Introduction

Hip and knee replacement procedures are a treatment option for patients experiencing severe pain and limited mobility, usually associated with arthritis or another joint disorder. During the surgery, an artificial joint replaces the damaged joint. Since the procedure was first introduced in the late 1950s and popularized in the early 1980s, many studies have found it to be a relatively low-risk procedure, often resulting in considerable improvement in a patient’s functional status and quality of life.

In 2004, Canada’s first ministers identified joint replacement as a priority for wait time reduction, along with cancer, heart surgery, sight restoration and diagnostic imaging. Waits for joint replacement surgery are among the longest across the five priority areas. One strategy being pursued to improve access and reduce wait times is to increase the number of procedures being done. In 2005–2006, the first fiscal year following the first ministers’ agreement, hip and knee replacements grew by 17%.

In addition to its prominence as a wait time priority area, joint replacement surgery has received considerable attention in policy, management and clinical circles for several reasons:

- **Frequently performed surgery.** Hip and knee replacements are among the most common elective surgeries performed in the country.

- **Resource-intensive procedure.** Joint replacements are major surgery, typically involving hospital stays of six to eight days. Average hospital costs for the procedure are more than $9,000 for unilateral hip replacements and more than $8,000 for unilateral knee replacements.

- **Growing and changing utilization.** Recent data from the Canadian Institute for Health Information (CIHI) show that the number of joint replacement procedures performed in Canada has doubled over the past 10 years. Some of this growth may be associated with people living longer and an increasing prevalence of arthritis as the population ages. Another factor is changing indications for surgery. For example, while total knee replacement rates have increased for all age groups, rates grew much more quickly than the average for those aged 45 to 54, suggesting a shift in the types of patients receiving surgery. Yet another factor influencing growth may be the designation of joint replacement as a wait time priority area.
Study Approach

While most joint replacements are performed without complication, there are some risks, and outcomes vary from patient to patient. In light of the rapid increase in joint replacement surgeries, the predominately elective nature of the procedure, and the high cost of surgery, it is helpful to examine some of the consequences of joint replacements and understand their implication on costs in the hospital system. Assessing patient outcomes, such as complications and readmissions, can provide important insights into quality of care for patients. It may also suggest opportunities to reduce health system costs and improve both hospital and surgeon availability for other patients who need care.

The study looked at three questions:

• Part 1: How many joint replacement patients are hospitalized in the year after their surgery (excluding admissions for another primary joint replacement)? How does this compare with the experience of the same group in the year before surgery?
• Part 2: Of the hospitalizations in the year following surgery, what proportion is related to infection or early revision?
• Part 3: What are the resource implications of any “extra” hospital use?

Analysis of CIHI’s Discharge Abstract Database (DAD) showed that more than 65,000 hip and knee replacement patients were discharged from Canadian acute care hospitals outside of Quebec in 2005–2006. Most were hospitalized for a primary (or first) joint replacement, while about 5,000 were hospitalized for a revision of a joint replacement done in a previous admission. Because revisions are more complex surgery and typically have a greater likelihood of complications, only patients with primary joint replacements were considered.9 Some patients had more than one hospitalization for a primary procedure in 2005–2006. For each patient, the first primary joint replacement was selected as the index procedure, leaving a total of 58,351 hip and knee replacement patients in the study group. Overall, 54% of the study group patients had a knee replacement and 34% had a hip replacement not related to hip fracture. These groups together are referred to as “elective.” Those who had a hip replacement following a hip fracture constituted 13% of the study group and are referred to as “emergency.”

The study group included both partial and total joint replacements. Total hip, total knee and partial knee replacements are primarily performed to treat arthritis and other forms of cartilage damage. Partial hip replacements are primarily performed to repair hip fractures. Most elective hips (97%) in the study group had a total joint replacement, while most emergency hips (81%) had a partial joint procedure. Additional details on the study approach can be found in Appendix A.

