Hip and Knee Replacements in Canada

2007 Annual Report

Canadian Joint Replacement Registry (CJRR)

Canadian Institute for Health Information
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Acknowledgements

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CJRR Advisory Committee:

- Dr. Robert Bourne (Co-Chair), London Health Sciences Centre, Ontario
- Dr. Eric R. Bohm (Co-Chair), University of Manitoba Joint Replacement Group, Manitoba
- Dr. Michael Dunbar (Co-Chair), Queen Elizabeth II Health Sciences Centre, Nova Scotia
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Executive Summary

The purpose of the *Canadian Joint Replacement Registry (CJRR) 2007 Annual Report on Hip and Knee Replacements in Canada* is to characterize hip and knee replacement procedures performed in Canada according to their epidemiology and by selected clinical and surgical parameters.

Hip and knee replacement procedures are undertaken as a treatment when patients are experiencing severe pain and limited mobility, usually associated with arthritis or another joint disorder. The surgery provides a successful, relatively low-risk intervention that can provide significant pain and disability relief by enabling the new joint to move normally. This usually results in considerable improvement in a patient's functional status and quality of life. For 2005–2006, there were 68,746 hospitalizations for hip (28,045) and knee (40,701) arthoplasty performed in Canada, representing a 10-year increase of 101%, and a 17% annual increase. Generally, patients undergoing hip replacement had longer hospital stays than those undergoing knee replacement, while length of stay for both procedures has decreased considerably over the last decade.

Arthritis and other joint disorders are correlated with advancing age, and so an aging population contributes to an increase in hip and knee replacement procedures. The majority of Canadians receiving a joint replacement in 2005–2006 were 65 years of age or older (63% for hip and 66% for knee). When age–sex specific rates for joint replacements are examined, the most notable increases for knee replacement in the last decade have occurred in the 45-to-54-year age group (tripled for males, and more than tripled for females). For hip replacement procedures, the greatest increase was also seen in the 45-to-54-year age group, with a 68% increase for males and 52% increase for females over the last decade.

Joint replacement procedures are one of the five priority areas targeted federally for meaningful reductions in wait times. As a mechanism to inform these efforts, as of April 1, 2005, CJRR began collecting data related to wait times as part of a broader CIHI initiative to collect and report on national wait time data. This year's publication reports on this information for the first time. Analysis shows that wait times for hip replacements (median wait of 127 days) were significantly shorter than for knee replacements (median wait of 182 days). Wait times for hip and knee replacement revisions were significantly shorter than for primary hip and knee replacements.

In addition, new technologies are emerging in the surgical treatment of arthritis and arthritis-related disorders. These factors will likely increase the demand for surgery in the coming years. This year, CJRR has introduced a special focused chapter in the annual report; the focus of this year's chapter is on one of these emerging technologies: *minimally invasive surgery*. The findings reported here set the framework for further research in the area. The procedure is an emerging one and so is not used frequently (10% of joint replacement cases in the CJRR reported use of minimally invasive surgery); however, over the last three years, the number of hip and knee procedures performed through minimally invasive techniques has increased by 1.7 times, with the odds of undergoing a minimally invasive procedure being significantly higher in an urban centre community.

Participation in the CJRR has been steadily increasing since orthopedic surgeons began submitting operative data in May 2001. As of April 2006, 70% of orthopedic surgeons performing hip and knee replacement surgery in Canada were participating in the registry. On average, CJRR now receives approximately 1,800 hip- and knee-replacement forms on a monthly basis from all provinces in Canada.

Methodology

Findings in this report were obtained from two sources: the Hospital Morbidity Database (HMDB) and the CJRR database, both of which are managed by the Canadian Institute for Health Information (CIHI).

The hospitalization statistics in this report are taken from the HMDB, while the surgical and orthopedic implant information is taken from the CJRR. Surgical and orthopedic implant data in this report are based on a total of 92,167 procedures that were submitted by surgeons participating in the CJRR for surgeries in fiscal years 2002–2003 through 2005–2006. The fiscal year is from April 1 through March 31.

All analyses were conducted using the SAS (version 9.1.3, Cary, NC, USA) statistical software package. A p value of <0.05 was used to assess statistical significance.

Printed copies of the 2007 report can be purchased through the CIHI Order Desk at www.cihi.ca. Electronic copies of the annual report, media release and recent bulletins can be downloaded free of charge from the CJRR website (www.cihi.ca/cjrr). Queries regarding this report may be sent to cjrr@cihi.ca.

Introduction

Osteoarthritis (OA) and related conditions comprise a large group of disorders affecting the joints, ligaments, tendons, bones and other components of the musculoskeletal system. These conditions are highly prevalent and are major causes of morbidity, disability (loss of productivity of persons with illness), and health care utilization.[1]

Hip and knee replacements provide great success as treatment for arthritis; the procedures are a cost-effective means of improving quality of life by reducing chronic pain and increasing the ability to function independently.[1, 2] Hip replacement is a surgical option for nearly all individuals with disease of the hip that causes chronic discomfort and significant functional impairment.[3] Successful replacement of deteriorated, arthritic and severely injured hips has contributed to enhanced mobility and comfortable, independent living for many people who would otherwise be substantially disabled.[4] Knee replacement is a safe and cost-effective treatment for alleviating pain and restoring physical function in patients who do not respond to non-surgical therapies.[5, 6]

The purpose of this report is to characterize the epidemiologic characteristics of hip and knee replacement procedures performed in Canada, and to describe them according to person (patient demographics), place (provincial and national level data) and trends over time, by using selected clinical and surgical parameters.

About the Canadian Joint Replacement Registry

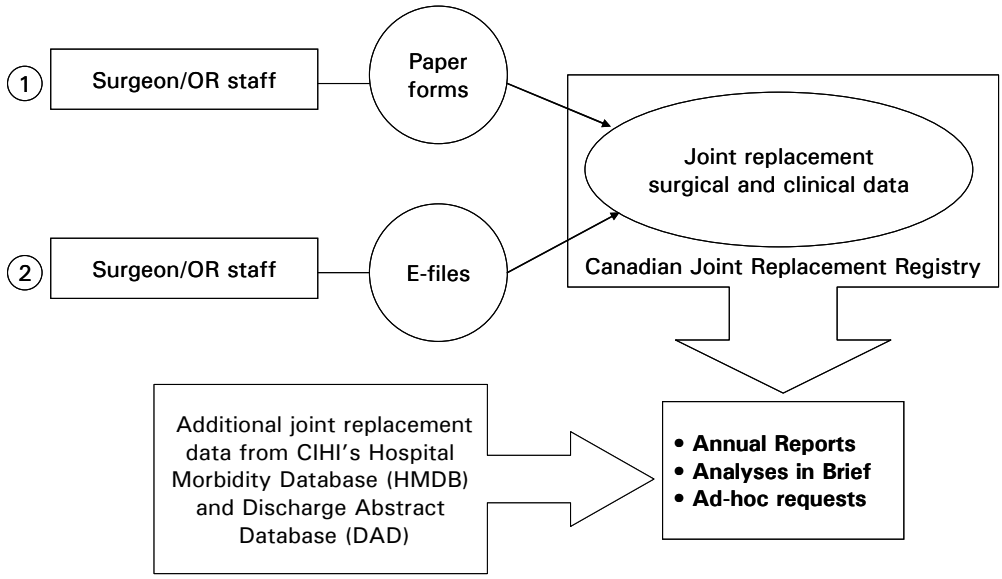
CIHI's Canadian Joint Replacement Registry (CJRR) serves as the country's leading source of information on hip and knee replacement surgeries. It captures national data on primary and revision hip and knee replacement surgeries, and patient outcomes over time. The goal of the CJRR is to improve the quality of care and clinical outcomes of joint replacement recipients.

The CJRR was developed through a joint effort between CIHI and the orthopedic surgeons of Canada. CIHI and orthopedic surgeons from each province who were working under the auspices of the Canadian Orthopaedic Association and the Canadian Orthopaedic Foundation upheld this initiative. A number of other key partners have contributed to the successful development and implementation of the CJRR including orthopedic patients; The Arthritis Society; and federal, provincial and territorial ministries of health.

Data Collection and Flow

The flow of data collection in the CJRR is shown in Figure 1. Data are currently obtained from either paper data collection forms or electronic file submissions.

Figure 1. Canadian Joint Replacement Registry (CJRR) Data Flow Diagram



Surgeons who contribute data directly to the CJRR submit via standardized paper data collection forms. Prior to surgery, patients are asked to provide signed consent to have their demographic and surgical information included in the CJRR. Once a patient's written consent is obtained, the surgeon and/or operating room staff completes a two-page data collection form. The data collection form captures patient demographics, clinical information and surgical information. The forms are couriered to CIHI in pre-paid and labeled envelopes.

Electronic data submission is another mode of transmitting data to the CJRR. In fiscal year 2005–2006, four facilities submitted data to CJRR electronically, which were then incorporated into the CJRR database.

Standardized edit checks are applied to all data submitted to the CJRR. These checks flag data elements that do not meet criteria for logic, value range and completeness. A record is classified as complete only if it successfully passes all edit checks. Erroneous data are referred back to their source for review and correction.

Privacy and Confidentiality

As custodian of numerous registries and databases, CIHI has stringent policies for ensuring that the privacy, confidentiality and security of its data holdings are protected. Information on CIHI's privacy and confidentiality policies and procedures are available on the CIHI website at www.cihi.ca. CJRR's Privacy Impact Assessment is also available on the website at www.cihi.ca/cjrr.

CJRR Surgeon Participation

CJRR is a voluntary registry, with surgeons participating from across Canada. Surgeons are considered to be "participating" if they have submitted data to, or registered with, the CJRR in fiscal years 2003–2004 through 2005–2006. This definition is the same as that used in the 2005 annual report, but different from reports prior to that.

