A Population-Based Nested Case-Control Study of the Costs of Hip and Knee Replacement Surgery

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Background: Studies of total joint arthroplasty (TJA) have not evaluated the costs and outcomes in the context of expected arthritis worsening.

Objectives: Using a cost-consequence approach, to examine changes in direct health care costs and arthritis severity after TJA for hip/knee arthritis compared with contemporaneous changes in matched controls.

Research Design: Case control study nested in a population-based prospective cohort.

Subjects: In a population cohort with disabling hip/knee osteoarthritis followed from 1996 to 2003, primary TJA recipients were matched with cohort nonrecipients on age, sex, region of residence, comorbidity, and inflammatory arthritis diagnosis.

Measures: Pre- and postoperative total and arthritis-attributable direct health care costs, arthritis severity, and general health status were compared for cases and matched controls.

Results: Of 2109 participants with no prebaseline TJA, 185 cases received a single elective TJA during the follow-up period; of these, 183 cases and controls were successfully matched. Mean age was 71 years, 77.6% were female, 35.5% had ≥2 comorbidities, and 81.5% had ≥2 joints affected. At baseline, controls had less pain and disability and lower total and arthritis-attributable health care costs than cases. After surgery, although overall health care utilization was unchanged, 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.

Conclusion: Compared with matched controls, arthroplasty is associated with significant reductions in pain, disability, and arthritis-attributable direct costs.

Key Words: osteoarthritis, total joint arthroplasty, joint replacement, direct costs, cost-consequence

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Symptomatic osteoarthritis (OA) currently affects 9.6% of men and 18% of women aged ≥60 years.[1] Increased life expectancy and lifestyle changes (increased obesity, less physical activity) are anticipated to make OA the fourth leading cause of disability by 2020.[1]

When OA pain and disability become intolerable, total joint arthroplasty (TJA) of the hip or knee is the accepted treatment; OA accounts for 95% of hip and all knee TJA procedures.[2] Technical advances, reduced complications, and greater perceived efficacy have contributed to expanded indications for and a marked increase in the provision of TJAs. In 2005, 381,318 hip and 549,867 knee arthroplasties were performed in the United States.[3]

Although reported costs for a primary TJA may be more than $US 20,000,[4–7] cost-utility analyses rank this procedure at or near the top among medical and surgical interventions, with costs per quality-adjusted life year as low as $3268, averaged over the lifetime of the prosthesis.[4,5] At least one study suggested that hip replacement may be cost-saving.[8] However, economic studies of TJA have largely been performed in academic, high volume centers,[4–6,8–11] and thus, may represent an overly optimistic perspective.[12–14] Only 1population-based study has been performed,[15] and no study to date has evaluated the costs of arthroplasty, with reference to costs for nonrecipients with advanced hip/knee arthritis at a population level. Capitalizing on the existence of a longitudinal population-based cohort with hip and knee arthritis, the objective of our study was to use a cost-consequence

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approach to describe changes in direct health care costs and arthritis pain and disability in recipients of a single elective primary TJA procedure compared with similar changes in matched controls.

METHODS

Subjects

A population cohort with disabling hip/knee arthritis, residing in 2 regions of Ontario, Canada—1 urban and 1 rural—has been followed from 1996 to date. Details of cohort recruitment and study design have been published previously.[11,16,17] Cohort participants were identified from 100% of the population aged 55 years or older as those with: (i) difficulty in the last 3 months with each of stair climbing, rising from a chair, standing, and walking; (ii) swelling, pain, or stiffness in any joint lasting at least 6 weeks, and (iii) indication that a hip and/or knee had been 'troublesome'. Respondents were surveyed initially (baseline), and then annually, to assess general health status (Health Survey Short-Form General Health [SF-36 GH] subscale),[18–21] comorbidity, arthritis type (inflammatory vs. osteoarthritis), and arthritis severity (Western Ontario and McMaster Universities Osteoarthritis [WOMAC] Index, with subscales for pain, physical function, and stiffness).[22] Comorbidity was assessed by asking respondents to report (from a list of 17 health problems, including mental health disorders) concurrent health problems for which they had received treatment or had seen a physician in the past year, and current height and weight (to calculate body mass index).

Identification of Cases

Participants' survey data were linked to provincial administrative databases, using unique anonymous patient identifiers.[23–25] The Canadian Institute for Health Information Discharge Abstract Database (DAD), which records all hospital admissions, was searched for the occurrence of a TJA at any time between the baseline assessment and September 30, 2003, allowing 1½ years of postsurgery follow-up for those that had surgery. People with a pre-baseline TJA were excluded to exclude revision TJA procedures. Cases were those with a first TJA during the defined period. Cases were excluded if the index TJA was not an elective procedure for arthritis (ie, it was because of a fracture or cancer), the individual was not alive at the end of the postsurgery follow-up period (to ensure both costs and arthritis pain and disability could be evaluated post TJA), or the individual had a second TJA, including a second primary or a revision, before the end of the follow-up period (to enable attribution of changes to the index TJA). The procedure and diagnostic codes used to identify cases are presented in Appendices A and B, http://links.lww.com/A1274.