---
i. Due to differences in the specificity of classifications systems used in Quebec, we were unable to conduct the analysis in a similar fashion.
Figure 1  Distribution of Study Group Patients by Joint and by Type of Surgery

Patients in study group
58,351

Hip replacements

26,978

Total
20,537

Partial
6,441

Emergency
1,423

Elective
19,114

Knee replacements

31,373

Total
28,891

Partial
2,482

Emergency
5,899

Elective
542

Source
Discharge Abstract Database, 2005–2006, Canadian Institute for Health Information.
Part 1: Hospitalizations Following Surgery

While the positive outcomes of joint replacement surgery in reducing pain and improving function are well documented, there is more limited research on whether the surgery reduces patients’ need for hospitalization following surgery. To address this question, we looked at the number of patients hospitalized at least once in the year following their surgery. Hospitalizations for any reason other than a second primary joint replacement were considered (see sidebar). It was difficult to find an appropriate procedure with which to compare post-surgery hospitalization rates. Instead, hospitalizations following joint replacements were compared to the experience of the same group in the year before surgery. Results for elective and emergency patients are presented separately, as different patterns emerged for the two groups.

Elective Patients

More than 7,700 people, or 15% of elective hip and knee replacement patients, were hospitalized at least once in the year after surgery. As has been reported in other studies, those with diabetes (19%) and patients older than 80 (22%) are more likely to be readmitted.11, 12 Of the 15% of patients who were hospitalized, most (80%) were hospitalized once in the year following surgery, 14% were hospitalized twice and the remaining 6% were hospitalized three or more times.

The post-surgical hospitalizations represent a change in hospital use relative to the experience of the same patient group in the year before surgery:

- 2,038 more patients (4% of all joint replacements, a 36% increase over the year before) were hospitalized at least once in the year following surgery than in the year before surgery.
- Hospitalizations occurring in the year after the initial surgery accounted for more than 94,000 hospital days. This represents an increase of over 44,000 hospital days (88%) when compared to the hospital days used by the same group of patients in the year before surgery.

Behind the Hospitalization Data

Two important steps were taken to improve the usefulness of the analysis:

Hospitalizations for additional primary joint replacements excluded: Due in part to additional wait times funding, there was a sharp increase in the number of joint replacements performed in 2005–2006 compared to the previous year. Of the 58,351 patients included in this study, 5,435 (9%) were admitted to hospital at least once in the 365 days after the index procedure to have another primary procedure. This is more than twice as many joint replacements as the same group of patients had in the year before their index procedure. To improve comparison between pre- and post-surgery hospitalizations, other admissions for primary joint procedures were excluded from the analysis.

Transfers treated as a single hospitalization: If a patient had surgery at one hospital and was transferred to another acute facility for further treatment or for recuperation, this was treated as a single hospitalization. The same “episode of care” approach was used to count all hospitalizations (either before or after the initial surgery).
The top two diagnoses for elective patients hospitalized at least once in the year after surgery are *complications of internal orthopedic device* and *complication of procedure*. These diagnoses accounted for 18% of hospitalizations in the year following surgery.

Table 1  Comparison of Hospitalization Patterns Before and After Surgery for Elective Primary Hip and Knee Replacements in 2005–2006

<table>
<thead>
<tr>
<th>Elective Patients (n = 51,029)</th>
<th>Hospitalizations in Year Before Surgery</th>
<th>Hospitalizations in Year After Surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients hospitalized at least once</td>
<td>5,732 (11% of patients affected)</td>
<td>7,770 (15% of patients affected)</td>
</tr>
<tr>
<td></td>
<td>Total hip: 2,365</td>
<td>Total hip: 2,769</td>
</tr>
<tr>
<td></td>
<td>Partial hip: 166</td>
<td>Partial hip: 148</td>
</tr>
<tr>
<td></td>
<td>Total knee: 2,971</td>
<td>Total knee: 4,551</td>
</tr>
<tr>
<td></td>
<td>Partial knee: 221</td>
<td>Partial knee: 302</td>
</tr>
<tr>
<td>Inpatient days</td>
<td>50,080</td>
<td>94,302</td>
</tr>
</tbody>
</table>

Top 5 reasons for hospitalization:
1. Persons encountering health service for specific procedures, not carried out (6%)
2. Complications of internal orthopedic device (3%)
3. Fracture of the femur (3%)
4. Chronic ischemic heart disease (2%)
5. Pain in throat and chest (2%)

1. Complication of internal orthopedic device (13%)
2. Complication of procedure (5%)
3. Heart failure (2%)
4. Acute myocardial infarction (heart attack) (2%)
5. Atrial fibrillation and flutter (2%)

Note
Hospitalizations exclude other primary joint replacements.