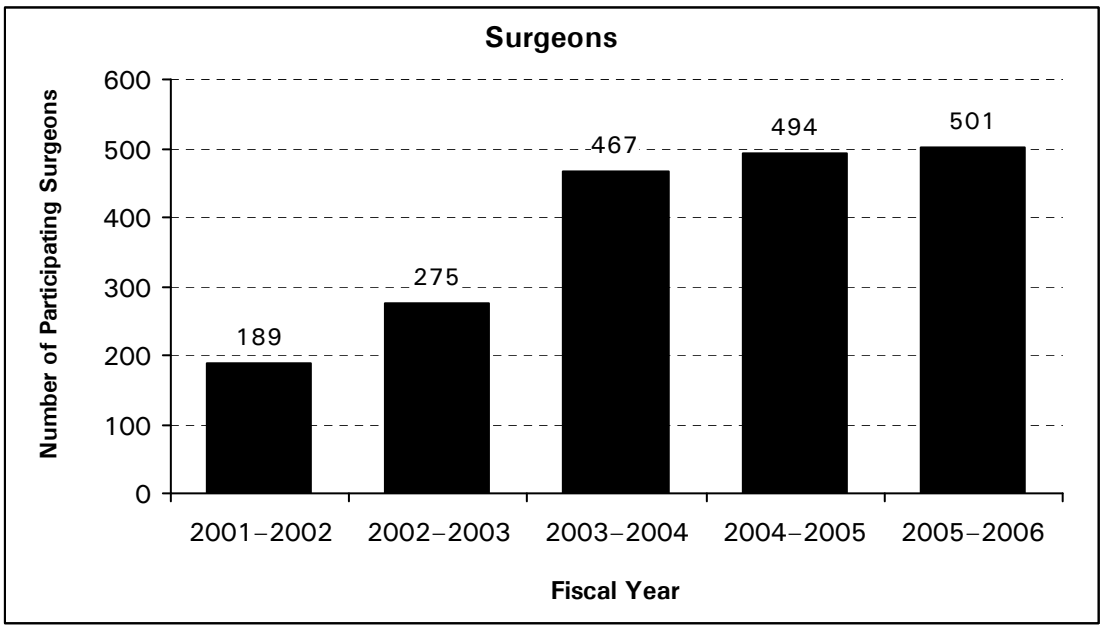
CJRR participation is tracked and reported as the percent of eligible surgeons who have agreed to submit data to the CJRR. Surgeons performing hip and knee replacements during the reporting period are considered eligible to participate in the CJRR. The CJRR team works with orthopedic surgeons across the country to identify and recruit eligible surgeons.

Participating surgeons earn Continuing Professional Development (CPD) credits by submitting operative data to the CJRR. Submission of six completed data collection forms to CIHI will earn each surgeon one credit under activities outlined in Section 6 (Educational Development, Teaching and Research) of the CPD Framework of the Maintenance of Certification Program. The CJRR team at CIHI provides surgeons with annual updates on the number of CPD credits earned through their participation in the CJRR.

Surgeon Participation Over Time

Data collection from surgeons began in May 2001. Figure 2 shows surgeon participation between fiscal years 2001–2002 and 2005–2006. During this time, the number of participating surgeons increased from 189 to 501 respectively, an increase of 165%.

Figure 2. Number of Participating Surgeons, 2001–2002 Through 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2001–2002 to 2005–2006.

Surgeon Participation by Province

Table 1 shows surgeon participation by province compared to the estimated number of surgeons performing hip and knee replacement procedures as of March 31, 2006. CJRR's overall participation rate was estimated at 70%. Provinces with the largest number of surgeons (Ontario, Quebec, British Columbia and Alberta) accounted for 77% of all CJRR participating surgeons. Participation rates by province and territory ranged from 33% in PEI to 100% in New Brunswick, Nova Scotia and Northwest Territories.

CJRR provincial representatives and many site leaders have been instrumental in promoting the benefits of the registry and, by extension, increasing surgeon participation and commitment for submitting operative data to the CJRR in their respective provinces.

Table 1. CJRR Surgeon Participation by Province/Territory as of March 31, 2006

Province	Number of Participating Surgeons	Number of Eligible Surgeons*	Percentage of Participation
Newfoundland and Labrador	12	15	80
Prince Edward Island	1	3	33
Nova Scotia	27	27	100
New Brunswick	27	27	100
Quebec	85	193	44
Ontario	193	241	80
Manitoba	22	24	92
Saskatchewan	22	24	92
Alberta	47	54	87
British Columbia	58	97	60
Yukon	0	0	N/A
Northwest Territories	2	2	100
Nunavut	0	0	N/A
Total	**496**	**707**	**70**

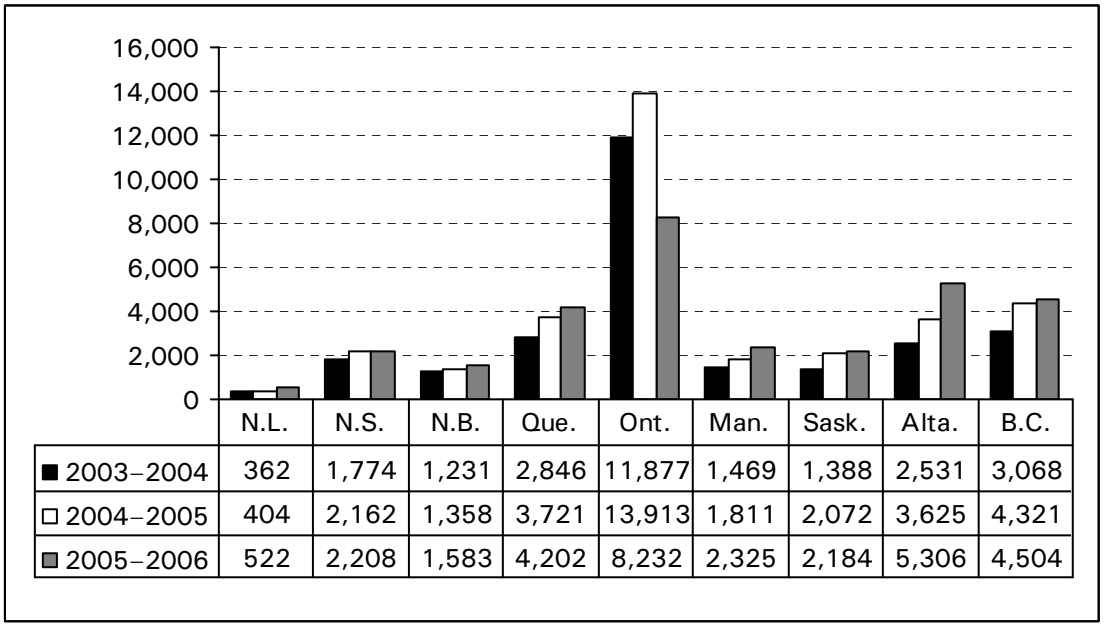
Note:

* To be eligible, the orthopedic surgeon must be actively performing hip or knee replacement surgery. Surgeons are deemed to be participating if they have submitted in 2003–2004 through 2005–2006 or signed up within the period. The number of eligible surgeons is based on reports from CJRR provincial representatives, and may not be exact.

Joint Replacement Cases Reported to CJRR

Figure 3 shows the changes in submission to CJRR during the past two years across different provinces and territories. From fiscal 2003 to 2005, the data submissions increased considerably for Alberta (+110%), Manitoba (+58%) and Quebec (+48%), followed by the rest of the provinces. Over the same period there was a 31% decrease for Ontario, largely related to a transition following the end of the Ontario Joint Replacement Registry (OJRR) in October 2005. Increased surgeon participation is a priority for the CJRR.

Figure 3. Hip and Knee Replacement Procedures Across Provinces 2003–2004, 2004–2005 and 2005–2006



	N.L.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.
■ 2003–2004	362	1,774	1,231	2,846	11,877	1,469	1,388	2,531	3,068
□ 2004–2005	404	2,162	1,358	3,721	13,913	1,811	2,072	3,625	4,321
■ 2005–2006	522	2,208	1,583	4,202	8,232	2,325	2,184	5,306	4,504

Note:
N.W.T., P.E.I. and Y.T. each had fewer than five surgeons submitting data to CJRR in 2005–2006.

Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2005–2006.

Methodological Notes

Data in this annual report are taken from two sources. The Hospitalization Statistics' section contains data from the Hospital Morbidity Database (HMDB), a national database that captures administrative, clinical and demographic information on hospital discharges, primarily from acute care Canadian facilities. Data in the Surgical and Clinical Characteristics' section come from the Canadian Joint Replacement Registry (CJRR), a national registry that collects information on primary and revision hip and knee replacement surgeries performed in Canada. The use of both databases provides a unique opportunity to look at hip and knee replacement procedures in Canada from administrative and clinical perspectives.

Appendices A and B provide the methodology used and methodological notes for both the Hospitalization Statistics and Surgical and Clinical Characteristics sections of the annual report. Appendix D provides the methodology used for the Focus on Minimally Invasive Surgery section of the annual report.

All analyses were conducted using the SAS (version 9.1.3, Cary, NC, USA) statistical software package. Additional methodological detail is found in Appendix A, Appendix B and Appendix D.

Hospitalization Statistics

Important Note: Analyses for this section are based on the HMDB and report fiscal year data (April 1 to March 31). Please refer to Appendix A for methodological detail pertaining to this database and these data.

This section provides information on hospitalization rates of Canadians who have undergone hip and knee replacements in 2005–2006, as well as information on historical trends at the national and provincial/territorial levels. In addition, it reports on patient province of residence as compared to province of treatment. Patient demographics, along with the hospitalization length of stay, are also included.