Estimating Health Care Costs

Health care utilization was determined for the pre-TJA period (1 year, ending 6 weeks before the TJA), the perioperative period (surgery-related costs; from 6 weeks before to 6 months post-TJA; the period in which most costs directly relevant to the TJA, including consultations and tests, the surgery itself, and the postsurgery recovery, would be incurred), and the post-TJA period (1 year, starting 6 months after the TJA).

Use of publicly-funded health care services were obtained for: (a) physician and laboratory services (using the Ontario Health Insurance Plan [OHIP] Physician and Laboratory Claims Databases); (b) prescription drugs for individuals aged 65 years and older—70% of the cohort at baseline (Ontario Drug Benefit Plan [ODB] database provides the cost, including dispensing fee, for each prescription); (c) inpatient hospitalizations and same-day surgery encounters (DAD and National Ambulatory Care Reporting System (NACRS) databases); (d) emergency department visits (extracted from the Physician Claims Database before April 2002 and the NACRS from April 2002); (e) rehabilitation hospital stays (DAD through March 2003 and National Rehabilitation System database thereafter); (f) home care services (Ontario Home Care Administration System database); (g) chronic care stays (Ontario Continuing Care Patient System database and Chronic Care Reporting System); and (h) long-term care (identified using specific fee codes in OHIP, and the long-term care indicator in ODB[26]).

These databases do not capture nonphysician outpatient services (eg, physiotherapy), physician services provided under Alternative Funding Programs (less than 5% of all physician services), and services funded by private insurance, or paid for out-of-pocket by the care recipient (eg, prescription drugs for people younger than 65 years).

Service costs were assessed using a previously defined methodology.[27] To ensure that cost estimates reflected only the services received, average provincial costs rather than location-specific costs, were used to evaluate each service. Costs were adjusted by the change in the Consumer Price Index for Canada between July 2001 and July 2007 to reflect costs in 2007.

Arthritis-Related Costs

The diagnoses associated with hospitalizations, ambulatory care visits, and physician billing records were used to categorize costs as arthritis-attributable or not (see Appendix B, http://links.lww.com/A1274). Prescription drugs were similarly categorized.

Matching Cases and Controls

In the absence of a TJA, costs associated with both arthritis-related health care and care associated with other chronic health problems may increase over time. Thus, assessing only the pre/post cost differences for cases that undergo TJA may underestimate the decrease in costs because of the TJA. Therefore, each TJA recipient (case) was matched with a non-TJA recipient on those variables that were significantly associated with presurgery costs (exact matches on region, sex, inflammatory arthritis diagnosis, and number of comorbidities, and age-matched to within 5 years), and requiring that the selected control was still alive at the end of the case's postsurgery time period. For each control, health care utilization was determined using the matched recipient's surgery date as the index date.

Analysis

Presurgery, surgery-related, postsurgery, and change in costs (postsurgery costs minus presurgery costs, thus negative values indicate a reduction in costs) were calculated, and compared, for cases and for these same time periods for controls. Similarly, presurgery, postsurgery, and changes in arthritis severity (WOMAC summary and subscale scores) and general health status (SF-36 GH subscale score) were calculated, and compared. WOMAC scores were normalized from 0 to 100; higher scores indicate worse arthritis symptoms and disability. SF-36 GH scores were also normalized from 0 to 100; here, higher scores indicated better general health status. Presurgery and postsurgery scores were those obtained at the interview closest in date and before the index TJA date, and closest in date to the end of the postoperative follow-up period (ie, 1½ years post surgery), respectively. 'Adjusted' costs were calculated as cases' costs minus controls' costs for the contemporaneous period. Paired comparisons were performed using Wilcoxon sign-rank tests for continuous variables, and McNemar or Bowker tests for categorical variables. Analyses were conducted using SAS (Version 9, SAS Institute, Cary, North Carolina). The Sunnybrook and Women's College Health Sciences Centre ethics review board approved the study.

RESULTS

Cases

Among 2411 cohort respondents, 302 had experienced a prebaseline TJA and were therefore excluded. Of the remaining 2109 respondents, 258 underwent a postbaseline primary TJA. Of these, 13 received their TJA for cancer or fracture. Fifty-six of the remaining 245 individuals (23%) experienced a second TJA procedure (1 of the 56 died subsequently, before the end of the follow-up period), whereas 4 others died before the end of the postsurgery period and 2 could not be matched to controls, leaving a total of 183 cases and controls—69 hip and 114 knee replacements. Cases excluded because of occurrence of a second TJA or death during follow-up were similar to those included in socio-demographics, general health status, arthritis severity, and presurgery costs (data not shown).