Source

Elective Patients: Reasons for Hospitalization Before Surgery

For elective patients, the top reasons for hospitalization in the year prior to joint replacement contain some diagnoses that at first glance are unexpected:

- The top diagnosis for elective patients, *Persons encountering health service for specific procedures, not carried out*, occurred in 459 hospitalizations. It may be related to patients who were booked for joint replacement surgery but had the procedure cancelled.
- *Complications of internal orthopedic device* was the most responsible diagnosis in 256 hospitalizations, even though hospitalizations for primary replacements (other than the index procedure) were excluded from the analysis. Those experiencing these complications may include patients who had joint replacement surgery performed before the one-year cut-off; hip fracture patients who experienced problems after having their hips pinned; or those with complications related to a revision (rather than primary) surgery.
• Fracture of the femur is the third most frequent diagnosis among elective patients, occurring in 215 hospitalizations. Most of these patients went on to have a knee replacement or a replacement of the other hip as their index procedure. Fracture of the femur remains a significant reason for hospitalization after surgery (170 hospitalizations, or 2%), although it drops below the top five.

Emergency Patients

Patients who had a hip replacement following a hip fracture (emergency patients) were heavier users of hospital services and did not show a substantial change in that usage after surgery when compared with before surgery (see Table 2).

Table 2  Comparison of Hospitalization Patterns Before and After Surgery for Emergency Primary Hip Replacements in 2005–2006

<table>
<thead>
<tr>
<th>Emergency Patients (n = 7,322)</th>
<th>Hospitalizations in Year Before Surgery</th>
<th>Hospitalizations in Year After Surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients hospitalized at least once</td>
<td>1,957 (27% of patients affected)</td>
<td>2,033 (28% of patients affected)</td>
</tr>
<tr>
<td></td>
<td>Total joint: 344</td>
<td>Total joint: 386</td>
</tr>
<tr>
<td></td>
<td>Partial joint: 1,613</td>
<td>Partial joint: 1,647</td>
</tr>
<tr>
<td>Inpatient days</td>
<td>42,672</td>
<td>41,033</td>
</tr>
<tr>
<td>Top 5 reasons for hospitalization</td>
<td>1. Chronic Obstructive Pulmonary Disease (6%)</td>
<td>1. Complications of internal orthopedic device (6%)</td>
</tr>
<tr>
<td></td>
<td>2. Heart failure (5%)</td>
<td>2. Heart failure (6%)</td>
</tr>
<tr>
<td></td>
<td>3. Pneumonia (3%)</td>
<td>3. Chronic Obstructive Pulmonary Disease (5%)</td>
</tr>
<tr>
<td></td>
<td>4. Fracture of the femur (3%)</td>
<td>4. Pneumonia (5%)</td>
</tr>
<tr>
<td></td>
<td>5. Acute myocardial infarction (heart attack) (2%)</td>
<td>5. Fracture of the femur (4%)</td>
</tr>
</tbody>
</table>

Note
Hospitalizations exclude other primary joint replacements.

Source

The tables above show that there are substantial differences in the patterns of hospitalization for elective patients and emergency patients. Additional analysis in this section to understand patterns of hospitalization both before and after surgery focuses on the elective population only (88% of all cases).
Hospitalizations for Conditions Associated With Post-Surgical Complications—Elective Patients

The literature suggests that a variety of post-surgical complications are associated with joint replacement, including wound-healing problems, wound and deep-tissue infection, deep vein thrombosis and pulmonary embolism, pneumonia, heart attack, joint fracture or instability, and nerve and vascular injuries. Some, but not all, of these potential conditions can be identified through administrative data. Table 3 outlines the hospitalizations for specific conditions both before and after elective surgery. It is not possible to attribute these conditions directly to the elective joint replacement, but in many cases hospitalizations are higher in the year following surgery than in the preceding year.

