Assessing the value of a total joint replacement

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Published online: 4 October 2012
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Abstract Total joint arthroplasty (TJA) continues to be one of the most successful surgical interventions in medicine. Demand is growing rapidly, placing an increasingly heavy cost burden on national health systems. Despite the popularity of these surgeries, high-quality cost-effectiveness studies evaluating TJA are few in number. This article summarizes the current literature on value in arthroplasty, identifying the various factors affecting costs and outcomes, and suggesting how policy makers can influence utilization of TJA to further improve value to society.

Keywords Total joint arthroplasty · Total hip arthroplasty · Total knee arthroplasty · Economic analysis · Cost effectiveness · Cost utility · Revision arthroplasty · Infection · Health policy

Introduction

Total joint arthroplasty is one of the great achievements in the last 50 years of medical advancements, allowing patients with arthritis to regain motion and lifestyle with exceptional reliability [1]. However, the success of these surgeries has created an increasingly difficult conundrum. The popularity of TJA places an enormous burden on the health care system. In the United States, TJA accounts for more Medicare spending than any other inpatient medical procedure, amounting to \$5 billion of the Medicare budget in 2006 [2].

Demand for TJA is expected to increase substantially as the population of the United States ages. From 1990–2002, the number of primary total hip arthroplasty (THA) cases increased from 119,000 cases per year to 193,000 cases per

year, representing a rate increase per 100,000 people of nearly 50 %. During the same time period, primary total knee arthroplasty (TKA) increased from 129,000 cases to 381,000 cases annually, corresponding to a nearly 300 % rate increase per 100,000 people [3].

Even more daunting are the projections for the TJA volume over the next 20 years. Using detailed demographic data, Kurtz et al. have projected that by 2030 more than 570,000 primary THA procedures will be performed annually in the U.S., representing an increase of 174 % from 2005 volume. Moreover, nearly 3.5 million primary TKA cases are estimated to be completed each year by 2030, a staggering 673 % increase [4]. This will raise Medicare's TJA spending to an estimated \$50 billion annually [2].

The objective of this paper is to provide an overview of how the value of TJA can be determined. As competition for limited healthcare resources increases, it is critical that policy-makers and healthcare providers dedicate resources towards interventions that provide maximum value to society. Thus, high-quality data on the costs and benefits of TJA are essential to guiding resource allocation, efficiently meeting the demand for joint replacement surgery.

How to determine the value of total joint arthroplasty: costs and outcomes

TJA is amenable to formal studies of costs and outcomes for several reasons. First, these procedures, as detailed above, are very commonly performed, not only in the United States but in developed countries around the world. Second, there are large databases and registries that track TJA patients and their clinical outcomes. Third, there are multiple well-validated outcome measurement tools for TJA that assess mobility and function, pain, quality of life, and multiple other parameters [5–8].

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The health economic analysis most commonly employed is cost-effectiveness analysis (CEA), which divides cost by a specific measurable outcome variable. A subset of cost-effectiveness analysis is cost-utility analysis (CUA), which uses the quality-adjusted life year (QALY) as the outcome measure. The great value of QALYs is that the cost utility of different health interventions can be compared using a common outcome measure, and thus policymakers can decide which interventions provide the most value. Table 1 lists the cost per QALY of various common health interventions. Cost-benefit analysis (CBA) is a model in which all costs and outcomes are expressed solely in monetary terms; thus, improvements in the outcome measure of choice are assigned a monetary value [9].

Determination of value also depends on what perspective the economic analysis takes. Direct costs are those incurred in providing the health service, such as physician fees, inpatient hospital costs, and implant costs. Indirect costs are costs that result from the patients' medical condition but are not directly related to a health service, including lost wages and decreased work productivity. Any health economic analysis must decide the perspective that is taken in calculating value; this can be the patient, physician, hospital, insurer, or society as a whole [9].

