 years, 45–64 years, 65–84 years, and 85 years and older) and found that hospitalization rates increased the most in patients in the 45–64 age bracket: for TKA, 157 % for females and 144 % for males and for THA, 81 % for females and 97 % for males (Wier et al. *2011*). In the 65–84 age bracket, hospitalization rates for TKA increased by 69 % for females and 55 % for males, and for THA it increased by 9 % for females and 22 % for males. For patients aged 85 years or older, hospitalization rates for TKA increased by 23 % for females and 36 % for males (Wier et al. *2011*), whereas hospitalization rates for THA decreased by 17 % for females and 12 % for males. In the 18–44 age bracket, THA hospitalization rates continued to mimic this upward trend observed in previous age groups, such that there was a 20 % increase in hospitalization rates for females and a 16 % increase for males. An opposite trend was observed for TKA hospitalization rates wherein the rates decreased for both men and women, with the decrease in males (−61 %) being much greater than that in females (−21 %). Although most growth in TKA and THA over the years is seen in the 45–64 age category, those aged 65–84 years continue to receive the majority of joint replacements.

In Canada, the CJRR stratifies the 45–64 age bracket further into two categories; 45–54 and 55–64 (*Canadian Institute for Health Information 2009*). A similar growth trend in knee replacement was observed in Canada for the years 2006–2007 compared to 1996–1997; the largest percent increases in

number of procedures were noted in the 45–54 age group for both females and males (337 % and 271 %, respectively), followed by the 55–64 age group for females (260 %) and the 85 and older age group for males (206 %) (*Canadian Institute for Health Information 2009*). For hip replacement, again, the largest percent increase for males was seen in the 45–54 age group (140 %). On the other hand, for females, the largest percent increase was seen in the 85 and older age group (105 %) (*Canadian Institute for Health Information 2009*). For knee replacement, the largest 10-year increase was observed in the 45–54 age group, wherein the rate of knee replacements more than doubled for males (171 %) and more than tripled for females (217 %), followed by the 55–64 age group (114 % for males and 144 % for females). For hip replacement, the largest 10-year increase among males was again seen in the 45–54 age group (76 %), followed by the younger than 45 age group (48 %), whereas for females, the largest increases were observed in the 85 and older age group (36 %), followed by the 55–64 and 45–54 age groups (32 % and 30 %, respectively) (*Canadian Institute for Health Information 2009*). The highest age–sex-specific rate for both procedures in both years (1996–1997 and 2006–2007) was consistently noted in the 75–84 age group (knee replacement, 786.7 per 100,000 for males and 890.9 per 100,000 for females; hip replacement, 490.7 per 100,000 for males and 634.2 per 100,000 for females) (*Canadian Institute for Health Information 2009*). A point to note is that these rates are reflective of procedures performed not only for degenerative OA, but also for osteonecrosis, acute fracture, inflammatory arthritis, and posttraumatic OA. Nonetheless, in 2006–2007, degenerative OA was the most common primary diagnosis documented for both knee (94 %) and hip (81 %) replacements.

Data from the NJR in the UK describe a strikingly different picture, wherein patient demographics in terms of age and gender distribution for joint replacement procedures have not changed substantially since 2003 (*NJR 2012*). Specific information on percent increase in growth for joint replacement procedures is not available by age categories; nonetheless, in 2011 the average age of patients undergoing hip replacement was 67.2 years, whereas the average age of patients undergoing knee replacement procedures was 67.4 years (*NJR 2012*). Despite the suggestion that joint replacement patients are getting younger, NJR data describe a very consistent age range of patients undergoing surgery over the last 8 years. For example, the proportion of patients undergoing hip replacement aged below 50 has remained at 6 %, and the proportion of those over the age of 80 has not changed from about 14 % (*NJR 2012*).

Significant variations in TJR utilization rates pertaining to race and ethnicity also exist, which are well documented in the literature. The review by Kane and colleagues included seven studies which primarily used Medicare national claims to examine rates of disparities (Kane et al. *2007*), with the exception of two: one examined a community cohort of elderly patients with OA, and the other examined a cross-sectional survey of individuals aged 55 or older in Ontario, Canada. All of the seven studies reviewed found that the use of TKA was higher in Whites compared to non-Whites (Kane et al. *2007*).

