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SYMPOSIUM: VALUE BASED HEALTHCARE

Measuring the Value of Total Hip and Knee Arthroplasty: Considering Costs Over the Continuum of Care

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Abstract

Background Controlling escalating costs of hip (THA) and knee arthroplasty (TKA) without compromising quality of care has created the need for innovative system reorganization to inform sustainable solutions.

Questions/purposes The purpose of this study was to inform estimates of the value of THA and TKA by determining: (1) the data sources data required to obtain costs across the care continuum; (2) the data required for different analytical perspectives; and (3) the relative costs across the continuum of care.

Methods Within the context of a pragmatic randomized controlled trial comparing alternative care pathways, we captured healthcare resource use: (1) 12 months before surgery; (2) inpatient; (3) acute recovery; and (4) long-term recovery 3 and 12 months postsurgery. We established a standardized costing model to reflect both the healthcare payer and patient perspectives.

Results Multiple data sources from regional health authorities, administrative databases, and patient questionnaire were required to estimate costs across the care continuum. Inpatient and acute care costs were approximately 60% of the total with the remaining 40% incurred 12 months presurgery and 12 months postsurgery. Regional health authorities bear close to 60%, and patient costs are approximately 30% of the mean total costs, most of which were incurred after the acute inpatient stay.

Conclusions To fully understand the value of an orthopaedic intervention such as THA and TKA, a broader perspective than one limited to the payer should be considered using a standardized measurement framework over a relevant time horizon and from multiple viewpoints to reflect the substantial patient burden and support sustainable improvement over the care continuum.

Level of Evidence Level III, economic and decision analyses study. See Guidelines for Authors for a complete description of levels of evidence.

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Introduction

Concerns about rising healthcare expenditures have fueled the increased interest in economic evaluation in

decision-making processes. Economic evaluation measures the value of medical interventions, considering both outcomes and costs to drive improvements in health care [7]. The demand for total joint arthroplasty (TJA) of the hip (THA) and knee (TKA) for end-stage osteoarthritis is growing exponentially, but its delivery is not yet optimized. Controlling the escalating costs of medical interventions without compromising the quality of care has created the need for innovative system reorganization to help inform sustainable solutions.

In 2003, the Alberta Orthopaedic Society and the Alberta Bone Joint Health Institute undertook an initial comprehensive analysis of the variability in practice patterns and designed a provincial clinical pathway for THA and TKA in Alberta. The goal was to reduce lengthy waiting times for consultation and surgery and to improve care for patients across the full continuum of care from patient referral to an orthopaedic surgeon through surgery, recovery, and rehabilitation. The project involved a partnership of the provincial government agency that funds healthcare (Alberta Health and Wellness), regional healthcare authorities (RHAs), and decision-makers: orthopaedic surgeons, general practitioners, other healthcare physicians, and allied health professionals. This effort resulted in a new evidence-based clinical pathway (NCP) for THAs and TKAs focused on the quality, coordination, and efficiency of care.

In the Alberta Hip and Knee Replacement Project (HKRP) pilot study [9], we found the expected major effects of the surgery and further small but statistically significant benefits using an explicit measurement framework. Our findings suggested the evidence-informed clinical pathway improved access to care and health-related quality of life of patients undergoing hip and knee arthroplasty in routine clinical practice for up to 12 months postoperatively [1].

Furthermore, in reference to our earlier article, we determined healthcare resource use over the continuum of care 12 months before and 12 months postsurgery to estimate (1) the proportion of costs borne by the regional health authority; (2) the proportion of costs generated by acute care versus longer-term care; and (3) the proportion of costs borne by the payer versus patient.