Total hip arthroplasty

In 1986, Liang et al. conducted the first prospective CEA of TJA (Table 2) [10]. The authors prospectively calculated cost-effectiveness ratios based on outcome questionnaires from 45 THA and TKA patients followed for 6 months after surgery. Patients who had more disability before surgery had more improvement for the same cost than those who were healthier, with a cost-effectiveness ratio 50 % greater than the healthier patients for a 6-month treatment cost of \$21,000–\$23,000. No significant differences were found in

cost effectiveness between THA and TKA patients. While the outcome measurement used was not easily compared with subsequent cost analyses, this study represents an important first step in evaluating the value of TJA.

Several years later, a Canadian randomized controlled trial (RCT) comparing cemented vs. cementless THA provided high-quality data on patient outcomes after THA as well as costs to the hospital and patient in the first year after THA. Patients showed significant clinical improvement with all 7 outcome measures utilized [11, 12]. Of the 250 patients in the study, inpatient and outpatient costs during the first year after surgery were collected on 60 patients. Cost utility was estimated at \$27,139 (Can) per QALY over the first year after surgery, and an additional \$8031 (Can) per QALY after 3 years if the outcomes were extrapolated [13].

Chang et al. performed an excellent CUA of THA from the health system perspective in the United States [14]. They modeled several scenarios and then calculated the costs necessary to obtain functional improvement, using outcome data from the literature. Their conclusion was that, even in worst-case scenarios, THA was still cost-effective. Their base scenario demonstrated that THA in a white female aged 60 was cost-saving by \$17,000 (USD) per QALY gained when compared with nonoperative osteoarthritis management. Older age did not cause THA to become especially costly, with the marginal cost per QALY calculated at \$4600 (USD) for an 85-year-old white male.

James et al. calculated cost utility for 9 common orthopedic procedures in the United Kingdom [15]. Prospective outcome surveys and surgical costs from 99 patients were collected. The authors found that primary THA in patients over age 40 had a cost per QALY of £333–£1899; this varied depending on the outcome survey used and whether the patient, or physician had completed the assessment. In all ranking permutations performed, primary THA ranked as one of the top 4 most cost effective orthopedic interventions. While sensitivity analyses were included in this study, the major weakness lies in the small patient cohort surveyed for 9 difference procedures.

Rissanen et al. performed a prospective cost-effectiveness study in Finnish patients who underwent either primary THA or TKA [16]. Outcome surveys were collected from 276 THA and 176 TKA patients, with follow-up of 2 years. They found that THA was more cost-effective than TKA; both procedures were similar in cost, so the superiority of THA was due to more improvement in the THA patients. Cost-effectiveness in THA did not vary significantly with age.

In another Finnish study, Rasanen et al. prospectively gathered data from 223 patients who underwent primary and revision THA, assessing outcomes and costs from the hospital perspective over the first year after surgery [17]. They calculated a cost utility of €6710 per QALY for primary THA, while revision THA had a value of €52,274.

Table 1 Cost per QALY of common health interventions

Intervention	Cost Per QALY (2011 USD)
Polypharmacy treatment for cardiac disease prevention [64]	\$6282
Coronary artery bypass graft using cardiopulmonary bypass [65]	\$41,152
Screening mammography every 3–4 years in low-risk women age 50–79 [66]	\$19,039–75,415
Lifetime hemodialysis for end-stage renal disease [67]	\$78,148
Implantable left ventricular assist device as bridge to heart transplantation [68]	\$414,275
Decompressive craniectomy for traumatic brain injury [69]	\$682,000