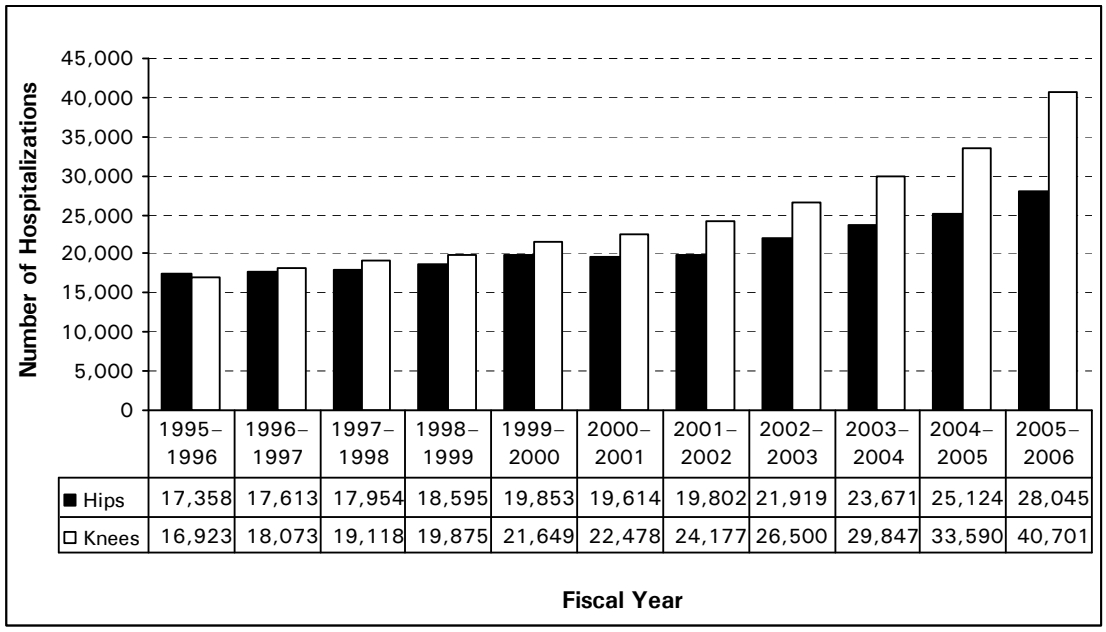
National Overview of Hip and Knee Replacements

There were 68,746 hospitalizations for hip and knee replacements in Canada on Canadian residents in 2005–2006, representing a 10-year increase of 101% from 34,281 procedures in 1995–1996 and a one-year increase of 17% from 58,714 procedures in 2004–2005. This one-year increase is larger than that observed in the last fiscal year (2004–2005), when the one year increase from the previous year was under 10% (9.7%).

In 1995–1996, the number of hip replacements exceeded the number of knee replacements in Canada (17,358 versus 16,923 surgeries, respectively). Since then, knee replacements have annually surpassed the number of hip replacements, and the gap has been steadily widening (Figure 4).

In 2005–2006, there were 40,701 hospitalizations for knee replacements and 28,045 hospitalizations for hip replacements. The number of knee replacements in 2005–2006 more than doubled since 1995–1996 (an increase of 140%), with a 21% increase compared to the previous year (2004–2005). The number of hip replacements, on the other hand, increased by 62% compared to 1995–1996, and by 12% compared to 2004–2005.

Figure 4. Number of Hospitalizations for Hip and Knee Replacement Procedures in Canada, 1995–1996 to 2005–2006



	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000	2000–2001	2001–2002	2002–2003	2003–2004	2004–2005	2005–2006
■ Hips	17,358	17,613	17,954	18,595	19,853	19,614	19,802	21,919	23,671	25,124	28,045
□ Knees	16,923	18,073	19,118	19,875	21,649	22,478	24,177	26,500	29,847	33,590	40,701

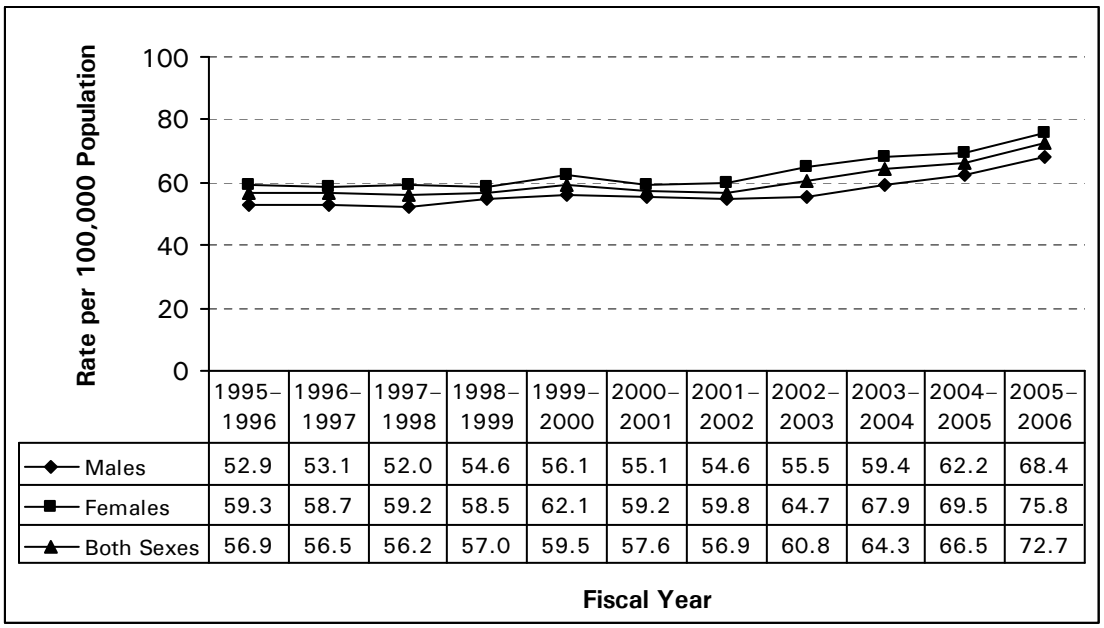
Source: Hospital Morbidity Database, Canadian Institute for Health Information, 1995–1996 to 2005–2006.

National Age Standardized Hospitalization Rates

Age-standardization is a common analytical technique used to compare rates over time, as it takes into account changes in age structure across populations and time. The age-standardized rates are reported per 100,000 of the population.

The age-standardized rate for hip replacement hospitalizations was 10.8% higher for females than for males (75.8 versus 68.4) (Figure 5). The hip replacement rate, regardless of sex, increased by 27.7 %: from 56.9 per 100,000 in 1995–1996 to 72.7% in 2005–2006. For males, the increase over the 10-year period was 29.3% (from 52.9 to 68.4 per 100,000). For females, the 10-year increase was 27.8% (59.3 to 75.8 per 100,000).

Figure 5. Age-Standardized Hospitalization Rates (per 100,000 Population) by Sex for Hip Replacement, in Canada, 1995–1996 to 2005–2006



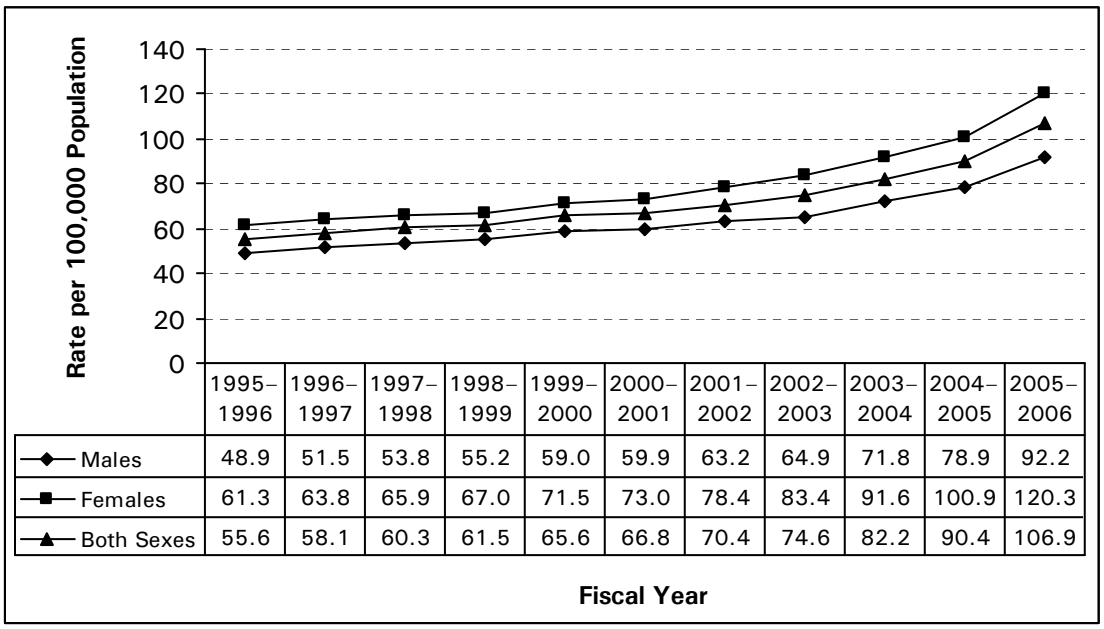
	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000	2000–2001	2001–2002	2002–2003	2003–2004	2004–2005	2005–2006
Males	52.9	53.1	52.0	54.6	56.1	55.1	54.6	55.5	59.4	62.2	68.4
Females	59.3	58.7	59.2	58.5	62.1	59.2	59.8	64.7	67.9	69.5	75.8
Both Sexes	56.9	56.5	56.2	57.0	59.5	57.6	56.9	60.8	64.3	66.5	72.7

Notes:
Rates calculated based on the patients' province of residence.
The 1991 Canadian population was used as the standard for rate calculation.

Source: Hospital Morbidity Database, Canadian Institute for Health Information, 1995–1996 to 2005–2006.

Larger differences, both between the sexes and over time, were observed for knee replacement rates (Figure 6). In 2005–2006, the age-standardized knee replacement rate was 120.3 for females, compared to 92.2 for males: a difference of 30.5%. The overall age-standardized rate almost doubled over the 10-year period, from 55.6 in 1995–1996 to 106.9 in 2005–2006, an increase of 92.3%. During this time period, an 88.5% increase was noted for males (from 48.9 to 92.2 per 100,000), while for females the corresponding increase was 96.2% (from 61.3 to 120.3 per 100,000).

Figure 6. Age-Standardized Hospitalization Rates (per 100,000 Population) by Sex for Knee Replacements, in Canada, 1995–1996 to 2005–2006



	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000	2000–2001	2001–2002	2002–2003	2003–2004	2004–2005	2005–2006
Males	48.9	51.5	53.8	55.2	59.0	59.9	63.2	64.9	71.8	78.9	92.2
Females	61.3	63.8	65.9	67.0	71.5	73.0	78.4	83.4	91.6	100.9	120.3
Both Sexes	55.6	58.1	60.3	61.5	65.6	66.8	70.4	74.6	82.2	90.4	106.9

Notes:
Rates calculated based on patients' province of residence.
The 1991 Canadian population was used as the standard for rate calculation.

Source: Hospital Morbidity Database, Canadian Institute for Health Information, 1995–1996 to 2005–2006.