Table 3 Patients Hospitalized in the Year Before and After Elective Joint Replacement Surgery, Selected Diagnoses

<table>
<thead>
<tr>
<th>Most Responsible Diagnosis</th>
<th>Year Before Surgery</th>
<th>Year After Surgery **</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complications of internal orthopedic prosthetic devices, implants and grafts (includes some deep infection)*</td>
<td>225</td>
<td>1,187</td>
</tr>
<tr>
<td>Complications of procedures, not elsewhere classified (includes some wound infection)*</td>
<td>107</td>
<td>520</td>
</tr>
<tr>
<td>Acute myocardial infarction (heart attack)*</td>
<td>115</td>
<td>209</td>
</tr>
<tr>
<td>Fracture of the femur</td>
<td>213</td>
<td>168</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>121</td>
<td>156</td>
</tr>
<tr>
<td>Pulmonary embolism*</td>
<td>31</td>
<td>134</td>
</tr>
<tr>
<td>Deep vein thrombosis*</td>
<td>18</td>
<td>72</td>
</tr>
</tbody>
</table>

Notes
* Statistically significant change from year before (p<0.0001).
** Hospitalizations considered include only those after the initial episode of care. Some patients may have been diagnosed with the listed conditions during the same hospitalization as their initial surgery. As a result, the data provided cannot be used to determine post-procedural rates of the selected conditions.

Source
Factors Influencing Changes Between Pre- and Post-Surgery Hospitalization Patterns—Elective Patients

Overall, 2,038 more elective patients were hospitalized at least once in the year after surgery than in the year before surgery. A number of factors, including the joint involved, age, diabetes comorbidity and gender, were examined to see whether they were associated with larger or smaller increases in hospitalizations. Gender and diabetes comorbidity did not show a strong association. The findings related to type of surgery and age group may suggest areas of focus in reducing post-surgical hospitalization rates.

- **Hip or knee surgery.** A similar percentage of elective knee and hip patients were hospitalized in the year after surgery (15%). However, this represented a bigger change in hospitalization patterns for knee replacement patients than for hip replacement patients: 52% more knee replacement patients were hospitalized in the year after surgery than in the year before. For elective hip patients, this increase was only 15%.

- **Patient age.** Joint replacements are most frequently performed on patients aged 50 to 79. Over the past 10 years, there has been a significant increase in surgeries for those younger and older than the traditional age group. The proportion of patients hospitalized in the year following surgery increased with age. However, both the youngest (+ 15%) and oldest (+ 32%) age groups experienced a smaller increase in patients hospitalized when compared with the more traditional 50 to 79 age group (+ 38%).

Table 4 Patients Hospitalized Before and After Elective Joint Replacement

<table>
<thead>
<tr>
<th>Patient Sub-Group</th>
<th>Patients Hospitalized in Year Before Surgery</th>
<th>Patients Hospitalized in Year After Surgery</th>
<th>Percent Change</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of surgery</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knee replacement</td>
<td>3,192</td>
<td>4,853</td>
<td>+ 52%</td>
</tr>
<tr>
<td>Hip replacement</td>
<td>2,531</td>
<td>2,917</td>
<td>+ 15%</td>
</tr>
<tr>
<td><strong>Age group</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 50</td>
<td>323</td>
<td>371</td>
<td>+ 15%</td>
</tr>
<tr>
<td>50–79</td>
<td>4,278</td>
<td>5,917</td>
<td>+ 38%</td>
</tr>
<tr>
<td>80 +</td>
<td>1,122</td>
<td>1,482</td>
<td>+ 32%</td>
</tr>
</tbody>
</table>

Source
Part 2: Unfavourable Outcomes—Revisions and Infections Within One Year of Surgery

As with all major surgeries, complications can occur. Various studies have found that patient-related factors, such as diabetes, rheumatoid arthritis, obesity and others can increase the likelihood of complications following joint replacement surgery. However, experts also suggest that complications that occur shortly after the initial procedure, such as revisions or infections within one year, may be related to the quality of care received at the time of surgery.13, 14, 15 Data in this section look at the experience of both elective and emergency patients.