Methods

The NCP was assessed against the conventional method of service delivery or standard of care (SOC) in a pragmatic randomized controlled trial conducted in three of the nine RHAs in Alberta, representing 80% of THAs and TKAs performed in Alberta. We invited 4985 patients who were indicated for THA or TKA to participate between April 2005 and May 2006, of which 3434 consented and were randomized to the NCP or SOC. We developed outcome measures using the Alberta Quality Matrix for Health (AQMH) framework to define the six dimensions of quality care: acceptability, accessibility, appropriateness, effectiveness, efficiency, and safety [12]. The AQMH is a framework that offers a common language, understanding, and approach to healthcare quality. As the primary effectiveness outcome, we compared improvement in WOMAC score [2] at 12 months postsurgery between patients who received THA or TKA in the NCP ($n = 1066$) versus the SOC ($n = 504$) within the study timeframe and had 12-month followup [1]. These results have been reported elsewhere [1, 9] and the focus of this article is on the collection of health resource use for costing over the continuum of care.

We measured health resource use to estimate the costs for surgical patients enrolled in the Alberta HKRP 12 months before and 12 months postsurgery. Resource use was summarized and categorized into four time components over the continuum of care (Table 1): (1) 12 months before surgery; (2) inpatient (including operating room, inpatient, and subacute care); (3) acute recovery—inpatient discharge to 3 months postsurgery; and (4) long-term recovery—3 months postsurgery to 12 months postsurgery.

A key principal in economic evaluation is to measure and summarize healthcare resource use separately from the valuation of the resources used [7]. We derived health resource use on an individual patient level during the study period from multiple sources to capture the full range of elements through the continuum of care for both the SOC and NCP. The data sources included administrative data from Alberta Health and Wellness (AHW) (eg, professional visits), the RHAs (eg, homecare and community physiotherapy), and hospital chart review (eg, surgical blood transfusions). Estimates of resource use that were not captured in AHW and RHA administrative health databases or hospital charts were collected through patient questionnaires administered at the time of randomization and 3 months and 1 year postsurgery (eg, use of a physiotherapist, chiropractor, and massage therapist) (Table 1). The key point to note is that some of these variables such as alternative care provider visits are not routinely collected in administrative databases but were included with the expectation that they may be important for resource use and costing purposes [13].

The next step in estimating costs was to obtain unit costs for each healthcare resource use item. Each regional hospital was responsible for the unit costs for acute care of all study patients and the new clinical pathway clinics. Historically, there was no standardized approach for costing each element for the inpatient TKA or THA procedure in Alberta. Consequently, it was challenging to compare

Table 1. Sources of resource use information for the Alberta Hip and Knee Replacement Project by time component in the continuum of care

Resource use variable	Data source
12 months before survey (presurgery)	
General practitioner visits MSK	Alberta Health and Wellness physician claims database
Orthopaedic consults MSK	
Other specialist MSK consults	
Anesthesiology consults (< 90 days presurgery)	
Internal medicine consults (< 90 days presurgery)	
Cardiology consults (< 90 days presurgery)	
Emergency room visits	
Alternative healthcare provider visits	Baseline patient questionnaire
Inpatient, operating room, and subacute care	
OR anesthesiology MSK	Alberta Health and Wellness physicians claims database
OR orthopedic surgeon MSK	
Emergency room visits	
Inpatient orthopaedic consults MSK	
Inpatient internal medicine consults	
Inpatient cardiology consults	
Inpatient other specialist MSK consults	
OR surgical assistants	Hospital chart
Acute recovery (3 months postsurgery)	
Homecare visits	Regional Health Authorities database
Community physiotherapy visits	
General practitioner visits MSK	Alberta Health and Wellness physician claims database
Orthopaedic consults MSK	
Other specialist MSK consults	
Alternative healthcare provider visits	3-month followup patient questionnaire
Long-term recovery (3–12 months postsurgery)	
Homecare visits	Regional Health Authorities database
Community physiotherapy visits	
General practitioner visits MSK	Alberta Health and Wellness physician claims database
Orthopaedic consults MSK	
Other specialist MSK consults	
Alternative healthcare provider visits	12-month followup patient questionnaire