International Comparisons

Crude rates of hip and knee replacements for selected countries are presented in tables 2 and 3. These rates have not been adjusted for age or sex. The rates help to roughly estimate the incidence of joint replacement procedures for primary and revision surgeries, for countries where this information was available. The reporting year is not uniform for all countries, and ranges from 2003 to 2006 based on the most recent data available. The Canadian crude rate for knee replacements includes partial knee replacements, which cannot be identified and separated from total knee replacements in the ICD-9/CCP coding classification system.

Sweden had the highest crude rate for primary hip replacements (153 per 100,000), while New Zealand had the highest rate for revisions (22 per 100,000). For knee replacements, the United States had the highest crude rate for primary knee replacements (144 per 100,000), while Australia had the highest rate for revisions (13 per 100,000).

Table 2. International Comparison of Hip Replacement Crude Rates (per 100,000 Population)

Country	Crude Rate per 100,000		Year	Reference
	Primary	Revisions		
Australia*	102	18	2005–2006	Australian Orthopaedic Association National Joint Replacement Registry, *Annual Report* (Adelaide: AOA, 2005)
Denmark	130	13	Calendar 2005	Danish Registry, May 2005
England and Wales	119.5	-	Calendar 2006	NJR Registry, June 2007
New Zealand	150	22	Calendar 2004	New Zealand National Joint Register
Norway	135	21	Calendar 2006	Norwegian Arthroplasty Register, April 2007
Sweden	153	15.6	Calendar 2006	The Swedish Hip Arthroplasty Register, May 2007
Canada†	**76.7**	**10**	**2005–2006**	**Canadian Joint Replacement Registry**
United States	112.8	12.4	Calendar 2003	American Academy of Orthopaedic Surgeons 1. National Hospital Discharge Survey, 1991–2003. Data obtained from U.S. Department of Health and Human Services; Centers for Disease Control and Prevention; National Centre for Health Statistics 2. Annual Estimates of the Population for the United States, Regions and Divisions: April 1, 2000 to July 1, 2005 (NST-EST2005-08). Source: Population Division, U.S. Census Bureau. Release Date: December 22, 2005

Notes:

* Excludes partial replacements.

† Crude rate calculations are based on counts from the HMDB, CIHI, 2004–2005. Counts are reported for all provinces and territories in Canada.

Table 3. International Comparison of Knee Replacement Crude Rates (per 100,000 Population)

Country	Crude Rate per 100,000		Year	Reference
	Primary	Revisions		
Australia*	131	13	2005–2006	Australian Orthopaedic Association National Joint Replacement Registry, *Annual Report* (Adelaide: AOA, 2005)
Denmark	90	9	Calendar 2005	Danish Registry, May 2005
England and Wales	118.5	-	Calendar 2006	NJR Registry, June 2007
New Zealand	102	8	Calendar 2004	New Zealand National Joint Register
Norway	66	5.7	Calendar 2006	Norwegian Arthroplasty Register, April 2007
Sweden	107.5	7	Calendar 2006	The Swedish Knee Arthroplasty Register, May 2007
Canada†	**117.3**	**8**	**2005–2006**	**Canadian Joint Replacement Registry**
United States	143.7	11.3	Calendar 2003	American Academy of Orthopaedic Surgeons 1. National Hospital Discharge Survey, 1991–2003. Data obtained from U.S. Department of Health and Human Services; Centers for Disease Control and Prevention; National Centre for Health Statistics 2. Annual Estimates of the Population for the United States, Regions and Divisions: April 1, 2000 to July 1, 2005 (NST-EST2005-08). Source: Population Division, U.S. Census Bureau. Release Date: December 22, 2005

Notes:

* Excludes partials for both hip and knee.

† Crude rate calculations are based on counts from the HMDB, CIHI, 2004–2005. Counts are reported for all provinces and territories in Canada.

Provincial/Territorial Variations

Most hospitalizations for hip and knee replacements in Canada were for primary procedures (88.7% for hip; 93.4% for knee) as shown in tables 4 and 5. Ontario reported the highest number of primary procedures and revisions for hip and knee replacements. The Territories had the highest proportion of revisions for hips (17.8%). For knee replacement procedures, New Brunswick reported the highest proportion of revisions (11.2%). Saskatchewan had the lowest percentage of revisions (8.0%) for hip replacement procedures, while Prince Edward Island reported the lowest proportion (5.3%) of knee revision procedures.

Table 4. Number of Hospitalizations by Type of Hip Replacements

Province	Total Number of Replacements 1995–1996	Total Number of Replacements 2005–2006	10-Year Increase (Percent)	Primary 2005	Revision 2005	Percent Revisions
Newfoundland and Labrador	206	372	80.6	328	44	11.8
Prince Edward Island	96	133	38.5	111	22	16.5
Nova Scotia	745	935	25.5	843	92	9.8
New Brunswick	462	656	42.0	544	112	17.1
Quebec	2,565	4,411	72.0	3,915	496	11.2
Ontario	7,111	12,103	70.2	10,802	1,301	10.7
Manitoba	681	1,248	83.3	1,045	203	16.3
Saskatchewan	849	1,059	24.7	974	85	8.0
Alberta	1,875	2,846	51.8	2,546	300	10.5
British Columbia	2,678	4,237	58.2	3,718	519	12.2
Territories*	34	45	32.4	37	8	17.8
Canada†	**17,302**	**28,045**	**62.1**	**24,863**	**3,182**	**11.3**

Notes:

* Territories include the Yukon, the Northwest Territories and Nunavut.

† Counts for 1995–1996 exclude 56 cases with unknown residence.

Source: Hospital Morbidity Database, Canadian Institute for Health Information, 1995–1996, 2005–2006.

Table 5. Number of Hospitalizations by Type of Knee Replacements

Province	Total Number of Replacements 1995–1996	Total Number of Replacements 2005–2006	10-Year Increase (Percent)	Primary 2005	Revision 2005	Percent Revisions
Newfoundland and Labrador	177	491	177	458	33	6.7
Prince Edward Island	71	207	192	196	11	5.3
Nova Scotia	896	1,284	43	1,180	104	8.1
New Brunswick	497	1,041	109	924	117	11.2
Quebec	2,227	5,865	163	5,485	380	6.5
Ontario	7,470	18,990	154	17,807	1,183	6.2
Manitoba	657	1,879	186	1,720	159	8.5
Saskatchewan	773	1,497	94	1,394	103	6.9
Alberta	1,775	4,001	125	3,722	279	7.0
British Columbia	2,299	5,374	134	5,065	309	5.7
Territories*	20	70	250	63	7	10.0
Canada†	**16,862**	**40,699**	**141**	**38,014**	**2,685**	**6.6**

Notes:
* Territories include the Yukon, the Northwest Territories and Nunavut
† Counts for 1995–1996 exclude 61 cases with unknown residence; counts for 2005–2006 exclude 2 cases with unknown residence.

Source: Hospital Morbidity Database, Canadian Institute for Health Information, 1995–1996, 2005–2006.

Tables 4 and 5 present the number of hip and knee replacement procedures by province of patient residence for 2005–2006 compared to 1995–1996, and the associated percent change. Over a 10-year period, Manitoba had the largest increase in the number of hospitalizations for hip replacements (83%). For knee replacements, the number of hospitalizations in the 10-year period more than doubled in most of the provinces. The greatest increase occurred in the territories (250%).

Table 6. Age Standardized Rate (per 100,000) for Hip and Knee Hospitalizations, Canada, 1995–1996, 2005–2006

Province	Hip Arthroplasty			Knee Arthroplasty		
	Fiscal Year 1995–1996	Fiscal Year 2005–2006	10-Year Change (Percent)	Fiscal Year 1995–1996	Fiscal Year 2005–2006	10-Year Change (Percent)
Newfoundland and Labrador	39.1	58.6	50	34.0	76.8	126
Prince Edward Island	62.6	80.5	29	48.6	119.4	146
Nova Scotia	73.2	78.5	7	88.8	108.1	22
New Brunswick	57.7	68.7	19	62.8	109.3	74
Quebec	33.9	46.2	36	29.6	61.8	109
Ontario	61.9	82.3	33	65.2	131.2	101
Manitoba	54.8	89.1	63	52.7	137.7	161
Saskatchewan	70.5	86.1	22	63.6	123.5	94
Alberta	78.8	86.2	9	76.3	125.2	64
British Columbia	65.4	79.5	21	56.3	102.3	82
Canada*	**56.8**	**72.7**	**28**	**55.6**	**106.9**	**92**

Note:
* Excludes non-Canadian residents and patients with unknown residence.

Source: Hospital Morbidity Database, Canadian Institute for Health Information, 1995–1996, 2005–2006.

As shown in Table 6, the age-standardized rates of hip and knee replacement procedures varied greatly across Canada, with Manitoba having the highest rate of hip replacement (89.1 per 100,000 population), followed by Alberta with 86.2 per 100,000 population. Quebec had the lowest hospitalization rates for hip replacements (46.2,) followed by Newfoundland and Labrador with 58.6 per 100,000 population.

The highest rate of knee replacements occurred in Manitoba (137.7 per 100,000), while Quebec had the lowest (61.8 per 100,000 population).

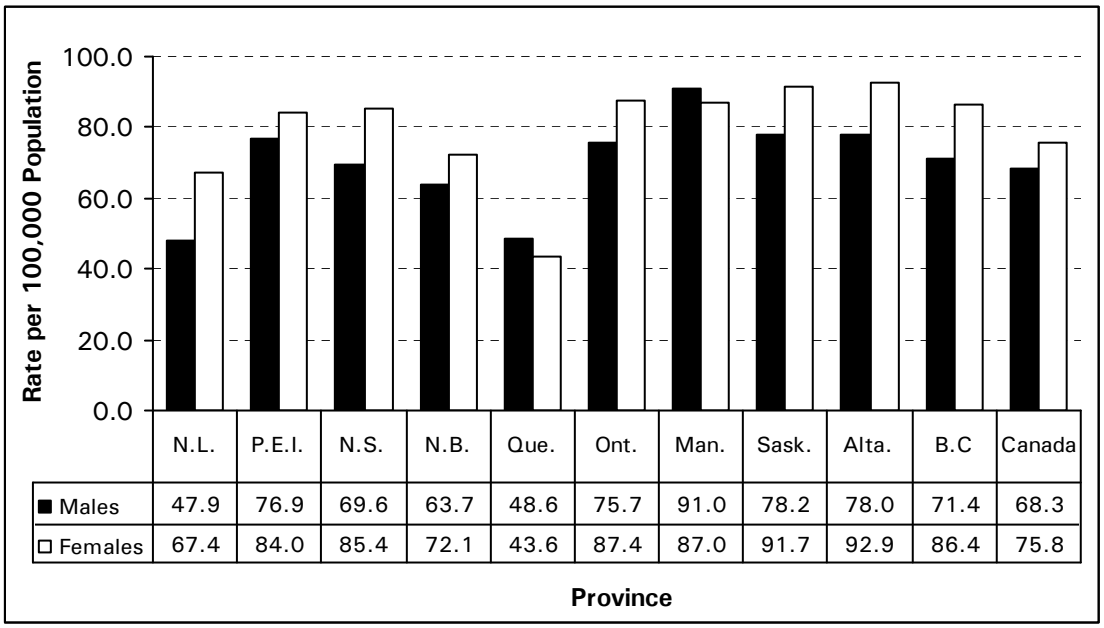
Since 1995–1996, the hip replacement rate has increased in all provinces. The greatest percent increase was seen in Manitoba (63%) followed by Newfoundland and Labrador (50%). The age-standardized rate of knee replacement increased in all provinces, with Manitoba showing the greatest increase (161%) followed by Prince Edward Island (146%). Nova Scotia recorded the lowest increase (22%).