Revisions Within One Year

A 2003 review of predominately North American knee replacement research showed that 90% of prostheses last more than 10 years, and 80% last more than 20 years.2 However, some joint replacements can fail over time and require a second surgery, or revision. A previous CIHI study looked at reasons for revisions within about two years of the initial surgery, as reported in the Canadian Joint Replacement Registry. Top reasons for revisions identified in that analysis were instability, aseptic loosening, infection and bone or implant fracture.16 Patients who experience these difficulties may require a revision much sooner than the typical patient. Of the 58,351 patients in this study, 756 (1.3%) had at least one revision within a year of their primary joint replacement.ii The rate of revision within one year was higher for emergency patients (2.0%) than for elective patients (1.2%). Within the elective group, hips (1.7%) had a higher revision rate than knees (0.9%). Mechanical complications were the most common reason for revision in hip replacement patients, affecting about 4 in 10 of both elective and emergency cases. For those undergoing revision of a knee replacement, infection was the most common reason for revision within one year, affecting 38% of patients.

Infections Within One Year

Infections are a complication sometimes associated with joint replacement surgery. Although relatively uncommon, they have serious consequences and may ultimately result in the removal of the implanted joint.9, 17 In our analysis, we looked only at infection of the joint, omitting generalized infections (such as fever) and wound infections. Of the 58,351 people in the study group, 780 (1.3%) were diagnosed with infection in the joint. This reflects only patients who were hospitalized with complications and does not include patients with infections who were being managed at home or in other settings. Infection data include patients whose infection occurred at any time in

---

ii. These data exclude 24 patients (20 elective and 4 emergent) who had a revision in the same operative episode as their index joint replacement. Revisions included a replacement of components or the insertion of a cement spacer (the first step in a two-step revision).
the year following surgery, including possibly after a revision surgery. There was no significant difference in the infection rates between elective and emergency patients.

Men (1.6%) were more likely than women (1.2%) to have a post-surgical hospitalization for infection, and patients with diabetes documented as a comorbidity at the time of the index procedure had a higher rate of infections (2.2%) than those without diabetes. The analysis did not find any significant association between hospitalizations for infection and the joint replaced (hip or knee). Likewise, infection rates did not vary significantly by age. Patients hospitalized for infection spent on average twice as long in hospital when compared with those admitted for other reasons following surgery.

Of the 780 patients hospitalized at least once with joint infection, 200 patients then had a revision within a year of their primary procedure. Figure 2 shows the relationship between early revision and infection. Overall, about 1 in 4 patients diagnosed with a joint infection have a revision within the year. This number is similar for both elective and emergent patients. For elective patients with infection, none of the factors investigated (including age, joint [hip or knee], type of surgery [partial/total], and presence of diabetic comorbidity) was associated with a higher rate of revision.

**Figure 2** Hospitalizations for Revisions and Infections Within One Year of Surgery

![Diagram showing the relationship between revisions and infections](image)

**Notes**
Includes emergency and elective patients (n = 58,351).
Infection data include patients whose infection occurred at any time in the year following surgery, including possibly after a revision surgery.