MSK codes = musculoskeletal diseases and MSK genetic disease codes; alternative healthcare visits = visits from physiotherapists, chiropractors, registered massage therapists, acupuncturist, and herbalists; OR = operating room.

across institutions or regions within a healthcare jurisdiction. A standardized approach had to be established for the evaluation of the new clinical pathway, whereby key financial experts from within the three participating regional health authorities, along with other costing experts, worked together using their respective historical administrative data to construct a standardized costing model for the hospital and regional health authority costs for THA and TKA procedures. The Alberta Standard Costing Model included costs from preoperative hospitalization visits to patient discharge from acute and subacute care. A listing of cost components was developed and agreed to by each of the three RHAs involved. Using historical data, each region provided cost averages, which were then weighted based on each regional health authority's patient population to develop a provincial standardized costing model. These cost averages were used to calculate key performance indicators such as acute care cost and the cost of surgical versus nonsurgical cases.

The costing approaches differed somewhat among the three RHAs; two used internal models that were specific to the region and one used manual costing. For example, in Calgary, a costing system was developed based on the activities reflecting a typical patient and the costs associated with those activities. Where there were differences in the costing procedure, a proxy value was used. As an

illustration, the anesthesiology technician and respiratory therapist were included in operating room costs in Edmonton, but not in Calgary; in this case, the additional cost for these positions was added to Calgary operating room costs to make them comparable to Edmonton.

In the HKRP, unit costs were obtained from the following sources: (1) AHW costs included all physician professional costs associated with patient consultations and performing medical procedures as well as nonphysician costs (eg, dietician visits, surgical assistants). The unit costs were obtained from the physician claims billing information based on the Alberta Fee Schedule for Medical Services; (2) RHA costs included nonphysician direct costs, including health professional salaries in the intervention clinic and the hospitals, clinic and hospital supplies and consumables, and indirect costs associated with outpatient clinics; acute care (hospital); subacute care; homecare; and community physiotherapy costs. This information was obtained from administrative data obtained from RHAs; and (3) patient costs included direct and indirect costs incurred by patients, including time off work; travel for physician visits and surgery; medication costs for the treatment of their hip or knee condition; and alternative care (eg, massage therapy). The associated resource use estimates were collected in the patient questionnaires at the time of consent for the period 1 year before surgery and 3 months and 12 months postsurgery. Costs for time off work for employed patients were estimated from the numbers of days off work and occupation code reported in the patient questionnaire and multiplied by the hourly compensation for each occupation as reported by Alberta Wage Statistics from the Alberta Wage and Salary Survey [10]. The cost for time lost from work was not calculated for retirees, homemakers, or students. For each patient, we estimated travel distances to the physician and hospital using postal codes and an electronic travel distance tool. A unit cost of 47.5 cents per kilometer was applied, consistent with the Government of Canada 2007 Travel Reimbursement Guidelines [6] to estimate the total travel cost.

Once the measurement framework and general approach to costing were decided, the first consideration in costing was to determine the range of costs to be included in the analysis [7]. Three key questions inform this decision: (1) the viewpoint of the analysis; (2) the relative order of magnitude of the costs; and (3) the time horizon over which costs are considered. Common viewpoints included in the evaluation of healthcare programs include those of the healthcare payer, the patient, and society. In the Alberta HKRP, data were collected to allow analysis from multiple viewpoints (Table 2): (1) healthcare payer: includes costs paid by the healthcare system: (a) Alberta Health and Wellness: all physician professional costs that occurred with patient consultations and performing medical procedures. These included professional costs from orthopaedic surgeons, general practitioners, and other physician specialists; (b) RHAs: the nonphysician health professional fees in the intervention clinic and the hospitals, clinic and hospital materials, and indirect costs associated with the outpatient clinics, acute care (hospital), subacute care, homecare, and community physiotherapy costs; (2) patient: includes all direct and indirect costs incurred by the patients. This may include time off work, travel time to and from physician visits and surgery, medication costs for the treatment of their hip or knee condition, and alternative care (eg, massage therapy).