QALY quality-adjusted life year, USD United States dollar

Table 2 Summary of TJA cost-outcome studies

Study	THA	TKA	Nation	Type	Perspective	Cost and outcome results	Study quality
Burns et al. 2006[30]		✓	Canada	CEA	Payer	Revision TKA has 56 % higher cost for the same clinical improvement as primary TKA	Few revision patients; lack of detailed methodology
Chang et al. 1996[14]	✓		USA	CUA	Health system	Best case: -\$17,115 (USD)/QALY (cost-saving) worst case: \$79,029 (USD)/QALY	Multiple health states modeled; published outcome data used to generate lifetime QALY valuations
Dakin et al. 2012[23•]		✓	UK	CUA	Payer	£5623/QALY	Prospective randomized trial; large patient cohort ($n=2131$); 5-year follow-up; sensitivity analysis performed
Fisman et al. 2001[36]	✓		USA	CUA	Society	Debridement/retention of infected THA more cost-effective than explantation; healthy 65 year-old: \$19,700–21,800 (USD)/QALY; frail 80 year-old: \$500–8200 (USD)/QALY	Markov analysis using published outcome data to generate lifetime QALY valuations; sensitivity analysis performed
Fordham et al. 2012[20]	✓		UK	CUA	Hospital	£7182/QALY	Prospective; large patient cohort ($n=938$); 5-year follow-up; sensitivity analysis performed; lack of detail on cost determination
Garellick et al. 1998[70]	✓		Sweden	CUA	Health system	\$3268 (USD)/QALY with 10-year survival	Prospective; moderately-size cohort ($n=372$) but cost data only obtained on 15 pts and quality data on 54 pts; mean 8-year follow-up; no sensitivity analysis
James et al. 1996[15]	✓	✓	UK	CUA	Health system	Primary THA: £333–1899/QALY Primary TKA: £703–6392/QALY	Prospective; small patient cohort ($n=99$ for 9 surgical procedures); short follow-up (6 mo); sensitivity analysis performed
Koskinen et al. 1998[24]		✓	Finland	CBA	Health system	Initial TKA more cost-beneficial than UKA	Retrospective; large patient cohort (50,000+) using joint registry; no sensitivity analysis
Krummenauer et al. 2009[22]		✓	Germany		Payer	€1795–3063/QALY	Prospective; small patient cohort ($n=65$); short follow-up (3 mo); sensitivity analysis performed
Larsen et al. 2009[55]	✓	✓	Denmark	CUA	Society	Accelerated postoperative rehabilitation protocol saved \$4000 (USD) per patient	Prospective randomized trial; small cohort ($n=87$); 1-year follow-up; sensitivity analysis performed
Laupacis et al. 1994[13]	✓		Canada	CUA	Patient	\$27,139 (Can)/QALY at 1 year	Prospective randomized trial; 1-year follow-up; no sensitivity analysis
Lavernia et al. 1997[21]		✓	USA	CUA	Hospital	\$11,560 (USD)/QALY at 1 year; \$6656 (USD) at 2 years; no difference in cost utility between unilateral and bilateral TKA	Prospective; 2-year follow-up; no sensitivity analysis
Lawless et al. 2012[18]	✓		USA	CUA	Health system	\$9773 (USD)/QALY; age and bilateral disease do not affect cost utility	Retrospective; large patient cohort ($n=1442$); wide variability in follow-up duration
Liang et al. 1986[10]	✓	✓	USA	CEA	Patient	THA and TKA not significantly different	prospective; short follow-up (6 mo); outcome score used not easily compared with other studies
Mahomed et al. 2008[57]	✓	✓	Canada	Cost only	Health system	Home postoperative rehabilitation cost \$3450 (Can) less than inpatient rehabilitation	Prospective randomized trial; moderately-sized cohort ($n=234$); 1-year follow-up; no QALY calculation
Novak et al. 2007[47]		✓	USA	CUA	Health system	Cost-utility of computer navigation \$45,554 (USD)/QALY	Markov analysis using published outcome data of non-navigated TKA used to extrapolate outcomes; sensitivity analysis performed

Table 2 (continued)

Study	THA	TKA	Nation	Type	Perspective	Cost and outcome results	Study quality
Rasanen et al. 2007[17]	✓	✓	Finland	CUA	Hospital	Primary THA: €6710/QALY revision THA: €52,274/QALY primary TKA: €13,995 per QALY	Prospective; sensitivity analysis performed
Rissanen et al. 1997[16]	✓	✓	Finland	CEA	Health system	THA more cost effective than TKA	Prospective; thorough cost analysis; 2-year follow-up; no sensitivity analysis
Slover et al. 2008[48]		✓	USA	CUA	hospital	Computer navigation more cost effective in higher-volume centers	Theoretical Markov analysis; sensitivity analysis performed
Tso et al. 2012[19•]	✓	✓	Canada	CUA	payer	Primary THA: \$5321 (Can)/QALY primary TKA: \$11,275 (Can)/QALY	Prospective; sensitivity analysis and discounting performed