**Source**
Part 3: Resource Use—Elective Patients Only

There are a variety of approaches to assess the increased resource utilization associated with hospitalizations following joint replacements. Joint replacement surgery has average acute care costs for typical patients of between $8,000 for unilateral knee replacements and $9,000 for unilateral hip procedures.iii For some patients, hospitalizations (and associated hospital costs) do not end with the initial surgery. While it is difficult to establish a comprehensive picture of hospital costs incurred by joint replacement patients with complications, some components are easier to quantify. For example, we can look at “additional days” used by joint replacement patients in the year after surgery compared to the year before. In this study, elective patients used approximately 44,000 more hospital days in the year after surgery than in the prior year. The additional hospital days result from both an increase in the number of hospitalizations (from 7,350 to 10,665) and an increase in the average length of stay (from 6.8 to 8.8 days). The “additional” hospital days represent the equivalent of more than 130 acute care beds (calculated at 90% occupancy).

A second option is to look at the change in weighted cases (as measured by Resource Intensity Weights, or RIWs) for elective patients hospitalized in the year before surgery compared to the year after surgery. A RIW is used to measure the resource consumption of an average patient within a similar patient group, called a Case Mix Group (CMG). Used in conjunction with cost per weighted case (that is, a measure of the average financial cost a facility incurs to treat a single inpatient), it is possible to estimate average patient costs for various procedures and/or conditions. Elective patients hospitalized in the year after surgery used almost 10,000 more weighted cases than those hospitalized in the year before surgery (11,184 RIW before; 21,169 RIW after). The 2005–2006 average cost per weighted case was approximately $4,500,18 excluding all physician costs (both salaries and fees-for-service). Based on the change in RIWs and the cost per weighted case, we can look at “extra” costs of acute inpatient hospitalizations for elective patients. The costs associated with additional hospitalizations in the year after elective joint replacement surgery are estimated to be in the range of $45 million in Canada outside Quebec.iv

Another approach is to focus on the costs associated with selected unfavourable outcomes, such as revisions within one year. Although these early revisions affect only a small group of patients, they represent a major hospital expense. Using Case Mix Groups, average costs can be examined separately for revisions with and without infection.7 The table below presents this information for elective patients only.

---

iii. Typical cases refer to patients who have undergone a normal and expected course of treatment. They exclude cases involving transfers between acute care facilities, deaths, sign outs and long-stay cases. All costs are rounded to the nearest thousand.

iv. Note that the estimate is based on a 2005–2006 cost per weighted case, even though some of the additional hospitalizations (and thus weighted cases) occurred in 2006–2007. 2006–2007 cost per weighted case data were not available at the time of publication.
### Table 5  
**Acute Inpatient Hospital Costs for Revisions Within One Year of Surgery—Elective Joint Replacement Patients**

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of Cases</th>
<th>Average Cost per Typical Patient</th>
<th>Total Acute Hospital Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revision with infection</td>
<td>158</td>
<td>$18,000</td>
<td>$2.8 million</td>
</tr>
<tr>
<td>Revision without infection</td>
<td>377</td>
<td>$11,000</td>
<td>$4.1 million</td>
</tr>
<tr>
<td>All revisions</td>
<td>535</td>
<td></td>
<td>$7.0 million</td>
</tr>
</tbody>
</table>

**Notes**

Acute hospital costs exclude physician costs.

Cost estimates are for revisions performed in a separate admission for revision surgery within the year, and do not include the 74 elective patients who had a revision within their initial hospitalization.

**Source**


Other costs associated with complications of joint replacement surgery may include rehabilitation, home care, physician office visits, hospital clinic and emergency department use, and prescription drug costs.

### Conclusion

Hip and knee replacements are a large and rapidly growing type of surgery in Canada. While the literature has demonstrated the procedure to be largely effective, 15% of elective hip and knee patients are hospitalized again in the year following their surgery, for a reason other than another primary joint procedure. Not all of these hospitalizations can be associated with the surgery, but elective patients are more likely to be hospitalized in the year following surgery than in the year before. These patients used an additional 44,000 hospital days and an estimated $45 million dollars in acute inpatient hospital costs (excluding physician costs). This increase is most dramatic for knee replacement patients, where there was a 52% increase in the patients hospitalized at least once in the year after surgery relative to the year before. By contrast, patients who had a hip replacement following a hip fracture (emergency patients) did not show a substantial change in hospital use after surgery when compared with before surgery.