There were two main steps to costing; each individual item was measured in terms of the quantity of resources that is consumed and then valued by assigning a cost to each unit of resource consumed [5]. The calculation of costs required both resource use and unit cost (or price). The quantity of resource use for each item is then multiplied by the relevant unit cost to obtain the total cost [7]. We summarized the distributions of continuous variables with means and percentages of total costs for each component of care by viewpoint.

Results

To inform estimates of the value of hip and knee arthroplasty across the continuum of care in the Alberta HKRP, multiple data sources were required for costs. This included the Alberta provincial Health and Wellness administrative data sets for physician medical services, the RHA administrative databases for nonphysician health professionals, and self-reported questionnaires for direct and indirect patient costs.

The viewpoint of the analysis had a substantial effect on the results in the Alberta HKRP (Table 3). Using the payer viewpoint, the cost to RHAs was close to 60% of the mean total cost ($14,342 of $24,422). From a patient perspective, the costs were considerable: time off work, travel to the clinic and hospital for preoperative and postoperative visits, medication costs, and costs associated with visits to alternative healthcare providers had a mean total cost of $7363, or 30% of the total cost over the continuum of care. Close to 80% of the costs borne by the patient occurred in the 12-month postsurgical time component. Although only 30% of the patients were employed; 75% of the total estimated costs were associated with time off work. This underscores the negative impact on work productivity up to 12 months postsurgery and will be a larger factor for those who have joints replaced during their active work years.

The distribution of costs among the four components of the continuum of care revealed that a substantive

Table 2. Resource use by payer perspective for Alberta Hip and Knee Replacement Project

Perspective	12 months presurgery	Inpatient (including OR and subacute)	Postsurgical recovery (3 months and 3–12 months postsurgery)
Health Care Payer	General practitioner visits (MSK diagnoses)	Operating room anesthesiology	Orthopaedic consults (MSK diagnoses)
Alberta Health and Wellness	Orthopaedic consults (MSK diagnoses)	Operating room orthopaedic surgeon	General practitioner visits (MSK diagnoses)
	Other specialist (MSK diagnoses)	Operating room surgical assist	Other specialist (MSK diagnoses)
	Anesthesiology consults (< 90 days presurgery)		
	Internal medicine consults (< 90 days presurgery)		
	Cardiology consults (< 90 days presurgery)		
Health Care Payer	Preadmission clinic (control only): presurgery clinic administration cost	Operating room nurses	Community physiotherapy
Regional Health Authorities	Intervention clinic visits	Operating room technical support	Homecare
	Pre-lab	Operating room drugs	Adverse event readmissions
	Nursing, physiotherapy, clerical, and supplies	Rehab compensation	
	Blood collection (phlebotomy)	Inpatient nurses	
	Prediagnostic images	Blood transfusions	
		Inpatient laboratory testing	
		Inpatient respiratory therapy	
		Inpatient ECG/ECHO	
		Inpatient drugs	
		Inpatient meals	
		Inpatient linen	
		Inpatient equipment	
		Prosthesis	
		Cement cost	
		Inpatient other supplies	
		Inpatient other direct and indirect costs	
		Transport to subacute	
		Transport to another region	
		LOS subacute	
Patient	Travel to all clinic visits	Travel to hospital	Analgesic medication cost
	Analgesic medication cost	Time off work	Time off work
	Time off work		Alternative health provider visits
	Alternative health provider visits		Travel to all clinic visits
			Travel for readmission

MSK codes = musculoskeletal diseases and MSK genetic disease codes; OR = operating room; ECG = electrocardiogram; ECHO = ultrasound; LOS = length of hospital stay.

proportion of the total costs were incurred outside of acute care (Table 3). Although much attention tends to be focused on the acute care costs (hospital stay and surgery), the inpatient component was approximately 60% of the total cost. The remaining 40% of costs occurred in the context of the continuum of care 12 months presurgery and 12 months postsurgery.