Skinner and colleagues used Medicare fee-for-service claims data between 1998 and 2000 to examine the use of TKA by hospital referral region, sex, and race or ethnicity. They reported that ethnic minority groups underwent significantly fewer TKAs than did White recipients, even after controlling for income (Skinner et al. *2006*). Use of TKA was consistently lower among Black men than among White men in nearly every hospital referral region, and in some regions, such as Jackson, Mississippi, and Detroit, Michigan, the number of Black men who underwent TKA was less than one-third the number of White men (Skinner et al. *2003*). They concluded that these persistent differences cannot be explained on the basis of financial or geographic barriers alone, because the pattern was not apparent for Black women living in the same neighborhoods.

Hawkins and colleagues, examined Medigap coverage, reporting that patients living in areas highly populated by minorities (defined as ≥60 % of the population in the zip code belonging to a non-White minority group) were 20 % less likely to undergo TKA than those who resided in areas not highly populated by minorities (Hawkins et al. *2011*). Bang and colleagues examined data from the Nationwide Inpatient Sample between 1996 and 2005 and found that non-White patients had lower rates for TKA than White patients: all racial/ethnic minority groups were 23–64 % less likely to undergo total joint replacement procedures than Whites (Bang et al. *2010*). Olson and Foland examined hospital discharge data for TKAs in Connecticut between 1996 and 1998 and found that the number of hospitalizations for TKA per 100,000 discharges, after adjusting for age, was significantly higher in Black women (115.8, 95 % CI 103.9–127.7) than in White women (84.9, 95 % CI 82.4–87.4), significantly higher among White men (66.4, 95 % CI 63.9–68.9) than in Black men (44.0, 95 % CI 34.9–68.9), and was lowest among Hispanic men (16.9, 95 % CI 10.1–23.8) and Hispanic women (47.5, 95 % CI 37.8–57.2) (Olson and Foland *2005*).

Using data from 1997 to 2001 hospital discharge records from two states included in the HCUP database, Basu and Mobley found no difference in the number of patients undergoing THA among Black, White, and Hispanic population groups in either 1997 or 2000, after adjusting for income, population density, distance from the hospital, and social isolation (Basu and Mobley *2008*). Two older studies (from the 1980s) examined racial disparities in THA hospital discharge records from Hawaii (Oishi et al. *1998*) and California (Giacomini *1996*). Oishi and colleagues found no differences in the use of THA between Whites and Asians for those younger than 50 years, but Asians older than 50 years underwent fewer THAs than Whites. Giacomini found no statistically significant differences in the use of THA, after adjusting for insurance status, age, and comorbidities, among White, Hispanic, and Black population groups; however, Asian patients underwent a greater number of THAs (odds ratio 0.47, CI 0.29–0.77).

Jha and colleagues examined trends in the rates of use of nine major procedures including THA and TKA among Black persons and White persons enrolled in Medicare between 1992 and 2001 (Jha et al. *2005*). They found that the rates of THAs and TKAs performed were greater among Whites than among Blacks (in both men and women), and the racial differences in these rates widened for both procedures over the years. Upon further examination by hospital referral regions for THAs, they observed that, in the early 1990s, White patients underwent more THAs than Black patients in every hospital referral region. By 2001, the difference between White and Black patients (in both men and women) in the use of THAs widened significantly in 18 hospital referral regions, narrowed significantly only in 1, and did not significantly change in the remaining hospital referral regions. At the end of the study period, they found no hospital referral regions in which the difference between White and Black patients in the use of THAs was eliminated for men or women (Jha et al. *2005*).

Dunlop and colleagues examined differences in the use of TKA/THA among Black, Hispanic, and White adults in 6 years (1998–2004) of longitudinal data from a national probability sample of adults aged 51 years or older and found that among those aged 65 years or older, Black and Hispanic individuals were significantly less likely to undergo TKA or THA than White individuals (Dunlop et al. *2008*). In contrast, among those aged 51–64 years, White individuals did not undergo more surgeries than other ethnic groups (Dunlop et al. *2008*). This was one of the first few studies that reported racial/ethnic patterns of TKA/THA use among individuals younger than 65 years based on a national probability sample (Gellad et al. *2011*).

In summary, studies of US populations have consistently found that Black patients undergo fewer TKAs than White patients. Data on racial/ethnic disparities in the use of THA in the USA are scant, and no definite conclusions can be drawn. Similarly, data about racial/ethnic disparities for groups other than Whites and Blacks (e.g., Hispanics, Asians) are limited. Moreover, majority of studies

documenting racial/ethnic disparities in joint replacement have been conducted in the USA, thereby making it difficult to comment on the nature and magnitude of these disparities in other countries.