Can Canadian dollar, *CBA* cost-benefit analysis, *CEA* cost-effectiveness analysis, *CUA* cost-utility analysis, *QALY* quality-adjusted life year, *TJA* total joint arthroplasty, *THA* total hip arthroplasty, *TKA* total knee arthroplasty, *UKA* unicompartmental knee arthroplasty, *USD* United States dollar

Lawless et al. conducted a retrospective study of 1442 THA patients, with follow-up ranging from 2 to 8 years [18]. They compiled hospital-based costs, calculating a cost utility of \$9773 (USD) per QALY. Importantly, they concluded that neither bilateral disease nor age greater than 65 years affected outcomes for THA.

Tso et al. calculated lifetime incremental cost-utility ratios comparing primary THA to medical management of hip arthritis, and arrived at a value of \$5321 (Can) per QALY for THA [19•]. There were 99 THA patients included, and outcome data was prospectively collected for 2 years after surgery. The authors performed sensitivity analyses and discounting, which did not alter their conclusion that THA was highly cost effective.

A recent British study by Fordham et al. calculated cost utility of primary cemented THA using a prospective cohort of 938 patients with 5-year follow-up [20]. They concluded that THA had a mean cost per QALY of £7182. This study looked at 231 patients aged 23–59 years; these patients had a cost utility of less than £6000 per QALY gained, demonstrating that THA has a very high cost utility in younger patients.

Total knee arthroplasty

In the study by James et al. referenced above, the cost per QALY of primary TKA was determined to range between £703–£6392 [15]. TKA had a lower cost utility than primary THA in patients over age 40, but was still considered to be a highly cost effective intervention.

Lavernia et al. calculated cost utility in 100 patients undergoing primary TKA in the United States, from the cost perspective of the hospital [21]. Follow-up duration was 2 years. The cost per QALY declined at each time point, valued at \$11,560 (USD) at 1 year and \$6656 (USD) at 2 years. Comparison of cost utility between unilateral and

bilateral TKAs yielded no significant differences at any time point, despite the higher implant cost of bilateral TKAs.

Rissanen et al. prospectively compared the cost effectiveness of primary THA and TKA, concluding that while both were effective surgeries, THA had greater cost-effectiveness [16]. They noted variability in TKA cost-effectiveness when analyzed by patient age, with patients over age 70 years having almost twice the cost for improvement as patients younger than age 70.

Rasanen et al. also measured cost utility for primary TKA in their study described above [17]. Their prospectively collected data generated a cost utility of €13,995 per QALY, more than twice the cost per QALY for what they calculated for primary THA but significantly less than a revision THA.

Krummenauer et al. conducted a prospective CUA of TKA from the payer's perspective [22]. Their study population consisted of 65 patients with a median age of 66 years; follow-up was only 3 months. Results demonstrated a cost utility of €1795–€3063 per QALY. The cost per QALY increased with age, as patients younger than age 60 had a cost utility of €1463/QALY and those aged 70 years or older had a cost utility of €3186/QALY.

Tso et al., in their study described above, also calculated incremental cost-utility ratios for 99 primary TKA patients compared with medical management of knee arthritis [19•]. TKA had a cost utility of \$11,275 (Can) per QALY, again more than twice the cost per QALY for THA. Sensitivity analyses did not significantly alter the findings.

In a British CUA, Dakin et al. found primary TKA to be a highly cost-effective procedure [23•]. The authors utilized data from a large RCT of several TKA prostheses, and evaluated patient comorbidities and severity of knee symptoms as primary variables in TKA cost utility. They concluded that primary TKA had a cost per QALY of £5623,

and that even performing TKA in patients with significant comorbidities had a cost per QALY less than £20,000.