Discussion

In the context of measuring the value of clinical pathways for TJA, costs should be considered across the full continuum of care, from patient referral to an orthopaedic surgeon through surgery, recovery, and rehabilitation. Furthermore, according to our earlier article based on the

Table 3. Estimated costs by viewpoint and component in the continuum of care

Component of care	RHA mean cost ($)	AHW mean cost ($)	Mean total cost ($) (payer and patient) and percent of total	Patient mean cost ($)	Mean total cost ($) (payer and patient) and percent of total
Presurgery	$1085	$465	$1550 (9%)	$1489	$3040 (12%)
Inpatient*	$12,958	$1800	$14,758 (87%)	$67	$14,825 (61%)
3 months postsurgery	$299	$105	$404 (2%)	$3359	$3763 (15%)
3–12 months postsurgery	†	$348	$348 (2%)	$2447	$2795 (12%)
Mean total cost	$14,342	$2718	$17,060	$7362	$24,422
Percent of total	59%	11%		30%	100%

* Inpatient cost included prosthesis without cement cost and subacute care; †homecare and community physiotherapy costs were not collected for 3- to 12-month followup; AHW = Alberta Health and Wellness; RHA = Regional Health Authorities.

Alberta Hip and Knee Replacement Project, we determined healthcare resource use over the continuum of care 12 months before and 12 months postsurgery to examine the proportion of costs borne by the different public payers, at different stages along the continuum, and by the payer versus patient viewpoint.

Readers should be aware of the limitations of our study. First, we considered only two specific clinical pathways associated with THA and TKA that were compared in the Alberta HKRP. Consequently, the specific findings with respect to costs relate to these particular pathways implemented in the Alberta context. However, the general conclusions about the importance of capturing costs across the continuum of care and considering costs from multiple viewpoints are relevant outside of this setting. Second, in a publicly funded healthcare system such as that in Alberta, Canada, it is not typical for health resource use to be tracked in detail. When considering the costs to include in an evaluation, the focus needs to be on key cost drivers, particularly those that are expected to differ between the interventions being compared. For example, in the Alberta HKRP, it was anticipated that a key cost driver would be hospital length of stay. The average inpatient cost per diem for the HKRP was $1793 (excluding the prosthesis, operative procedure day, and subacute care). Consequently, an increase in hospital length of stay by 1 day would increase the total mean cost of the replacement by approximately 7% ($1793 of $24,422). Because the mean length of stay in the NCP was 4.7 days compared with 6.0 days in the SOC, the mean cost of an inpatient care component differed by more than $2000 between the NCP and the SOC. Third, it is typical for healthcare resource use and costs to be skewed because of a few complicated cases with high costs [14]. In examining costs along the continuum of care, it is important to differentiate between variability in resource use that occurs because of uncontrollable patient variables that result in variable patient outcomes, but are nonetheless predictable, and systematic variability resulting from differences in practice patterns of care. For example, in the Alberta HKRP, we observed enormous variability in total costs for the cohort—ranging from a minimum of just under $8000 to a maximum of over $180,000—mostly as a consequence of extended hospital stays up to 26 days. However, if we focus on systematic variability resulting from differences in practice patterns between the SOC and NCP, we can identify numerous possible opportunities to reduce inefficiencies and waste in the delivery of care. Although the minimum and maximum length of stay (uncontrollable patient variability) for the SOC and NCP were the same (minimum of 2.0 days and maximum of 26.0 days), the mean length of stay for the SOC was 6.0 days and 4.7 days for the NCP. The unadjusted mean inpatient care costs were consequently reduced for the NCP; however, this cost reduction was offset by an increase in pre- and postsurgical costs attributable mainly to rehabilitation visits, resulting in no difference in the overall mean cost between the SOC and NCP clinical pathways ($24,124 versus $24,492, respectively). This would suggest that although the implementation of a standardized clinical pathway can reduce length of stay, it may not result in a cost reduction overall. Fourth, we used a followup time of 12 months. The time horizon over which costs are considered should be long enough to capture all the meaningful differences in costs and outcomes between the intervention and comparators [7]. It is unnecessary to extend the time horizon beyond the period when there are no meaningful differences such as when the costs and outcomes of alternatives converge, but at the same time, horizon should be applied to costs and outcomes for analytical consistency. National guidelines for economic evaluation suggest a lifetime time horizon as a default, particularly for chronic conditions such as osteoarthritis [4].