Explaining Variations in the Use of Total Joint Replacement Procedures

Several contributing factors have been proposed to explain the aforementioned variations in the use of total joint replacement, including patient-, provider-, and system-level factors.

Patient-Level Factors

SES: Studies examining the role of patient willingness and clinical need in explaining SES-related utilization patterns have consistently demonstrated equal and greater clinical need and willingness to undergo TJR in persons of low SES. Hawker and colleagues examined the effect of education and income on potential need for and willingness to consider hip and knee arthroplasty as a treatment option. They found that persons with lower SES had a greater need for and were equally willing to consider arthroplasty, compared with those with higher SES (Hawker et al. *2002*). In another study, Hawker and colleagues also demonstrated that patient willingness to consider TJR was the strongest predictor of the time to first TJR in population-based study consisting of an urban (with low TJR rates) and rural area (with high TJR rates) (Hawker et al. *2006*). Steel and colleagues examined clinical need and subsequent receipt of TJR in a national population survey in England. They found a significantly consistent increase in estimated clinical need, from the wealthiest to poorest quintile, while in contrast, the prevalence of TJR did not significantly differ by socioeconomic group (Steel et al. *2006*). Thus, observed SES disparities in the rates of performed arthroplasties cannot be explained by a lower need or less willingness to undergo arthroplasty in those with lower SES. Moreover, although access to care, more specifically health-care insurance status, is also associated with utilization rates, it cannot entirely explain the variation in rates documented across many different settings. Hence, this represents a true disparity in TJR rates by SES group.

Gender: Researchers have identified several possible reasons for gender disparities in the use of total joint replacement, including underrepresentation in clinical trials (Novicoff and Saleh *2011*), differences in willingness to undergo surgery (Souchek et al. *2005*), differences in pain response to underlying disease and treatment (Novicoff and Saleh *2011*), and differences in patient–physician relationships (Borkhoff et al. *2008*). Moreover, studies have continuously demonstrated that women are more prone to engaging in pain catastrophizing behaviors compared to men which may further contribute toward unwillingness to undergo surgery (Keefe et al. *2000*). Karlson and colleagues conducted focus groups with patients diagnosed with moderately severe OA of the hip or knee and who had been seen at an arthritis center. They concluded that men were more likely to choose surgery earlier in the disease than women and had higher expectations for surgical success, whereas women were more fearful of surgery. Additionally, women preferred to suffer arthritis pain rather than risk surgery and indicated they would delay surgery to await better technology and to avoid disrupting caregiving roles for dependent spouses and others (Karlson et al. *1997*). Compared to men, women also tend to be more concerned about anesthesia, pain management, and recovery after TJR (Fortin et al. *1999*; Chang et al. *2004*).

Race: With respect to racial/ethnic disparities, in general, Black patients, compared with White patients, place lower values and preferences on improvements in knee OA (Byrne et al. *2004*), are less

likely to choose joint replacement surgery (Souchek et al. *2005*), have lower expectations about the effectiveness of total joint replacement (Ibrahim et al. *2002b*), are less likely to perceive benefits of the procedure, are more likely to recognize barriers to the procedure (Suarez-Almazor et al. *2005*; Ibrahim et al. *2002b*; Figaro et al. *2004*; Weng et al. *2007*), are less familiar with the procedure (Suarez-Almazor et al. *2005*; Ibrahim et al. *2002b*), are more likely to have fears about the procedure (Figaro et al. *2004*), and may be more likely to view prayer and other techniques as useful for managing arthritis pain (Ang et al. *2002*). In addition, Black patients have less trust in the health-care system in general than Whites, and among Black patients, those who do not have a primary care physician have even less trust (Kroll et al. *2007*; Ibrahim et al. *2002b*). All of these factors can contribute to a lower preference and willingness among Black patients, compared with White patients, to consider total joint replacement which could explain the reported racial disparities (Allen et al. *2011*; Ibrahim et al. *2002a*).