Some patients experienced negative outcomes that experts have suggested may be associated with the quality of care provided at the initial surgery. Overall, 1.3% of patients were diagnosed with an infection of the joint, which often has serious consequences and may ultimately result in the removal of the implanted joint. A similar percentage of patients had a revision of their initial surgery within one year. Infection rates did not vary by the joint involved (hip or knee), but revision rates did—hip replacement patients were more likely to require an early revision.
This study provides new information on the number and profile of patients who are hospitalized after joint replacement, as well as cost estimates for the additional acute inpatient hospitalizations. The full effect of the growing number of joint replacement surgeries on hospital use can provide important insights into quality of care for patients, as well as assist system managers to identify opportunities to reduce health system costs and improve both hospital and surgeon availability for other patients waiting for care. Additional systematic research that would improve understanding of patterns and modifiable risks would be useful and important.

Acknowledgements

CIHI would like to acknowledge and thank the many individuals who have contributed to the development of this analysis, including Jennifer Frood, Thi Ho, Jin Huang, Tracy Johnson, Jenny Lineker, Maraki Merid and Kathleen Morris.

We would also like to thank external advisors Dr. Michael Dunbar and Dr. Eric Bohm who contributed to the project concept and reviewed preliminary results.
Appendix A—Study Approach

Data Sources and Limitations

Hospitalization data were obtained from CIHI’s Discharge Abstract Database (DAD). This database captures administrative, clinical and demographic information on patient events from acute care hospitals in Canada. Data from Quebec were not included due to differences in data collection methodology (diagnosis codes used in Quebec could not be mapped precisely to the ICD-10-CA codes used in the rest of the country. The diagnosis codes were required for analysis of hospitalizations data). Information on joint replacements from an Alberta facility not submitting to the DAD was provided by Alberta Health and Wellness.

In all cases, patients were selected based on operative procedures performed in acute facilities between April 1, 2005, and March 31, 2006. These patients and their procedures are the indices for the analyses.

Methodology

Intervention codes reported on the discharge abstract were used to identify index procedures. Records with a procedure in the 2005–2006 fiscal year and a CCI intervention code of joint replacement were included. A complete list of relevant intervention codes used is provided in Table A-1. Only primary joint replacements, as opposed to revisions, were considered eligible as an index procedure. Where a patient had more than one primary replacement in the fiscal year, the first replacement was considered the index procedure.

Table A-1 Joint Replacement Codes

<table>
<thead>
<tr>
<th>Procedure</th>
<th>CCI code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total knee replacement</td>
<td>1.VG.53.LA–1.VG.53.LA-PP</td>
</tr>
<tr>
<td>Partial knee replacement</td>
<td>1.VG.53.LA-PM</td>
</tr>
<tr>
<td>Total hip replacement</td>
<td>1.VA.53.LA-PN–1.VA.53.PN-PN</td>
</tr>
<tr>
<td>Partial hip replacement</td>
<td>1.VA.53.LA-PM–1.VA.53.PN-PM</td>
</tr>
</tbody>
</table>

Discharges without a uniquely identifiable health card number (that is, health card number not submitted, out-of-country patients or patients under federal care) were excluded, as health card number was used to identify other hospitalizations for our sample patients occurring before and after the index procedure.

Index procedures were identified as either elective or emergent. A hip replacement was defined as emergent if a diagnosis of fractured femur (ICD-10: S72) prior to admit was present, or if a fracture occurred in hospital but was unrelated to a joint replacement.
(fractures related to joint replacement are coded ICD-10: M966, Y831). All knee replacements were considered elective. Characteristics of the patient, such as diagnosis of diabetes and age, were based on information recorded at the index hospitalization.

Due in part to additional wait times funding, there was a sharp increase in the number of joint replacements performed in 2005–2006 compared to the previous year. To improve comparisons between pre- and post-surgery hospitalizations, admissions for primary joint procedures other than the index procedure were excluded from the analysis. Remaining admissions for index patients for the 365 days preceding and following surgery were analyzed for patterns of general hospital resource use.