Cohort Characteristics

Baseline characteristics for cases and controls are shown in Table 1. Cases had a mean age of 70.9 years at the time of TJA and were mainly female (77.6%), 44.8% resided in the urban region, 25.7% lived alone, 77.0% had ≤ high school education, and 52.5% had an annual household in-

TABLE 1. Baseline Characteristics of the TJA Cases and Their Matched Controls

Variable	Cases (n = 183)	Controls (n = 183)	Case-Control Differences (n = 183 Pairs)	P*
Age at time of TJA (years)	70.9 (7.2)	70.7 (7.2)	0.2 (1.2)	0.05
Mean (SD)			44.8% exact matches	
Sex (% female)	77.6%	77.6%	Exact match	
Region (% urban)	44.8%	44.8%	Exact match	
Living alone (%)	25.7	35.0		0.07
≤ High school education (%)	77.0	83.6		0.44
Income ≤$20,000 (%)†	52.5	53.6		0.86
Inflammatory arthritis (%)	7.1%	7.1%	Exact match	
Number of troublesome hips/knees‡				0.56
1 (%)	14.8	11.5		
More than 1 (%)	65.0	62.3		
Missing	20.2	26.2		
Joint replaced (% knee replacement)	62.3	n/a		
Number of comorbidities			Exact match	
None	35.0%	35.0%		
1	29.5%	29.5%		
2+	35.5%	35.5%		
BMI (at baseline) mean (SD)	29.0 (5.6)	28.7 (6.0)	0.3 (8.5)	0.63
SF-36 general health subscale§				
mean (SD)	52.6 (22.6)	50.0 (23.3)	2.7 (30.2)	0.19
WOMAC (pain),§ mean (SD)	46.7 (17.3)	37.5 (22.0)	9.1 (28.9)	<0.0001
WOMAC (disability),§ mean (SD)	46.6 (17.2)	39.9 (21.6)	6.7 (28.2)	0.0007
WOMAC (total),§ mean (SD)	46.3 (16.3)	39.4 (20.7)	7.0 (27.1)	0.0003

*P testing the null hypothesis that there is no systematic difference between the cases and their matched controls. For continuous variables, a paired Wilcoxon sign rank test was used, for categorical variables, Bowker test (an extension of McNemar test) was used.

†Based on 124 pairs with non-missing data.

‡Based on 108 pairs with non-missing data.

§The WOMAC and SF-36 general health scores were rescaled to lie between 0 and 100. For WOMAC scores, higher scores indicate worse symptoms or disability. For the SF-36, higher scores indicate better health status.

SD indicates standard deviation.

come ≤$20,000. Only 7.1% had an inflammatory arthritis diagnosis; most (65.0%) had more than 1 troublesome hip or knee. For 62.3%, the index TJA was a knee replacement. Roughly, a third (35.5%) had 2 or more comorbidities and their mean BMI was in the 'overweight' category, at 29.0 kg/m^2. Mean WOMAC pain and physical function scores were 46.3/100 (SD 16.3) and 46.6/100 (SD 17.2), respectively. Controls were similar to cases in most respects, but they had significantly less pain and disability and were slightly younger.

Costs

Tables 2 through 4 show health system costs for the 3 time periods of interest for cases, and for the contemporaneous period for their matched controls. The number of cases and controls with costs in each category of health care utilization is provided, along with the mean cost for individuals with costs and the mean cost for the entire group (those with and without costs). For simplicity, reported below are mean costs for those who incurred costs.

All 183 cases accrued costs during the presurgery period compared with only 177 of their matched controls (Table 2). For cases, during the presurgery year, total direct health care costs excluding prescription drug costs, averaged $3,265 (SD $5210); this was largely because of hospitalizations (average $2714) and physician and laboratory services (average $1519). For those aged ≥65 years, prescription drug costs added an average $1186 (SD $1229) in costs. Total costs for controls for this same time period were similar to those for cases with one exception: controls had significantly lower costs than cases for physician and laboratory services (mean $1269 vs. mean $1519, respectively; $P = 0.01$).

For all categories of utilization, arthritis-attributable health system costs were significantly higher in the presurgery period for cases than for controls for the same time period (Table 2). Of the 183 cases, 176 had arthritis-related costs compared with only 57 of their matched controls. On average, cases' arthritis-attributable costs, excluding prescription drug costs, were $409 (SD $830), compared with $369 (SD $1321) for controls for the same time period.

The total costs associated with the surgery period averaged $14,761 (SD $8735) for the 183 cases compared with an average of $2603 (SD $5283) for the 174 controls with costs for the same time period (Table 3), giving a mean difference in total costs for cases versus controls for this period, excluding prescription drugs, of $12,287 (SD $10,181). For case-control pairs aged ≥65 years at baseline, the mean difference in overall health care costs, including prescription drugs, was $12,148 (SD 11,913). Although much of the difference in surgery period costs for cases versus controls was because of the cases' TJA hospitalizations (mean adjusted cost = $7849) and associated physician and laboratory services (mean adjusted cost = $1924), higher costs in cases versus controls were also because of the costs of postoperative rehabilitation. Sixty-one (33.3%) cases were admitted to a rehabilitation hospital after surgery, adding a mean adjusted cost of $2027. Nearly 60% (107/183) of cases received home care, with an average adjusted cost of $621. Included in these numbers are 29 cases (15.9%) who received both in-hospital and home care rehabilitation services.