Numerous investigations have shown that individual variations in pain-related beliefs are associated with differences in pain responses (Bradley et al. *2005*), and, more specifically, researchers have consistently demonstrated that Black patients have higher scores than White patients on measures of pain affect, catastrophizing, and hypervigilance (Hastie et al. *2004*). A study by Bradley and colleagues sought to demonstrate this difference in pain response with respect to knee pain in OA. Their results indicated that Black individuals tend to report higher levels of catastrophizing and pain-related affect than White individuals in both clinical and laboratory settings (Bradley et al. *2005*). The authors concluded that these findings were highly relevant to the associations observed between negative expectations of pain-related outcomes and the relatively low preferences for undergoing TKA among Black patients (Bradley et al. *2005*). Income inequalities also play a crucial role in racial disparities in joint replacement utilization. Skinner and colleagues showed that higher degrees of residential racial segregation (among Black women) and low income (among Hispanic women and Black men) were associated with larger differences in TKA rates among Medicare enrollees (Skinner et al. *2003*).

Studies which have examined whether racial differences in the use of total joint replacement represent true disparities based on clinical need or appropriateness have concluded that, in general, both White and Black patients are equally likely to be appropriate candidates for total joint replacement surgery (Gellad et al. *2011*; Ang et al. *2009*).

Geography: Studies exploring patient-related factors in that result in geographical variation in joint replacement are few. Of those identified, a UK study by Dixon and colleagues analyzing regional variation in hip and knee replacement in England using HES data found that age was the single explanatory variable for regional variation in THA operation rates (Dixon et al. *2006*). About half of this regional variation in THA rates was explained by the proportion of older people (aged 65–84 years) in spite of the fact that the data used were age-standardized. For TKA, the explanatory variable was the number of NHS centers offering surgery, such that regions with fewer centers had the highest provision rates. This alone explained 58 % of the regional variation for TKA (Dixon et al. *2006*). They also observed that higher procedure rates tended to occur in regions with a smaller total population and a higher proportion of the working-age population in manual social classes. However, these variables were not strongly correlated with age-standardized operation rates (Dixon et al. *2006*).

Patient preferences have also been suggested to partially account for certain observed regional variations. A Canadian study by Hawker and colleagues investigated whether area hip and knee arthroplasty rates reflect patient-related demand factors in a high- and a low-use area of Ontario (Hawker et al. *2001*). They found a greater potential need for arthroplasty in the high-rate area as compared to the low-rate area (36.3 vs. 28.5 per 1,000 respondents, $P < 0.0001$). Furthermore, among those with potential need, only 14.9 % in the high-rate area and 8.5 % in the low-rate area were definitely willing to undergo arthroplasty ($P = 0.03$), thereby yielding adjusted estimates of need of

5.4 and 2.4 per 1,000 in the high- and low-rate areas, respectively (Hawker et al. *2001*). The authors concluded that demonstrable need and willingness were greater in the high-rate area, suggesting that these factors explain in part the observed geographic rate variations in joint replacement procedures (Hawker et al. *2001*).

Provider-Level Factors

Gender: Given the complexity of determining when total joint replacement is the best treatment option for OA, physician preferences can influence the patient's decision to undergo total joint replacement (*Fisher et al. 2010*; Lurie et al. *2009*). Evidence suggests that physician recommendations are affected by more than just a patient's condition. Numerous studies have shown that physicians are more likely to recommend joint replacement procedure to men than to women when treating patients with identical health status (Borkhoff et al. *2008*) and in spite of women having similar willingness to have surgery as that of men (Hawker et al. *2000*). Moreover, physicians have also been shown to be more likely to suspect a psychosomatic disorder in women compared with men and to refer women less often for specialty care (Suarez-Almazor *2002*; Bernstein and Kane *1981*; Franks and Clancy *1997*).

Race: Physician–patient communication styles and decision-making processes may also contribute to disparities in the use of total joint replacement. Studies have demonstrated that physicians provide less medical information and do not encourage as much participation in Black patients compared with White patients (Suarez-Almazor *2002*; Hall et al. *1988*; Kaplan et al. *1995*). In a review by Ashton et al. evaluating the evidence of poor physician communication on health disparities, the authors hypothesized that due to a conscious or unconscious racial bias, doctors may not suggest the same services for Blacks and Latinos as they do for Whites (Ashton et al. *2003*). They quoted the study by Schulman and colleagues wherein a computerized survey instrument was used to assess physicians' recommendations for managing chest pain. The doctors viewed videotapes of pre-scripted interviews in which actors portrayed patients with specific symptoms. The results revealed that doctors were less likely to refer Black women for cardiac catheterization than White men, Black men, and White women (Schulman et al. *1999*). Moreover, apart from skin color, other attributes such as the physician's perception of the patient's educational level may also lead to physician-induced bias (Ashton et al. *2003*). Using survey responses, Laine and colleagues compared the opinions of patients and physicians on several elements of health care. They found that patients placed a significantly higher emphasis on the provision of information than did physicians (Laine et al. *1996*). Another study by Saha and colleagues found that racial concordance between patient and physician affected how non-White patients perceived their quality of care and influenced their use of health care (Saha et al. *1999*). The importance of racial concordance has also been established in qualitative studies, examining decision-making factors that influence TKA preferences in patients with knee OA (Suarez-Almazor et al. *2010*). Thus, the underrepresentation of Black and Hispanic Americans in the health professions in general and in the fields of rheumatology and orthopedic surgery specifically could contribute to the ethnic disparities in the use of total joint replacement. The lack of consensus and differing opinions among physicians may account for variations in referral from primary care providers to orthopedists and/or disparities in the use of total joint replacement (Kane et al. *2007*).