Unicompartmental knee arthroplasty (UKA) has gained popularity for use in patients with unicompartmental arthritis. However, very few studies have evaluated the economic value of UKA vs. TKA. Koskinen et al. utilized the Finnish joint registry to evaluate the comparative longevity and revision rates of TKA and UKA [24]. At 15 years, TKA had an 80 % survival rate but UKA had only a 60 % survival rate. Performing a simple CBA, with revision as the outcome measure, they found that initial TKA was more cost-beneficial in the long term despite the initial lower implant cost and shorter hospital stays for UKA patients.

Revision arthroplasty and infection

Revision TJA, particularly for infection, is very costly. Current revision rates in the United States hover near 18 %–19 % for THAs and 8 % for TKAs [3, 25]. Revision caseload for THAs is anticipated to double by 2030, and revision TKA cases will potentially increase 6-fold [4].

Instability and dislocation are the most common indications for THA revision, accounting for 23 % of revision cases. Component loosening (20 %) and infection (15 %) are close behind in frequency [26]. The most common indication for TKA revision is infection (25 % of cases), followed by implant loosening (16 %) [27].

Both revision THA and TKA are associated with greater inpatient costs, nearly 40 % greater than primary TJA. The cost increases are particularly due to longer operative time and higher cost for revision implants [28, 29]. Average hospital charges for revision THA are in excess of \$50,000 per patient, with a mean length of stay of 6 days. Revision TKA is only slightly less costly, with hospital charges averaging \$49,000 for a mean of 5 hospital days [26, 27]. Burns et al. reported 60 % higher costs of revision TKA (all indications) compared with primary TKA, and calculated that cost-effectiveness was only 65 % of a primary TKA [30].

Incidence of TJA infection is reported to be between 0.88 %–2.4 % [31, 32]. In the United States, annual costs for revision TJA for infection alone increased from \$320 million (USD) in 2001 to over \$560 million (USD) in 2009. Because of the anticipated increase in the number of primary TJAs over the next decade, the cost of infected TJA revision is projected to exceed \$1.6 billion (USD) by 2020 [32].

Revision of infected THAs requires greater resource use than revision for non-infected implant failures [31]. Patients with infected THAs had significantly more hospitalizations and longer hospital stays, more total operations, more blood loss, and more complications than patients revised for aseptic loosening [33, 34]. Average per patient costs were \$48,348 (USD) for infected THAs vs. \$16,411 (USD) for

aseptic loosened THAs [33]. Patients with chronically infected THAs or failed revisions of THAs actually have lower utility survey outcomes than patients with chronic hip osteoarthritis who have not undergone THA [35].

Fisman et al. performed a CUA analysis using a Markov model to determine the relative cost-effectiveness of performing initial debridement and implant retention in infected non-loosened THAs vs. explantation and complete revision [36]. Interestingly, they found that initial debridement and implant retention was more cost effective. For theoretical cohorts of men and women aged 65 and 80 year, the cost per QALY gained with implant retention was less than \$25,000 (USD) in all cases. Sensitivity analysis demonstrated the retention strategy was most robust in frail patients over 80 years of age.

Cost effectiveness of new implant technology

The price of TJA prostheses continues to rise steadily, increasing 132 % from 1996 to 2006 [2]. Manufacturers continue to try to gain market share through design innovations such as improved bearing interfaces, new alloys, customized cutting blocks, and gender-specific implants. Direct-to-consumer marketing of implants has created further upward price pressure. However, there is frequently minimal data supporting dramatic quality increases to justify increased implant costs.

Faulkner et al. performed an extensive review of outcomes for various THA prostheses and created a cost-effectiveness model for the British National Health Service (NHS) [37]. They found that implant cost, hospital cost, and revision rate were the 3 primary variables determining the cost effectiveness of a prosthesis. Also, they concluded that a theoretical new THA prosthesis with a 0 % revision rate should cost no more than twice the cost of a cemented Charnley prosthesis to maintain equivalent cost effectiveness.