The mean change in total health care costs for cases after TJA was similar to the mean change in total costs for controls for the contemporaneous time period ($P = 0.26$) (Table 4). For both groups, total health care utilization was overall greater (associated with greater costs and in a greater number of cases and controls) in the postsurgery than the presurgery period, regardless of whether or not prescription drug costs were considered. However, for cases, but not controls, there was some variability in the change in use over time. For cases, total costs for physician and laboratory services decreased after TJA, compared with an increase in these costs for controls over the same time period ($P = 0.02$).

Although there was no significant reduction in overall healthcare utilization associated with TJA, this was not the case for arthritis-attributable use. Cases experienced reductions in arthritis-attributable healthcare utilization after TJA, whereas over the same time period, these costs increased among controls (Table 4). Although TJA-recipients continued to fill prescriptions for arthritis-related medications, their overall level of use fell, both viewed in isolation (mean decrease $47, $P = 0.003$) and compared with use by nonrecipients (mean adjusted difference = −$67, $P = 0.02$). TJA-recipients were also less likely to visit a specialist for their arthritis after surgery ($P = 0.02$); however, primary care visits did not change significantly ($P = 0.26$). For the TJA cases, the mean decrease in arthritis-attributable costs after TJA was $185 (SD $934); when prescription drugs were included and thus costs restricted to those aged 65 or older, the mean decrease was $278 (SD $1,070) (both $P < 0.0001$).

Changes in Arthritis and General Health Status

Over a third (37.5%) of the 366 cases and controls did not have an interview after the index TJA date; postsurgery data were available for 123 cases, 105 controls, and 86 case-control pairs. Those who did not complete a follow-up interview differed from those who did only in that they were older (73.1 years vs. 69.6 years, respectively). Table 5 shows WOMAC and SF-36 general health scores for the presurgery and postsurgery periods and change scores for the 86 pairs for whom both pre- and postdata were available. The results were not different when we examined changes including all available data (results not shown).

As anticipated, for the presurgery period, WOMAC pain, function, and summary scores were higher for cases than controls ($P < 0.001$ for all), indicating worse pain and disability; no differences were found for self-reported general health status (Table 5). In comparison, for the postsurgery period, WOMAC pain, function, and summary scores were lower for cases, indicating less pain and disability, than for controls ($P \leq 0.03$ for all). Pre/post surgery change scores indicated significant improvements in arthritis pain and disability for cases compared with no significant change or worsening for controls. No significant difference was observed for cases versus controls for change in general health status ($P = 0.10$).

TABLE 2. Total and Arthritis-Attributable Health System Costs for the Presurgery Period for Cases and for the Contemporaneous Period for Controls

	Case's Costs			Control's Costs			Case-Control Comparisons	
Health Care Area	Number of People With Costs in this Category	Mean Cost (SD) (for those who had costs)	Mean Cost (SD) for All Cases	Number of People With Costs in this Category	Mean Cost (SD) (for those who had costs)	Mean Cost (SD) for All Controls	Paired Difference in Costs for All Case-Control Pairs, Calculated as Case–Control: Mean (SD)	*P* for the Paired Difference*
Total costs for 183 matched pairs (all ages)								
Acute care hospitalizations	56	2714 (2737)	831 (1958)	53	3831 (6035)	1,110 (3,667)	−279 (3,912)	0.75
Physician and laboratory services	183	1519 (1330)	1519 (1330)	176	1269 (1197)	1,220 (1,199)	299 (1,781)	0.01
Total costs† (excluding prescription drugs)	183	3265 (5210)	3265 (5210)	177	3833 (8004)	3,708 (7,900)	−443 (8,846)	0.14
Arthritis-attributable costs for 183 matched pairs (all ages)								
Acute care hospitalizations	18	1709 (1642)	168 (716)	3	Cell size too small to report values	Cell size too small to report values	108 (1,004)	0.002
Physician and laboratory services	176	228 (238)	218 (237)	57	171 (257)	53 (164)	165 (280)	<0.0001
Total arthritis-attributable costs (excluding prescription drugs)	176	409 (830)	393 (817)	57	369 (1321)	115 (752)	279 (1,118)	<0.0001
Total costs for pairs aged ≥65 yr at baseline (137 matched pairs)								
Acute care hospitalizations	49	2766 (2851)	989 (2154)	44	4190 (6471)	1,346 (4134)	−356 (4,394)	0.77
Physician and laboratory services	137	1600 (1389)	1600 (1389)	133	1337 (1253)	1,298 (1255)	302 (1941)	0.04
Total costs (excluding prescription drugs)	137	3515 (5255)	3515 (5255)	134	4527 (9006)	4,427 (8931)	−913 (9737)	0.38
Prescription drugs	134	1186 (1229)	1160 (1228)	132	1593 (2150)	1,535 (2130)	−376 (2298)	0.07
Total costs (including prescription drugs)	137	4675 (5594)	4675 (5594)	134	6095 (9976)	5,962 (9906)	−1287 (10,635)	0.93
Arthritis-attributable costs for pairs aged ≥65 yr at baseline (137 matched pairs)								
Acute care hospitalizations	15	1880 (1757)	206 (815)	3	Cell size too small to report values	Cell size too small to report values	125 (1154)	0.01
Physician and laboratory services	131	237 (249)	226 (248)	45	175 (273)	58 (176)	168 (294)	<0.0001
Total arthritis-attributable costs (excluding prescription drugs)	131	459 (934)	439 (918)	45	426 (1482)	140 (866)	299 (1273)	<0.0001
Arthritis prescription drug costs	103	271 (291)	204 (279)	81	191 (253)	113 (215)	90 (302)	<0.0001
Total arthritis-attributable costs (including prescription drugs)	137	642 (992)	642 (992)	91	380 (1124)	253 (933)	389 (1376)	<0.0001