To reflect the fact that some joint replacement patients are transferred from one facility to another, episode building techniques were employed. An episode of care extends from the time the patient is admitted to an acute facility through transfers and ends when the patient is discharged from an acute facility. A visit was considered a transfer if a) a transfer to/from an acute facility was indicated in the readmit or in the previous discharge or b) admission to an acute care hospital occurred 12 hours prior to the previous acute care discharge.

Reason for hospitalization, or most responsible diagnosis, is documented at every hospital admission. The first three digits of the ICD-10 code recorded were used to compile the most common reasons for hospitalizations. Where transfers occurred, reason for hospitalization was based on the first record of each episode of care.

The time to readmit was defined as the time from final discharge where transfers were involved to the next readmit date. Only readmits that occurred within 365 days of discharge from index hospitalization were retained for the purposes of these analyses.

Patients hospitalized at least once for selected conditions were analyzed. Conditions were selected using the following codes in the most responsible diagnosis (MRDx).

Table A-2  Codes for Selected Conditions Reported in Table 3

<table>
<thead>
<tr>
<th>Most Responsible Diagnosis</th>
<th>ICD-10 code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complications of internal orthopedic prosthetic devices, implants and grafts (includes deep infection and dislocation)</td>
<td>T84</td>
</tr>
<tr>
<td>Complications of procedures, not elsewhere classified (includes some wound infection)</td>
<td>T81</td>
</tr>
<tr>
<td>Acute myocardial infarction (heart attack)</td>
<td>I21</td>
</tr>
<tr>
<td>Fracture of the femur</td>
<td>S72</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>J18 or J95.88 as most responsible and J18.9 as a type 3 diagnosis</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>I26</td>
</tr>
<tr>
<td>Deep vein thrombosis</td>
<td>I80</td>
</tr>
</tbody>
</table>
Revisions of a joint replacement and joint replacement-related infections were outcomes of particular interest. The study looked at revisions that occurred within 365 days of the index surgical episode. Some revisions occurred in the same hospitalization (episode of care) as the index procedure, while others occurred in a separate hospitalization. Revisions that occurred within the same surgical episode as the index procedure were excluded (n = 24). Revisions were identified using CCI codes identified in Table A-1 with a status of revision or cement spacers (1.VG.53.LA-SL-N and 1.VA.53.LA-SL-N), which was considered the first step in a two-step revision. Time from the index procedure to the revision was calculated using dates of surgical episodes.

Infections were identified by ICD-10 diagnostic codes at any point in the hospitalization (ICD-10: M00, M86, T84.5, T84.6). These infections were specific to joints and did not include general infections or infections specific to the surgical wound. A patient was considered to have an infection if the infection occurred during or within 365 days of the index procedure.

For reasons for revision, other than infection, diagnostic information documented at time of revision was used to categorize revisions into mechanical complications (ICD-10: T8403, T8404, T8413), complications involving bone (ICD-10: S72, Z50, M966) or other complications.

The costs associated with additional hospitalization of elective patients before and after the index procedure was estimated by summing the Resource Intensity Weights (RIWs) for each index patient’s hospitalizations (other than those associated with other primary joint replacement procedures) in both the year before and the year after the index surgery. An RIW is used to measure the resource consumption of an average patient within a similar patient group, called a Case Mix Group (CMG). The difference in RIW values was multiplied by the average cost per weighted case. The 2005–2006 average cost per weighted case was approximately $4,500, excluding all physician costs (both salaries and fees-for-service). Note that the estimate is based on a 2005–2006 cost per weighted case, even though some of the additional hospitalizations (and thus weighted cases) occurred in 2006–2007. 2006–2007 cost per weighted case data were not available at the time of publication.

Costs for revision surgery were calculated using Case Mix Groups 316, 317, 318 and 319 from the CMG+ methodology. The costs used were average costs for typical patients in 2005–2006. Custom analysis was conducted to arrive at a weighted average cost for CMGs 316 and 318 (with infection) and 317 and 319 (without infection).
References