Geography: Physician practice styles have been implicated as the principal reason for regional variation in the use of joint replacement surgeries (Center for the Evaluative Clinical Sciences *2000*). It has been noted that although all surgeons exercise mostly the same judgment (benefits vs. risks) in making recommendations about joint replacement, regional variation in surgery rates alludes to the

fact that they greatly vary in their perceptions of the indications for and outcomes of joint replacement (Wright et al. *1995*; Coyte et al. *1996a*), thereby coming to different conclusions (Center for the Evaluative Clinical Sciences *2000*). A Canadian study by Wright et al. aimed to identify determinants of regional variation in use of knee replacement study in Ontario. The authors found that in spite of controlling for population characteristics and access to care, orthopedic surgeons' opinions or enthusiasm for the procedure was the dominant modifiable determinant of area variation (Wright et al. *1999*). A similar phenomenon was reported by the Center for the Evaluative Clinical Sciences, Dartmouth Medical School. They described the existence of certain idiosyncrasies in the use of joint replacement (Center for the Evaluative Clinical Sciences *2000*). They explained that regions have different "signatures" in their use of joint replacement that presumably reflect their surgeons' level of enthusiasm for surgical intervention in patients with degenerative joint disease. The authors also stated that a lack of physician consensus on the timing of surgical intervention also contributed to this effect (Center for the Evaluative Clinical Sciences *2000*). Physician volume, particularly orthopedic surgeons, had been previously presumed to be a driver for area variation in joint replacement rates. However, research has failed to show a significant relationship between the two, thereby indicating that this is not the case (Coyte et al. *1996b*; Peterson et al. *1992b*).

System-Level Factors

Race: Access to care is also a widely recognized reason for disparities in health care. Although the apparent lack of access may be less relevant with respect to joint replacement considering the fact that most of these patients are above 65 years of age and thus are covered by Medicare, several studies have demonstrated that health service utilization patterns and outcomes are unfavorable to Black patients compared with White patients (Suarez-Almazor *2002*; Schneider et al. *2002*). Moreover, it has been seen that these differences only decrease slightly after adjusting for income (Suarez-Almazor *2002*). Beyond utilization, a number of studies have reported that patients who undergo THA or TKA performed by surgeons with low surgical volume or at hospitals with low surgical volume are more likely to have worse outcomes (Katz et al. *2001*). In addition, non-White or minority patients were more likely to have surgery performed by low-volume surgeons and at low-volume hospitals (Losina et al. *2007*). Whether these results relate to differences in utilization is not known.
Research has shown that demographic and geographic variations cannot be explained by socioeconomic or health system factors since disparities remain after controlling for insurance status and clinical need (*Fisher et al. 2010*; Jones et al. *2005*).

Summary

The prevalence of osteoarthritis is steadily increasing with rising trends in TKA and THA utilization. Overall, surgical outcomes associated with THA and TKA are predominantly good with minimal failure rates. However, significant variation and disparities still exist in utilization rates for these procedures owing to a host of factors as previously described. Because joint replacement is an elective surgical procedure, some of the observed variations may result from patient preferences. Yet uninformed decisions cannot be viewed as "true preferences." In addition, physician and system factors also appear to play a role in the reported variation and disparities. Whether the variation represents over- or underutilization of the procedure on the basis of appropriateness criteria remains to be determined. Hence, with an ever-increasing burden of OA and decreasing health budgets, it will be

necessary to clearly establish clinical need for joint arthroplasty and, on the basis of this need, attempt to decrease variation while considering patient preferences and societal values.

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