In a similar review for the British NHS, Fitzpatrick et al. compiled existing data on cost utility in THA [38]. They calculated that for a theoretical new implant priced at 150 % the cost of a Charnley prosthesis, revision rates would need to decrease 15 %–41 % over 20 years to maintain cost neutrality. For younger patients, less decrease in revision rate was needed to make the new technology rational in terms of cost.

Gillespie et al. modeled the “break-even” point of theoretical newer, more-expensive THA prostheses [39]. Their projections indicated that in patients aged 55–64 years, a new prosthesis that reduced revision rates by 20 % at 15 years would only be justified if the increase in price of the prosthesis was between 1.2 and 1.3 times that of a conventional cemented THA prosthesis. These projections were based from the Swedish joint registry data on the survival of Charnley low-friction cemented THAs.

Bozic et al. performed a CEA to evaluate the reduction in revision rate that would be necessary to make a more expensive THA bearing cost-effective (examples: highly cross-linked polyethylene, next-generation ceramics) [40]. If the bearing cost increased by \$2000 (USD), then a 19 % reduction in 20-year revision rate would be needed to achieve overall cost savings. The authors also evaluated the effect of patient age on cost effectiveness, concluding that in patients over age 75 a bearing interface more expensive than the standard metal on ultra-high molecular weight polyethylene would not be cost-effective.

Computer-navigated arthroplasty

Computer navigation has been adapted for use in TJA, and a number of studies have shown that navigation helps surgeons achieve better radiographic implant alignment [41–45]. However, the tradeoff for increased accuracy has been longer operative times. Blakeney et al. conducted an RCT and found that while TKA alignment was better with navigation, operative times were nearly 30 minutes longer than with traditional anatomic guides [45]. In another RCT, Chin et al. found similar results, with an added operative time of 20–30 minutes with navigation [42]. However, Molli et al. recently showed that upgraded software dramatically reduced operative times from the previous version, showing no significant difference from standard non-navigated technique [44]. Further refinements in navigation technology will likely be made, but each at a cost to hospitals and surgeons.

There are no prospective studies showing that computer navigation reduces revision rates or increases long-term patient outcomes [44, 46]. Novak et al. performed a CUA of computer-navigated TKA, using previous studies of revision rates in malaligned TKA to extrapolate outcomes [47]. Given that coronal malalignment reduces longevity of TKA, they calculated that computer navigation had a cost per QALY of \$45,554 (USD). One assumption was that navigation added \$1500 to the cost of each surgery; if this cost fell to \$629 (USD), then navigation was actually cost-saving. Slover et al. found that computer navigation was more cost-effective in hospitals with high volumes of TJA. While low-volume arthroplasty surgeons are most likely to achieve improved results with navigation, from the health system perspective, the potential economic benefit of this technology is greatest at high-volume centers [48].

Computer navigation may be beneficial to a hospital or surgical practice from a marketing standpoint. However, investment in the expensive technology as well as the added time to learn and use navigation in the operating room may prove too substantial for widespread implementation [46].

Health system efficiency and resource allocation

Establishment of implant selection protocols and resource-use committees can help hospitals significantly reduce their expenditures for TJA and allow them greater negotiating power with implant manufacturers. Martineau et al. found that hospital costs for TJA were lower in high-volume Canadian hospitals than in low-volume hospitals. Implant costs were the biggest variable in the analysis; the high-volume centers were able to minimize this cost more effectively [49]. Zuckerman et al. were able to reduce implant costs by 23 % in a single year using this strategy [50]. Scranton reported decreased implant costs, decreased operating room time, decreased average length of stay, and decreased hospital costs [51]. Also, quality can be improved by creating a multi-disciplinary clinical pathway for perioperative care of TJA patients. Healy et al. were able to implement both an implant cost-reduction program and a standardized clinical care pathway in their institution, achieving hospital cost reductions of nearly 20 % for primary TKA [52]. However, several other studies have cautioned that while multi-disciplinary pathways do maintain high quality levels for patient care, implementation alone does not necessarily achieve direct cost savings. Rather, the additional time and labor needed to create these teams can actually increase costs in some settings [53, 54].