We have illustrated some of the key principals for the economic evaluation of surgical orthopaedic interventions using the Alberta HKRP as an example. Ideally, all elements of the care process would be tracked, but this is not always practical in a public health system given the diverse

array of elements in the care process and the complex system of care delivery. We used a predefined measurement framework that attempts to identify the common elements in the care delivery pathway and consistently measure costs and outcomes using common metrics over the continuum of care [12]. Published methodological guidelines for economic evaluation state that all relevant costs, calculated from healthcare resource use, should be considered in the analysis [7, 8]. Consequently, in the HKRP, we captured healthcare resource use 12 months before and 12 months postsurgery, because an important aspect of the NCP was the optimization of patients before surgery and rehabilitation after surgery. We derived health resource use during the study period from multiple sources to capture the full range of elements through the continuum of care for both the SOC and NCP.

By summarizing resource use into four components over the continuum of care using the measurement framework, it was revealed that 12-month postsurgery costs were a substantial component of total costs. This pattern is consistent with the Canadian case-control study of knee surgery reported by Hawker et al. [11]. Inpatient costs are the largest component of total care costs (61% and 68% in our study and Hawker et al.'s study, respectively) with pre- and postsurgical costs making up the remainder. However, Hawker et al. did not include the cost of services paid by patients and used a time period of 6 to 12 months for the postsurgical component of care. A literature review by Bozic et al. confirmed that most hip arthroplasty studies (62%) only consider costs during the initial acute care hospitalization or rehabilitation stay [3].

Furthermore, by examining costs from multiple viewpoints, the substantial burden to patients in terms of time away from work and out-of-pocket costs becomes apparent. In our HKRP study, patient costs were 30% of mean total costs over the continuum of care, 80% of which were incurred after the acute inpatient stay. To fully understand the costs and benefits of an intervention such as THA and TKA, a broader perspective than one limited to the payer should be considered because of this avoidable burden to patients. Nonetheless, the review by Bozic et al. [3] found that only a minority (17%) of economic evaluations considered costs beyond those incurred by the payer.

Finally, for surgical orthopaedic interventions, in which revisions are an important factor affecting outcomes and costs, it is appropriate to consider modeling as a complementary approach to extrapolate beyond the short timeframes typical of surgical trials. From a long-term perspective, it is relevant to consider the benefits and costs of alternative prosthetic technologies and their expected survival and arthroplasty requirements. Thus, although some prostheses are considerably more expensive compared with others as a one-time equipment cost, if we consider the long-term time horizon, and their potential to avoid revision surgery, they may be better value for money depending on the age of the patient receiving the arthroplasty. In this situation, it is necessary to use modeling as a complementary approach to extrapolate beyond the 12-month time horizon of the Alberta HKRP trial or have long-term registry data. Building databases through registries is a key strategy to informing such models.

We suggest future efforts to measure the value of surgical orthopaedic interventions should focus on developing sustainable improvement beyond the acute surgical component and over the continuum of care. Measures should include relevant outcomes and costs considering the viewpoint of the analysis, the key cost drivers and sources of variability, and the implications of the time horizon for analysis.

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