*Paired analyses (using Wilcoxon signed rank tests) were used to obtain the *P*-values.

†Hospital, physician and laboratory services, and prescription drug costs (where available) are the largest components of total costs. In addition, the total includes costs for emergency department visits, chronic care hospital and long-term care stays. Rehabilitation costs (home care and in-patient rehabilitation) are not shown separately due to small numbers.

Costs in cells representing fewer than 6 people are suppressed. Cells that can be combined with other cells to obtain information representing fewer than 6 people are also suppressed.

TABLE 3. Total and Arthritis-Attributable Costs for the Surgery Period for Cases and for the Contemporaneous Period for Controls

	Case's Costs			Control's Costs			Case-Control Comparisons	
Health Care Area	Number of People With Costs in this Category	Mean Cost (SD) (for those who had costs)	Mean Cost (SD) for all Cases	Number of People With Costs in this Category	Mean Cost (SD) (for those who had costs)	Mean Cost (SD) for all Controls	Paired Difference in Costs for all Case-Control Pairs, Calculated as Case–Control: Mean (SD)	*P* for the Paired Difference*
Total costs for 183 matched pairs (all ages)								
Acute care hospitalizations	183	8634 (4671)	8634 (4671)	42	3421 (4917)	785 (2744)	7849 (5482)	<0.0001
Physician and laboratory services	183	2639 (871)	2639 (871)	173	756 (725)	715 (725)	1924 (1111)	<0.0001
Home care	107	1436 (1780)	840 (1533)	22	1819 (1151)	218 (710)	621 (1681)	<0.0001
Rehabilitation	61	6188 (4245)	2063 (3808)	1	Cell size too small to report values	Cell size too small to report values	2027 (3766)	<0.0001
Total costs† (excluding prescription drugs)	183	14,761 (8735)	14,761 (8735)	174	2603 (5283)	2475 (5181)	12,287 (10,181)	<0.0001
Arthritis-attributable costs for 183 matched pairs (all ages)								
Acute care hospitalizations	182	7960 (3189)	7917 (3234)	4	Cell size too small to report values	Cell size too small to report values	7884 (3238)	<0.0001
Physician and laboratory services	179	1025 (378)	1004 (403)	51	141 (185)	40 (116)	964 (391)	<0.0001
Total arthritis-attributable costs (excluding prescription drugs)	182	8973 (3266)	8924 (3324)	52	259 (567)	74 (322)	8851 (3333)	<0.0001
Total costs for pairs aged ≥65 yr at baseline (137 matched pairs)								
Acute care hospitalizations	137	9097 (5263)	9097 (5263)	35	3842 (5285)	982 (3132)	8116 (6254)	<0.0001
Physician and laboratory services	137	2706 (916)	2706 (916)	130	783 (756)	743 (757)	1964 (1164)	<0.0001
Total costs (excluding prescription drugs)	137	15,508 (9488)	15,508 (9488)	131	3136 (5962)	2999 (5865)	12,508 (11,385)	<0.0001
Prescription drugs	137	694 (784)	694 (784)	128	1129 (2011)	1055 (1963)	−361 (2001)	0.029
Total costs (including prescription drugs)	137	16,202 (9637)	16,202 (9637)	134	4143 (6643)	4054 (6597)	12,148 (11,913)	<0.0001
Arthritis-attributable costs for pairs aged ≥65 yr at baseline (137 matched pairs)								
Acute care hospitalizations	136	8257 (3589)	8197 (3645)	2	Cell size too small to report values	Cell size too small to report values	8163 (3647)	<0.0001
Physician and laboratory services	133	1,047 (372)	1,016 (406)	40	124 (162)	36 (104)	980 (398)	<0.0001
Total arthritis-attributable costs (excluding prescription drugs)	136	9285 (3659)	9218 (3730)	41	240 (583)	72 (335)	9146 (3738)	<0.0001
Arthritis prescription drugs costs	80	158 (167)	92 (150)	73	142 (219)	75 (174)	16 (200)	0.022
Total arthritis-attributable costs (including prescription drug costs)	137	9310 (3754)	9310 (3754)	84	240 (473)	148 (388)	9162 (3766)	<0.0001