Larsen et al. performed a CUA as part of an RCT that evaluated an accelerated post-TJA rehabilitation protocol using a multi-disciplinary team of nurses and therapists [55, 56]. They found that the accelerated protocol was cost-saving compared with their standard rehabilitation protocol, reducing hospital length of stay, and improving patient outcomes as measured by QALYs. Cost savings per patient were approximately \$4000 (USD). Mahomed et al. conducted an RCT comparing inpatient vs. home rehabilitation after TJA [57]. They found no significant differences in patient outcomes, but the home rehabilitation group had lower therapy costs and total costs by a mean \$3000 (Can). Total inpatient length of stay in the hospital and rehabilitation facility was also less for the home rehabilitation group.

A 2008 Cochrane review of post-TJA rehabilitation concluded that current evidence supports the benefits to patients of early post-operative rehabilitation and implementation of multi-disciplinary clinical pathways [58]. Home therapy rather than prolonged inpatient therapy was more effective as well. According to the review, current evidence suggests that these practices are potentially cost-saving. However, the low quality and heterogeneity of rehabilitation studies did not allow for definitive conclusions regarding overall costs.

Given the demand for TJA, waiting lists for surgery are common even in developed nations. Unfortunately wait times may actually add to the cost burden on the health system. Saleh et al. calculated that a 6-month waiting period

for THA resulted in an additional \$9254 (Can) of costs [59]. In a prospective study, Mahon et al. found that patients who waited more than 6 months for THA had clinically significant declines in quality of life and mobility [60]. Kili et al. noted that hip function declined in a linear fashion with length of time spent on a waiting list [61]. Thus, policy changes to decrease wait times may actually be cost-saving to national health systems.

Summary: how do we increase value?

In conclusion, both primary THA and primary TKA have excellent relative value to other common health interventions over short- and long-term follow-up periods. THA does tend to have slightly better cost effectiveness than TKA, although TKA is more commonly performed. Existing economic studies of TJA are of variable quality, but in recent years more rigorous and robust methodologies are being utilized in orthopedic cost-effectiveness research.

As the demand for TJA continues to rise while financing of health care grows more challenging, advances in arthroplasty will increasingly be influenced by national health policy. In order to increase the value of TJA and maximize the number of patients who can receive these surgeries, orthopedic surgeons will need to join with policy makers to reduce costs and maximize outcomes. In order to do this, high-quality prospective data and rigorous health economic methodologies are essential. Relatively few orthopedic cost-effectiveness studies have been published, and even fewer have been high-quality, well-controlled studies. In 2004, Bozic et al. identified 81 economic analyses of TJA. However, after reviewing each, they concluded that only 6 met criteria for a comprehensive economic analysis [9].

One important step to improve economic research is establishment of joint registries. In 2011, the American Joint Replacement Registry completed an initial pilot program and has enrolled more than 19,000 patients since its inception [62]. Expansion of this national arthroplasty registry will help researchers perform better-quality cost-effectiveness studies by pooling nationwide data. The registry will enable comparisons of various prostheses and bearing surfaces, and identify early problems with certain implants. Sweden is perhaps the prime example of how a national joint registry can help achieve cost savings and increase patient safety. Currently Sweden's THA revision rate is 7 %, just one third that of the United States at 18 % [2, 3].

Also, more transparency in the costs of TJA implants to hospitals would potentially reduce regional discrepancies and help give health providers more leverage to control the rising cost of these devices [2]. Metz and Freiberg conducted a survey study of arthroplasty surgeons in 30

countries. They found that the cost of identical THA prostheses varied as much as 700 % worldwide [63]. In 2007 the Medical Device Pricing Transparency Act was introduced into the U.S. Senate, which would have mandated reporting of the sale prices of medical devices; however, this proposed legislation was ultimately not passed.

Arthroplasty surgery continues to make dramatic improvements in the lives of patients; physicians will need to be informed and active in influencing health policy in the coming decades to continue the benefits of joint replacement.

Disclosure DB Bumpass: none; RM Nunley: consultant to Wright Medical Technology, Smith and Nephew.

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