Provincial Age Standardized Rates by Sex

The age-standardized rates by sex and province for hip replacements (Figure 7) were generally higher for females than for their male counterparts. Manitoba is the exception, where the rates were highest for males (91 per 100,000 versus 87 for females).

Manitoba had the highest knee replacement age standardized rate for females (151.3 per 100,000), followed by Ontario (149.6 per 100,000) (Figure 8). The highest rate of knee replacements for males was recorded in Prince Edward Island (135.1 per 100,000). The lowest rates for both females and males were recorded in Quebec (70.9 and 51.1 per 100,000 respectively).

Figure 7. Age-Standardized Rates (per 100,000 Population) for Hip Replacement Procedures, by Sex, 2005–2006

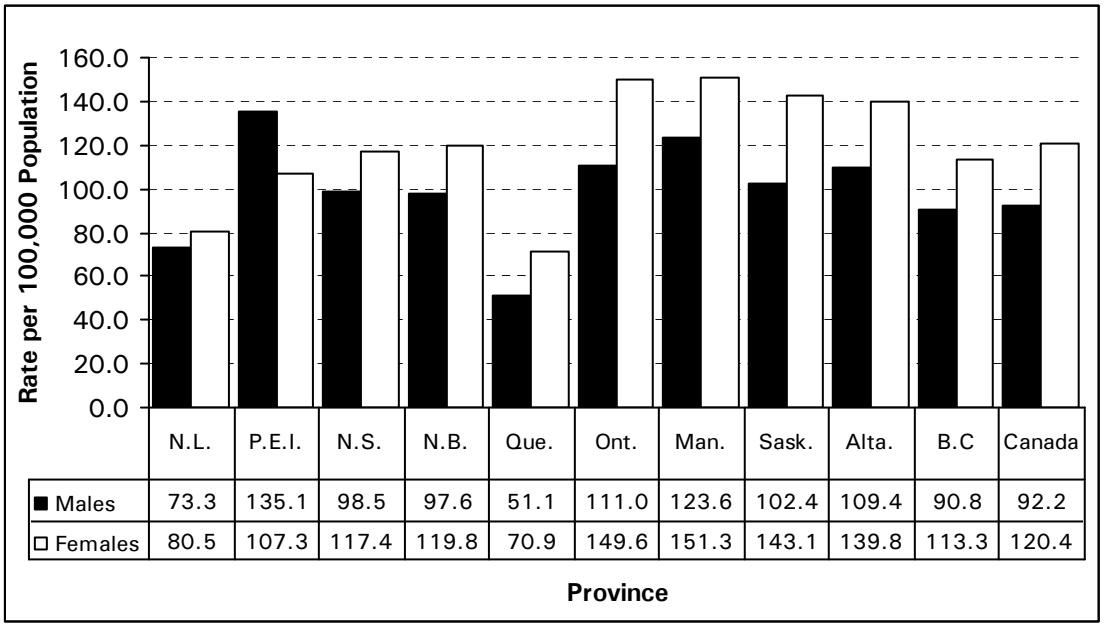


	N.L.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C	Canada
■ Males	47.9	76.9	69.6	63.7	48.6	75.7	91.0	78.2	78.0	71.4	68.3
□ Females	67.4	84.0	85.4	72.1	43.6	87.4	87.0	91.7	92.9	86.4	75.8

Notes:
Rates calculated based on patients' province of residence. Yukon, Northwest Territories and Nunavut rates are suppressed due to small numbers, but are included in the national calculation.
The 1991 Canadian population standardized rates.

Source: Hospital Morbidity Database, Canadian Institute for Health Information, 2005–2006.

Figure 8. Age-Standardized Rates (per 100,000 Population) for Knee Replacement Procedures, by Sex, 2005–2006



	N.L.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C	Canada
■ Males	73.3	135.1	98.5	97.6	51.1	111.0	123.6	102.4	109.4	90.8	92.2
□ Females	80.5	107.3	117.4	119.8	70.9	149.6	151.3	143.1	139.8	113.3	120.4

Notes:
Rates calculated based on patients' province of residence. Yukon, Northwest Territories and Nunavut rates are suppressed due to small numbers, but are included in the national calculation.
The 1991 Canadian population standardized rates.

Source: Hospital Morbidity Database, Canadian Institute for Health Information, 2005–2006.

Interprovincial/Interterritorial Movements

Most patients had their joint replacement surgeries performed in their province of residence, with the exception of patients in the Yukon Territory and Nunavut. Possible reasons for undergoing joint replacement in a province other than the home province include the potential for a shorter wait time, access to a sub-specialty, or services not being available in the home province. As hip replacements are not performed in the Yukon Territory, and neither hip nor knee replacements are performed in Nunavut, residents of these two territories travel to other provinces to have hip and knee replacements performed.

The provincial/territorial movements of hip replacement patients are presented in Table 7. Residents of the Yukon, Nunavut, Prince Edward Island, Saskatchewan, Nova Scotia, Northwest Territories and Manitoba were most likely to undergo hip replacement surgery in another province. Residents of Ontario, Quebec and Alberta were least likely to travel to another province for their hip replacement surgery (0.4%, 0.7% and 0.9%, respectively) (Table 7).

With respect to the percentage of the flow of patients into provinces for hip replacement surgery, New Brunswick (6%) and Manitoba (4%) had the highest proportion of out-of-province patients coming to their province for surgery. In absolute numbers, however, Alberta (n = 70) and Ontario (n = 58) received the highest number of patients from out-of-province for hip replacement procedures.

Table 7. Movement of Hip Replacement Patients Across Provinces, 2005–2006

Patients' Province of Residence	Province Where the Procedure Was Performed*										
	N.L.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	N.W.T.
N.L.	371					<5					
P.E.I.		117	15						<5		
N.S.			901	31		<5					
N.B.	<5		6	648		<5					
Que.	<5			<5	4,387	18				<5	
Ont.	<5		<5	<5		12,068	32				
Man.						<5	1,241	<5	<5		
Sask.						<5	10	1,018	27	<5	
Alta.			<5			5		<5	2,829	10	
B.C.						<5	<5	<5	28	4,204	
Y.T.						<5			<5	11	
N.W.T.									<5		27
Nun.							<5				

Note:
* There were no hip replacements performed in the Yukon and Nunavut.

Source: Hospital Morbidity Database, Canadian Institute for Health Information, 2005–2006.

Table 8 shows the interprovincial movement of patients who underwent knee replacements in Canada in 2005–2006. More residents of the Northwest Territories, the Yukon, Nunavut, Prince Edward Island, Nova Scotia, Newfoundland and Saskatchewan had their knee replacement surgery in another province, as compared to the other provinces and territories. Similar to the pattern seen for hip replacement recipients, only a small proportion of residents of Alberta (0.3%), Ontario (0.4%), and Quebec (0.7%) had their knee replacement surgeries in a province other than their province of residence. New Brunswick (5.6%) had the highest proportion of out-of-province residents coming into the province to have knee replacement surgery. Of note, 37.5% of the knee replacement surgeries performed on patients from Nunavut were performed in Northwest Territories.

Table 8. Movement of Knee Replacement Patients Across Provinces, 2005–2006

Patients' Province of Residence	Province Where the Procedure Was Performed*											
	N.L.	P.E.I.	N.S.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	N.W.T.	Y.T.
N.L.	487		<5			<5						
P.E.I.		203	<5									
N.S.			1,231	49		<5				<5		
N.B.			<5	1,036		<5						
Que				8	5,826	31						
Ont.	<5		<5	<5		18,938	48			<5		
Man.						7	1,859	7	5	<5		
Sask.						<5	6	1,436	52	<5		
Alta.								6	3,987	8		
B.C.						6	<5	<5	52	5,312		
Y.T.										10		8
N.W.T.									<5		27	
Nun.						10	5				9	

Notes:
Counts exclude two patients whose province of residence was unknown.
* There were no knee replacements performed in Nunavut.

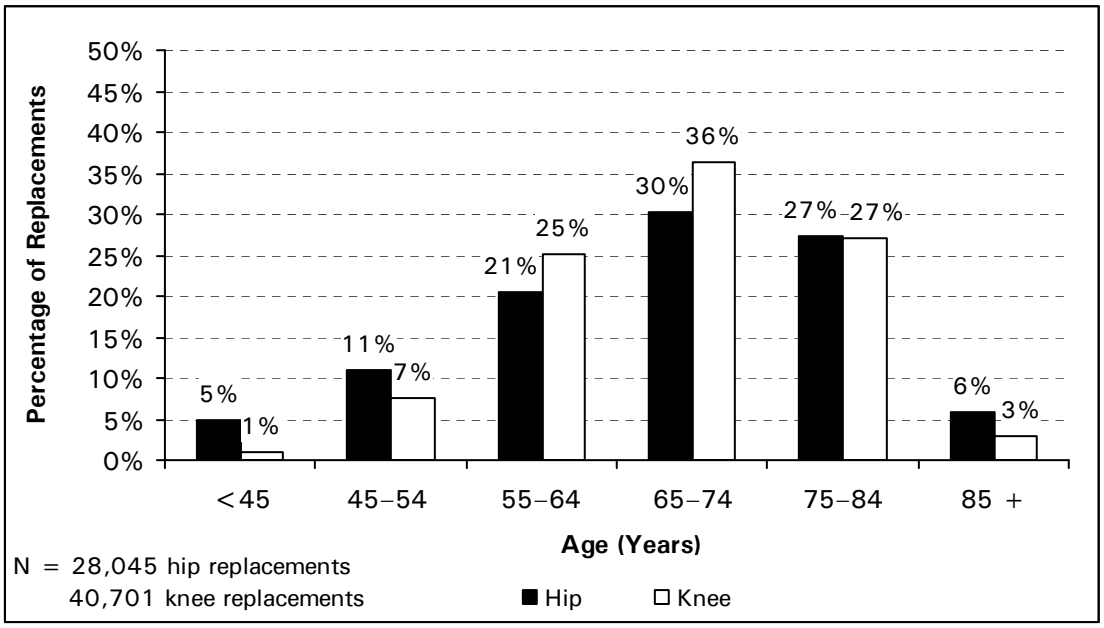
Source: Hospital Morbidity Database, Canadian Institute for Health Information, 2005–2006.