*Paired analyses (using Wilcoxon signed rank tests) were used to obtain the *P* values.
†Hospital, physician and laboratory, and prescription drug costs are the largest components of total costs. In addition, the total includes costs for ED visits, chronic care hospital, and long-term care stays.
Costs in cells representing fewer than 6 people are suppressed. Cells that can be combined with other cells to obtain information representing fewer than 6 people are also suppressed.

TABLE 4. Total and Arthritis-Attributable Costs for the Postsurgery Period Health System Costs and Change in Costs Following Surgery for Cases and for the Contemporaneous Periods for Controls

	Cases					Controls						
	Postsurgery Costs			Change in Costs (Post-Pre)		Postsurgery Costs			Change in Costs (Post-Pre)		Adjusted Change* in Cases' Costs	
Health Care Area	Number With Costs	Mean Cost (SD) (for those with costs)	Mean Cost (SD) (for all cases)	Mean Change (SD) for all cases	$P^{\dagger}$	Number With Costs	Mean Cost (SD) (for those with costs)	Mean Cost (SD) for all Controls	Mean Change (SD) for all Controls	$P^{\dagger}$	Adjusted Change in Costs for Cases	$P^{\ddagger}$
Total costs for 183 matched pairs (all ages)												
Acute care hospitalizations	41	5642 (5004)	1264 (3326)	434 (3469)	0.33	50	5047 (9937)	1379 (5627)	270 (6654)	0.77	164 (7270)	0.45
Physician and laboratory services	182	1333 (1143)	1325 (1144)	−195 (1280)	0.08	178	1418 (1601)	1,379 (1597)	159 (1707)	0.31	−354 (2133)	0.02
Total costs[§] (excluding prescription drugs)	182	3592 (6254)	3572 (1162)	307 (6450)	0.97	179	4965 (11,330)	4,857 (11,342)	1149 (11,381)	0.14	−842 (12,880)	0.26
Arthritis-attributable costs for 183 matched pairs (all ages)												
Acute care hospitalizations	6	3111 (3023)	102 (748)	−66 (865)	0.13	3	Cell size too small to report values	Cell size too small to report values	44 (1202)	0.88	−110 (1478)	0.16
Physician and laboratory services	153	125 (188)	105 (178)	−114 (244)	<0.0001	61	150 (256)	50 (163)	−3 (124)	0.93	−110 (277)	<0.0001
Total arthritis-attributable costs (excluding prescription drugs)	153	248 (859)	207 (791)	−185 (934)	<0.0001	61	467 (1714)	156 (1008)	41 (1229)	0.71	−226 (1548)	<0.0001
Total costs for pairs aged ≥65 yr at baseline (137 matched pairs)												
Acute care hospitalizations	34	5965 (5332)	1481 (3686)	490 (3868)	0.50	40	5972 (10,924)	1743 (6454)	397 (7,653)	0.87	93 (8312)	0.68
Physician and laboratory services	136	1389 (1217)	1379 (1219)	−221 (1400)	0.10	133	1506 (1798)	1462 (1789)	163 (1890)	0.63	−384 (2361)	0.07
Total costs[†] (excluding prescription drugs)	136	3957 (6701)	3927 (6685)	412 (7208)	0.88	134	6079 (12,891)	5946 (12,780)	1519 (13,077)	0.25	−1107 (14,718)	0.33
Prescription drugs	136	1270 (1435)	1261 (1434)	101 (706)	0.19	129	2118 (4126)	1994 (4034)	459 (2490)	0.07	−357 (2541)	0.26
Total costs (including prescription drug costs)	137	5,188 (7,312)	5188 (7312)	513 (7351)	0.99	135	8058 (14,109)	7940 (14,037)	1978 (13,303)	0.04	−1,465 (15,015)	0.13
Arthritis-attributable costs for pairs aged ≥65 yr at baseline (137 matched pairs)												
Acute care hospitalizations	4	Cell size too small to report values	Cell size too small to report values	−102 (966)	0.05	3	Cell size too small to report values	Cell size too small to report values	59 (1389)	0.88	−162 (1688)	0.09
Physician and laboratory services	110	131 (207)	105 (192)	121 (253)	<0.0001	48	163 (287)	57 (185)	−1 (123)	0.96	−119 (283)	<0.0001
Total arthritis-attributable costs (excluding prescription drugs)	110	259 (948)	208 (855)	−185 (934)	<0.0001	48	564 (1,924)	198 (1163)	41 (1,229)	0.71	−226 (1548)	<0.0001
Arthritis prescription drug costs	93	230 (288)	156 (259)	−47 (223)	0.003	83	220 (396)	133 (327)	20 (257)	0.84	−67 (339)	0.02
Total arthritis-attributable costs (including prescription drugs)	127	393 (959)	364 (930)	−278 (1070)	<0.0001	95	477 (1427)	331 (1206)	79 (1463)	0.80	−356 (1842)	<0.0001

*The adjusted change in each case's health costs was calculated as the change in case cost minus the change in the matched controls. Changes were calculated as (postsurgery − presurgery), therefore negative values indicate a cost savings.

[†]*P* value testing the null hypothesis that there was no change in mean cost of health care utilization for the specified group (cases or controls) of patients. Changes in costs (presurgery − postsurgery) were tested using Wilcoxon signed rank tests.

[‡]*P* value testing the null hypothesis that the adjusted mean change in case health care costs is 0. Paired analyses (using Wilcoxon signed rank tests) were used to obtain the *P*-values.

[§]In addition to hospital and physician and laboratory service costs, the total includes costs for ED visits, chronic care hospital, and long-term care stays. Rehabilitation costs (home care and in-patient rehabilitation) are not shown separately due to small numbers.

Costs in cells representing fewer than 6 people are suppressed. Cells that can be combined with other cells to obtain information representing fewer than 6 people are also suppressed.

TABLE 5. Changes in Arthritis Severity and General Health Status for Cases and Controls (n = 86 Case-Control Pairs)

	Presurgery Period			Postsurgery Period			Change in Scores (post score–pre score)		
	Cases	Controls	*P**	Cases	Controls	*P**	Cases	Controls	*P*†
WOMAC (0-100)									
Pain	47.8 (17.8)	37.0 (21.8)	0.0003	32.0 (18.2)	37.9 (18.9)	0.03	−15.7 (21.3)	0.9 (22.5)	<0.0001
Physical function	46.6 (18.1)	38.2 (19.3)	0.002	36.2 (17.6)	41.8 (18.6)	0.03	−10.4 (20.8)	3.6 (23.9)	<0.0001
Summary	46.4 (17.1)	38.0 (18.8)	0.001	34.7 (16.8)	40.5 (17.6)	0.02	−11.7 (19.9)	2.5 (22.0)	<0.0001
SF-36 general health scale (0–100)	54.5 (22.7)	52.0 (22.3)	0.42	54.0 (22.3)	46.5 (22.5)	0.03	−0.5 (21.8)	−5.5 (23.1)	0.10

**P* testing the null hypothesis that there was no difference between the cases and their matched controls were obtained using paired *t* tests.
†*P* testing the null hypothesis that the change in function scores between the presurgery and the postsurgery period was the same for the cases and their matched controls were obtained using paired *t* tests.

DISCUSSION

To our knowledge, this is the first study to examine the impact of primary hip and knee replacement surgery in terms of changes in health care utilization and health status, in relation to similar changes over time in matched non-TJA recipients at a population level. On average, cases that underwent primary hip or knee TJA experienced significant reductions in pain, disability, associated arthritis-attributable health care costs, and stable general health status. In comparison, over the same time period, matched arthritis controls experienced worsening of both their general health and arthritis status, and health care costs remained stable or increased. Through comparison of TJA recipients with matched controls, we have shown that prior TJA cost studies that have not controlled for expected time-dependent changes in health status in older individuals may have underestimated the benefits of this common procedure on health care costs, pain, and disability.

An additional strength of the current study over prior TJA cost studies is that it evaluated changes in costs and health status at a population level, whereas prior studies have largely evaluated patients within high volume academic centers. As noted earlier, because of the documented relationships between patient case-mix, and surgeon and hospital volume and TJA outcomes,[12–14] it is likely that these prior studies represent an overly optimistic view of the benefits of TJA. It is encouraging, therefore, that at a population level we found clear evidence of benefit in terms of costs, pain, and disability. However, the distribution of cost differences was wide, indicating significant variability across patients. Similarly, although mean changes in arthritis pain and disability associated with TJA were positive among cases, there was significant variability observed. Using the Minimal Clinically Important Difference for WOMAC scores recommended by Angst et al,[28] we estimate that 59.4% of the cases improved after their TJA, 23.6% did not experience meaningful change, and 17.1% were worse after surgery. Together, these findings underscore the need for additional research to examine patient and system level factors that affect this variability in costs and benefits to better target TJA to those most likely to derive benefit.

Only 1 prior study[15] has examined costs of TJA from a population perspective. This Finnish study compared costs for the 12-month period before and the 24-month period after a single primary hip or knee replacement. No comparison with 'control' patients who did not undergo surgery was performed. Despite methodological differences, our results for cases are remarkably consistent with theirs. These authors reported postsurgery cost-savings largely related to a reduction in visits to physicians and physiotherapists; prescription drug use was unchanged. In our study, cases experienced a reduction in both overall and arthritis-attributable physician visits and in arthritis-related prescription drug use, but not overall prescription drug use. The latter is not unexpected since older individuals undergoing TJA have significant comorbidity necessitating ongoing use of prescription medications. The observed reduction in physician visits after TJA highlights the importance of uncontrolled chronic joint pain as a motivator of physician visits for arthritis.