Patient Demographics

In 2005–2006, the mean age of patients who underwent hip replacements in Canada was 67.5 years (69.2 years for females and 65.4 years for males). The mean age of knee replacement patients was 68.4 years (68.5 years for females and 68.4 years for males). Overall, patients undergoing knee replacements were significantly older then their hip replacement counterparts.

The age distribution of hip replacement recipients were similar to that of knee replacement recipients, with the majority of patients in both groups being 65 years of age or older (63% of hip and 66% of knee replacement recipients). Only small proportions of patients for both procedures were younger than 45 years (5% of hip and 1% of knee replacement recipients) (Figure 9).

Figure 9. Age Distribution of Hip and Knee Replacement Recipients, Canada, 2005–2006



Source: Hospital Morbidity Database, Canadian Institute for Health Information, 2005–2006.

Females were more likely to undergo hip arthroplasty as compared to males in 2005–2006; the age-standardized rate for females was 75.8 per 100,000 population compared to 68.4 for males (Figure 5). Females also had a higher rate of knee replacements (120.3) as compared to males (92.2) (Figure 6). In 2005–2006, 56% of hip replacement recipients were female and 44% were male; of the knee replacement recipients, 61% were female and 39% were male (Table 9).

Over the decade from1995–1996 to 2005–2006, the largest increases in the number of hip replacement procedures for both males and females were seen in the 45-to-54-year age group (126% and 107% respectively) and followed by the 85-year-and-older age group (123% and 104%, respectively) (Table 9).

For knee replacement procedures, the largest increases were noted in the 45-to-54-year age group (282% for males and 327% for females), followed by the 85-year-and-older age group for males (222%) and the 55-to-64-year age group for females (229%) (Table 9).

Table 9. Number of Hip and Knee Arthroplasties by Age and Sex, Canada, 1995–1996 and 2005–2006

Hip Arthroplasty						
Age Group (Years)	Males			Females		
	1995–1996	2005–2006	10-Year Change (Percent)	1995–1996	2005–2006	10-Year Change (Percent)
<45	485	747	54	469	629	34
45–54	770	1,739	126	653	1,351	107
55–64	1,636	2,800	71	1,727	2,978	72
65–74	2,618	3,647	39	3,745	4,848	29
75–84	1,548	2,797	81	2,916	4,857	67
85+	203	452	123	588	1,200	104
Total	**7,260**	**12,182**	**68**	**10,098**	**15,863**	**57**
Knee Arthroplasty						
Age Group (Years)	Males			Females		
	1995–1996	2005–2006	10-Year Change (Percent)	1995–1996	2005–2006	10-Year Change (Percent)
<45	125	143	14	164	267	63
45–54	297	1,135	282	448	1,913	327
55–64	1,325	3,966	199	1,892	6,217	229
65–74	3,036	6,243	106	4,539	8,596	89
75–84	1,672	4,198	151	3,030	6,836	126
85+	128	412	222	267	775	190
Total	**6,583**	**16,097**	**145**	**10,340**	**24,604**	**138**

Source: Hospital Morbidity Database, Canadian Institute for Health Information, 1995–1996, 2005–2006.

Table 10 shows the age-specific rates for hip and knee replacements, by sex for 2005–2006, as compared to 1995–1996. For hip replacement procedures, the highest age–specific rates in 2005–2006 were noted in the 75-to-84-year age group for both males and females (447.6 and 556 per 100,000, respectively), followed by the 65-to-74-year age group (341.3 and 411.2 per 100,000, for males and females respectively). For males, the largest 10-year increases were seen among the 45-to-54-year age group (68%), followed by the less-than-45-year age group (56%). For females, the highest rates were observed in the 45-to-54-year age group followed by 85-year-and-older age group (52% and 36%, respectively).

Substantial increases in age–sex specific rates for knee arthroplasty have occurred in the last decade (1995–1996 to 2005–2006). The most notable increases were observed in the 45-to-54-year age group, where the rate of knee replacements more than tripled for males and females (183% and 213% increase respectively). However, the highest age–sex specific rate of knee replacements is consistently observed in the 75-to-84-year age group (671.9 per 100,000 for males and 782.5 per 100,000 for females) (Table 10). It is important to note that the Canadian population in the 40-to-59-year age group has increased by 34% over the decade between 1995–1996 and 2005–2006, while the number of Canadians 60 years of age and older has increased by 23%.[7]

Table 10. Age-Specific Rates (per 100,000) by Age Groups and Sex, Canada, 1995–1996, 2005–2006

Hip Arthroplasty						
Age Group (Years)	Males			Females		
	1995–1996	2005–2006	10-Year Change (Percent)	1995–1996	2005–2006	10-Year Change (Percent)
<45	4.8	7.5	56	4.8	6.5	35
45–54	42.1	70.6	68	35.7	54.2	52
55–64	132.1	159.3	21	135.8	164.7	21
65–74	278.2	341.3	23	333.2	411.2	23
75–84	359.9	447.6	24	437.8	556.0	27
85+	208	291.0	40	255.3	346.3	36
Total	**49.8**	**75.9**	**52**	**67.9**	**97.0**	**43**
Knee Arthroplasty						
Age Group (Years)	Males			Females		
	1995–1996	2005–2006	10-Year Change (Percent)	1995–1996	2005–2006	10-Year Change (Percent)
<45	1.2	1.4	17	1.7	2.8	65
45–54	16.3	46.1	183	24.5	76.7	213
55–64	107.0	225.6	111	148.8	343.9	131
65–74	322.6	584.2	81	403.9	729.1	81
75–84	388.8	671.9	73	454.9	782.5	72
85+	131.1	265.2	102	115.9	223.7	93
Total	**45.1**	**100.3**	**122**	**69.5**	**150.4**	**116**

Source: Hospital Morbidity Database, Canadian Institute for Health Information, 1995–1996, 2005–2006.

Between 1995–1996 and 2005–2006, the number of hip replacements performed on patients under the age of 20 dropped by 14%. In 2005–2006, among all hip replacements reported, less than 1% of hip replacements were performed on Canadians younger than 20 years of age.

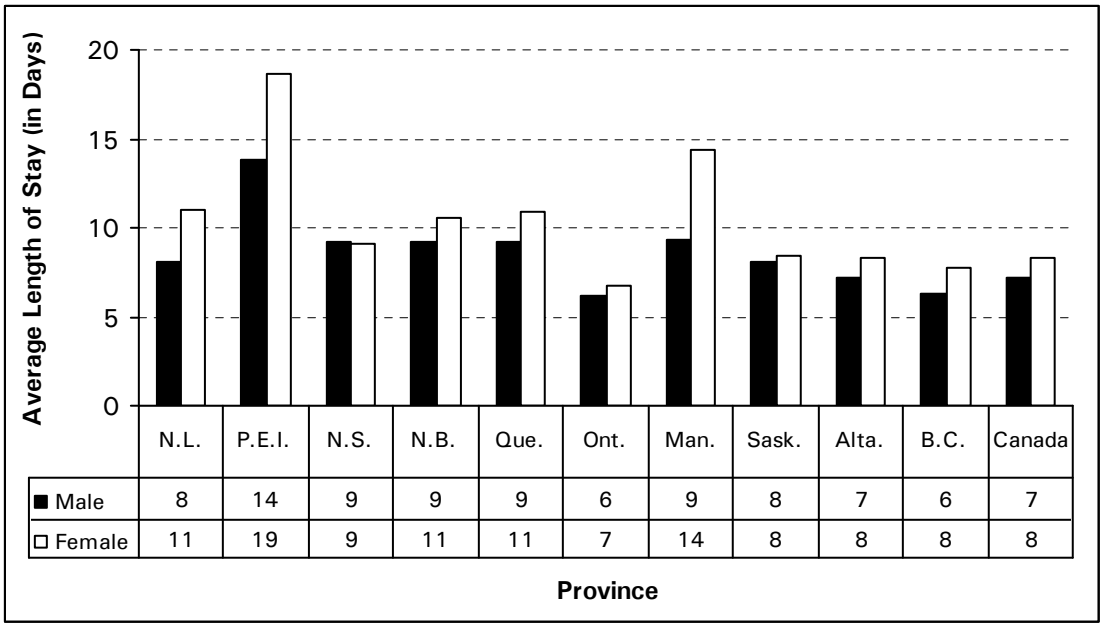
Between 1995–1996 and 2005–2006, the number of knee replacements performed on patients under the age of 20 dropped by 71.4%. In 2005–2006, among all knee replacements reported, less than 1% of knee replacements were performed on Canadians younger than 20 years of age.

Length of Stay (LOS) and Outcomes for Hip and Knee Replacements in Canada

Provincial average LOS in hospital for hip and knee replacement patients in 2005–2006, by sex, are shown in figures 10 and 11. Generally, patients undergoing hip replacements had longer hospital stays than those undergoing knee replacements.

Ontario had lower average LOS than the national average for both hip and knee replacements. In contrast, Manitoba, Prince Edward Island, Newfoundland and Labrador, New Brunswick and Quebec had higher than the national average LOS for both hip and knee procedures, as shown in figures 10 and 11.