Largely based on availability of data, and thus power, we defined our postsurgery period to be 1 year in length. Although this time period is appropriate to capture the majority of surgery-related complications, including immediate dislocations, it is inadequate to examine subsequent costs for revision surgery. Future efforts should focus on longer follow-up, to assess longer term costs and associated benefits, such as those because of an impact on recipients' ability to live independently or, as a result of reduced physical disability and possibly weight loss, potentially an effect on spending for other comorbidities.

To attribute changes in costs and arthritis severity to the index primary TJA, we excluded potential cases that underwent a second TJA within the index TJA surgery or postsurgery periods. As a result, we cannot comment on the costs and outcomes for a relatively large subgroup of TJA recipients who undergo bilateral same admission or staged bilateral procedures (these individuals comprised almost one-quarter of potential cases). Future studies are warranted to examine the costs and benefits of TJA in such individuals.

Strengths of our study include its prospective, population-based design and the use of linked survey and administrative data, which permitted a comprehensive evaluation of the use of health care services without relying on patient recall. However, there are some limitations. Our case-control design was nested within an established population based cohort with moderate to severe hip or knee OA; thus, cases and controls fulfilled the same inclusion/exclusion criteria at baseline inclusion in the cohort, as noted. However, our

previous work has shown that many factors impact likelihood of receipt of TJA among people with advanced hip/knee arthritis, including age, level of education, comorbidity, arthritis severity, and preference for or willingness to consider TJA.[29] The latter has been shown to be related to individuals' perceptions of TJA indications, risks and benefits, which in turn relate strongly to their socio-demographic characteristics.[30] Although cases and controls were matched for most of these factors, they were not matched on preferences for care, which may influence health care utilization. However, we would not expect preferences for care to have a significant impact on changes in costs over time for cases or controls, and thus our comparison of pre/post changes in costs for these 2 groups. There has been criticism of surgical studies in which the pain and functioning benefits of TJA have been based on postoperative patient reports to the surgeon, because of concerns about social desirability bias.[31] As interviews in the current study were conducted independent of the TJA by a trained, nonphysician interviewer as part of a longitudinal arthritis cohort study, we believe the likelihood of such a bias is low. Certain health care system costs are not captured by the administrative databases, including the cost of outpatient physiotherapy (physiotherapy provided in the context of post-TJA rehabilitation was included), and the cost of services provided by non fee-for-service physicians. If use of such services was also reduced as a result of TJA, then our results underestimate the cost-savings associated with TJA. We considered only direct costs to the health care system, not costs incurred by the patient. Previous research by our group and others has demonstrated that indirect and out-of-pocket costs incurred by OA patients are substantial,[32] even exceeding direct health care costs among patients on waiting lists for TJA.[33] Although we were able to evaluate pre/post surgery cost differences for all case-control pairs, we did not have interview data, and thus WOMAC and SF-36 scores, for over a third of the sample for the postsurgery time period. Although nonparticipants were older, there was no evidence that they differed in other respects (health, disability, function, income, or education). Nor was there any evidence that age, the factor associated with missing data, was related to either the unadjusted or adjusted pre/post changes in WOMAC or SF-36 scores. Thus, it is unlikely that our results represent an overestimate of the benefits of surgery. Our analyses focused on average rather than actual costs. Cases and controls were matched for number but not severity of comorbidities. It is possible that controls included individuals who were deemed ineligible for surgery based on the severity of their other medical problems. If so, this would affect our estimates of total health care costs, increasing the potential to detect a benefit for surgery. However, this should not impact our assessment of arthritis-attributable costs. We excluded as cases and controls those who died during the follow-up period; this may have resulted in over- and/or under-estimation of the impact of TJA on costs. Finally, patterns of use of health care services in Canada, and their associated costs, may have changed over time and may differ from those in other health care jurisdictions, potentially limiting the generalizability of our findings.

CONCLUSION

In this population-based study, comparing pre- and post-TJA direct health care utilization costs for community-living individuals with disabling hip and knee arthritis, a single primary hip or knee replacement surgery significantly improved arthritis pain and disability and reduced associated arthritis-attributable health care costs. In comparison, over the same time period, matched hip/knee arthritis controls experienced worsening of their arthritis and no change or increases in their arthritis health care use. Identification of factors that predict changes in costs and benefits following TJA, such as demographics, health status, and disease severity, would be useful in identifying subgroups of the population for whom TJA results in greatest cost savings. An examination of costs from a societal perspective, as well as consideration of improvements to quality of life, will round out the assessment of the overall costs and benefits of TJA.

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