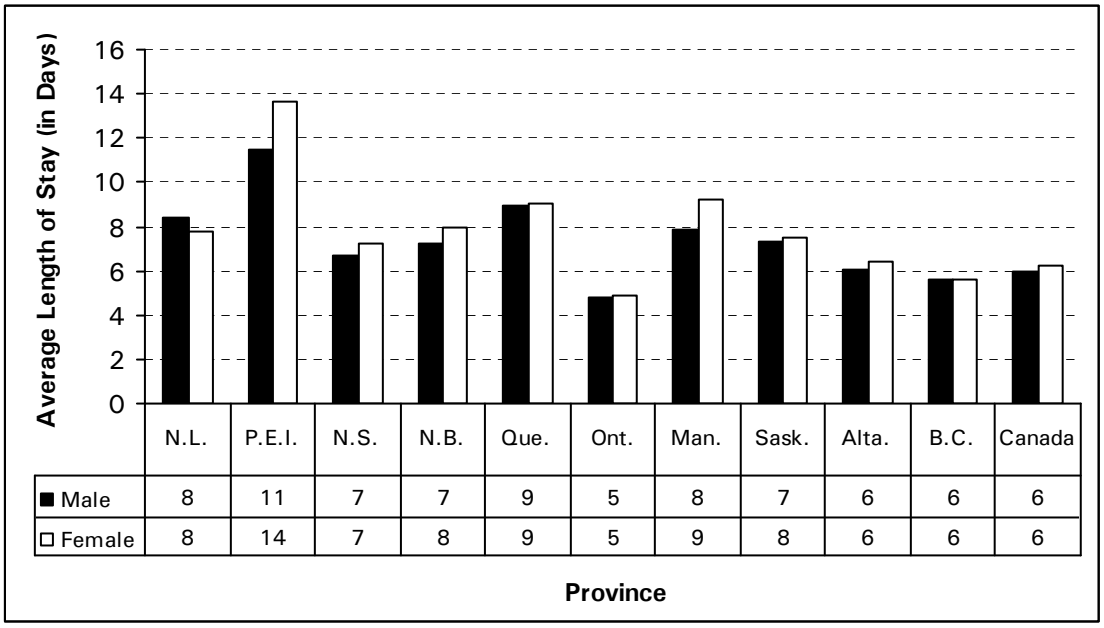
Figure 10. Average Length of Hospital Stay for Hip Replacement Patients by Sex and Province, 2005–2006



Note:
Northwest Territories, Nunavut and Yukon numbers are suppressed, but are included in overall national average.

Source: Hospital Morbidity Database, Canadian Institute for Health Information, 2005–2006.

Figure 11. Average Length of Hospital Stay for Knee Replacement Patients by Sex and Province, 2005–2006

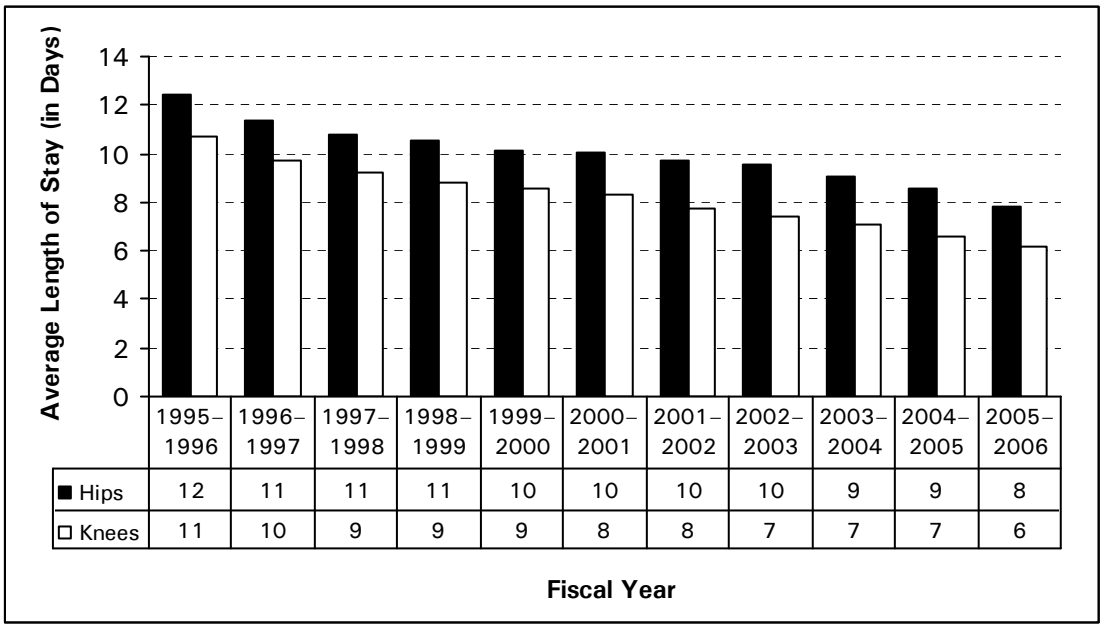


Note:
Northwest Territories, Nunavut and Yukon numbers are suppressed, but are included in overall national average.

Source: Hospital Morbidity Database, Canadian Institute for Health Information, 2005–2006.

Over the decade, the average LOS for knee replacement hospitalization declined from 11 days in 1995–1996 to 6 days in 2005–2006, a decrease of 45%. For hip replacement hospitalization, the average LOS decreased by 33%, from 12 days in 1995–1996 to 8 days in 2005–2006 (Figure 12). In 2005–2006, knee replacement recipients were discharged sooner than hip replacement recipients (LOS was six days and eight days respectively).

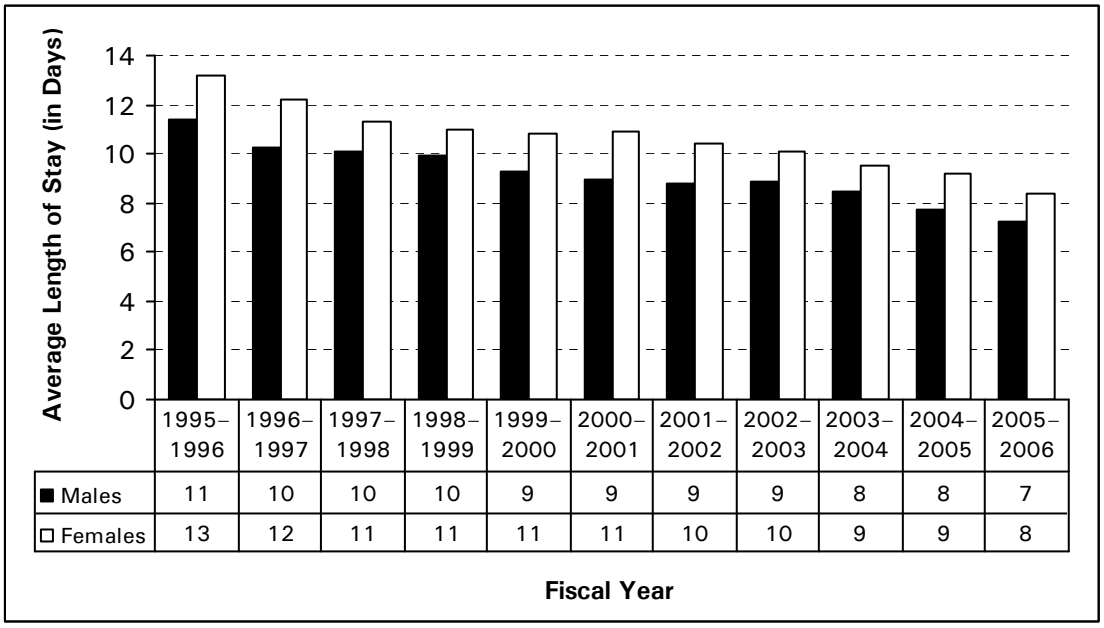
Figure 12. Average Length of Hospital Stay for Hip and Knee Replacements, in Canada, 1995–1996 to 2005–2006



Source: Hospital Morbidity Database, Canadian Institute for Health Information, 1995–1996 to 2005–2006.

In 2005–2006, the average LOS for female hip replacement recipients was longer than for their male counterparts (eight days and seven days respectively). However, over the last decade, the average LOS for females has dropped, from 13 days in 1995–1996 to 8 days in 2005–2006 (decrease of 38%). For males, the average LOS has decreased from 11 days to 7 days (36%) (Figure 13). Similarly, knee replacement recipients (male and female) now spend an average of 6 days each in hospital compared to 10 days and 11 days respectively in 1995–1996, a decrease of 45% and 40% respectively (Figure 14). On average, females undergoing a hip or knee replacement procedure remained in hospital longer than their male counterparts.

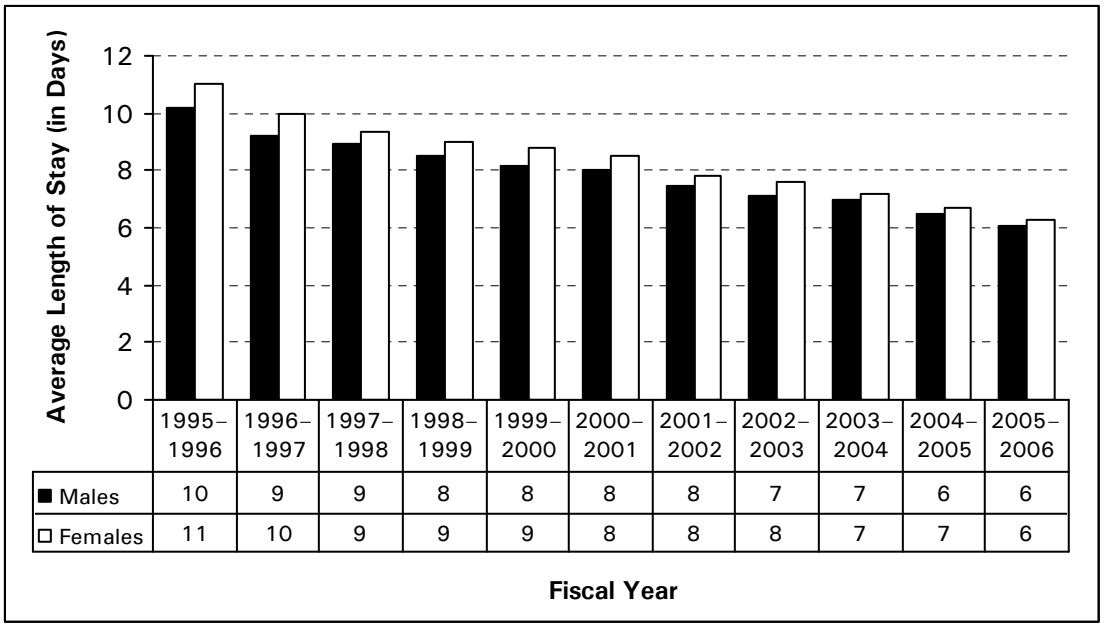
Figure 13. Average Length of Stay for Hip Replacements by Sex, in Canada, 1995–1996 to 2005–2006



	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000	2000–2001	2001–2002	2002–2003	2003–2004	2004–2005	2005–2006
■ Males	11	10	10	10	9	9	9	9	8	8	7
□ Females	13	12	11	11	11	11	10	10	9	9	8

Source: Hospital Morbidity Database, Canadian Institute for Health Information, 1995–1996 to 2005–2006.

Figure 14. Average Length of Stay for Knee Replacements by Sex, in Canada, 1995–1996 to 2005–2006



	1995–1996	1996–1997	1997–1998	1998–1999	1999–2000	2000–2001	2001–2002	2002–2003	2003–2004	2004–2005	2005–2006
■ Males	10	9	9	8	8	8	8	7	7	6	6
□ Females	11	10	9	9	9	8	8	8	7	7	6

Source: Hospital Morbidity Database, Canadian Institute for Health Information, 1995–1996 to 2005–2006.

In-Hospital Mortality

Post-operative in-hospital mortality is a relatively rare event among patients receiving either hip or knee replacement surgery (Table 11). Overall, in 2005–2006, less than 1% of patients undergoing hip or knee replacement surgery died in hospital (0.7% and 0.2%, respectively).

The risk of post-operative in-hospital death increases with age (Table 11). Seventy-eight percent of deaths among hip replacement recipients and 65% of deaths after knee replacement procedures occurred in patients 75 years of age or older. This age-related pattern is consistent for both males and females.

Table 11. Number of In-Hospital Deaths After Hip and Knee Arthroplasty by Patient's Age and Sex, 2005–2006

Hip Arthroplasty					
Age Group (Years)	Number of Deaths			Number of Patients	Percentage of Deaths
	Males	Females	Total		
<75	16	25	41	18,739	0.2
75–84	41	31	72	7,654	0.9
85+	32	44	76	1,652	4.6
All Ages	89	100	189	28,045	0.7
Knee Arthroplasty					
Age Group (Years)	Number of Deaths			Number of Patients	Percentage of Deaths
	Males	Females	Total		
<75	16	13	29	28,480	0.1
75–84	27	17	44	11,034	0.4
85+	5	<5	9	1,187	0.8
All Ages	48	34	82	40,701	0.2

Summary of Findings

The number of hip and knee replacement surgeries has increased considerably (by 101%) in Canada over a 10-year period, since 1995–1996. Hospitalizations for knee replacements increased by 140% in this period, while hospitalizations for hip replacements increased by 62%.

Canadians are staying in hospital for a shorter period of time after joint replacement surgery. Over the decade, the length of stay has decreased for both knee and hip replacements by 45% and 33% respectively.

For hip and knee replacements, substantial provincial/territorial variation was seen in 2005–2006, with Manitoba having the highest age standardized rate (89.1 and 137.7 per 100,000 respectively) and Quebec having the lowest at (46.2 and 61.8 per 100,000 respectively).

Characteristics of Hip and Knee Joint Replacement Patients Reported in CJRR

Methodological Notes:

- Analyses in this section are based on the CJRR data for fiscal years 2003–2004 through 2005–2006, unless otherwise stated.
- Data submission by orthopedic surgeons to the CJRR is voluntary; not all eligible surgeons are participating. Each surgeon may not have submitted all procedures performed.
- Where the term "significant" is used in this report, a two-sided statistical test (Chi-square, non-parametric or Wilcoxon test) was performed. The interpretation of the result is considered statistically significant at the .05 level.
- Throughout this report, the term "components inserted" refers to components replacing the natural bone, as in the case of primary procedures. The term "components replaced" is used to refer to replacing existing artificial implants, as in the case of revision procedures or components replacing the natural bone as in the case of primary procedures.
- Additional methodological details are presented in Appendix B.

This section provides specific surgical information about hip and knee replacement procedures performed in Canada. It also provides information regarding the length of time patients waited for either a hip or knee replacement surgery. Patient characteristics and diagnoses are also included.

Longevity of primary joint replacements as determined by the length of time to early revision following the primary joint replacement, and the time patients waited to have their joint revised surgically, are reported.

National Trends

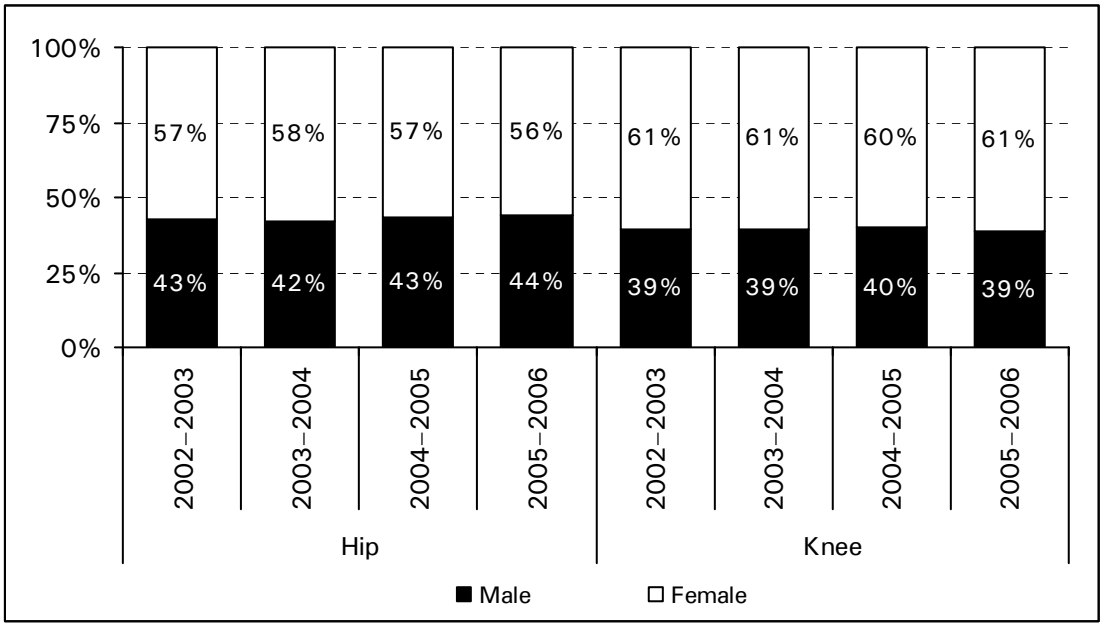
In the CJRR, for the 2005–2006 period, 31,124 hip and knee replacement procedures were voluntarily reported; the majority (58%) were knee replacements, while hip replacements represented 42% of the total.

Patient Demographics

There were observed demographic differences between patients receiving hip replacements and those receiving knee replacements.

In 2005–2006, females accounted for significantly ($p < 0.0001$) more hip and knee replacements than males (56% and 61%, respectively) (Figure 15).

Figure 15. Sex Distribution for Joint Replacements Recipients, CJRR, 2002–2003 to 2005–2006

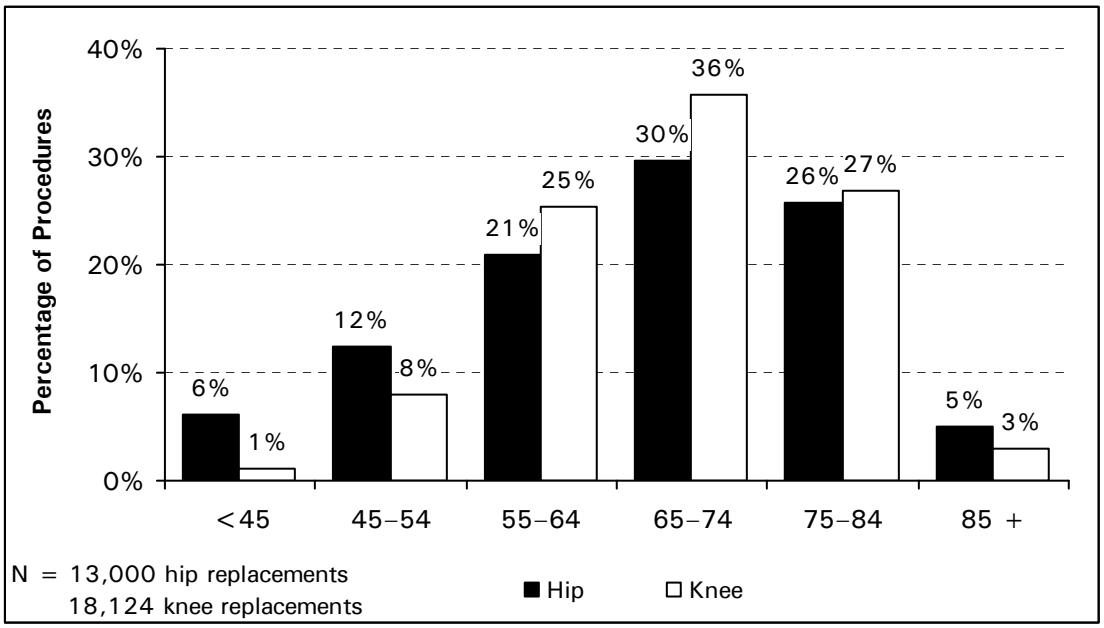


Note:
The number of procedures presented in Figure 11 are the denominators used to calculate the percentages.

Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2002–2003 to 2005–2006.

Patients aged 65 to 74 accounted for the highest proportion of hip and knee replacements reported to the CJRR in 2005–2006 (30% for hip and 36% for knee). Patients between 75 and 84 years of age represented the second-largest group for hip (26%) and knee (27%) replacements in Canada in 2005–2006. Younger (under 45 years of age) and the older (85 and older) patients comprised the lowest proportions of recipients for hip and knee replacements in the CJRR (Figure 16). Overall, Canadians who underwent knee replacements were significantly older than those who underwent hip replacements ($p < 0.0001$).

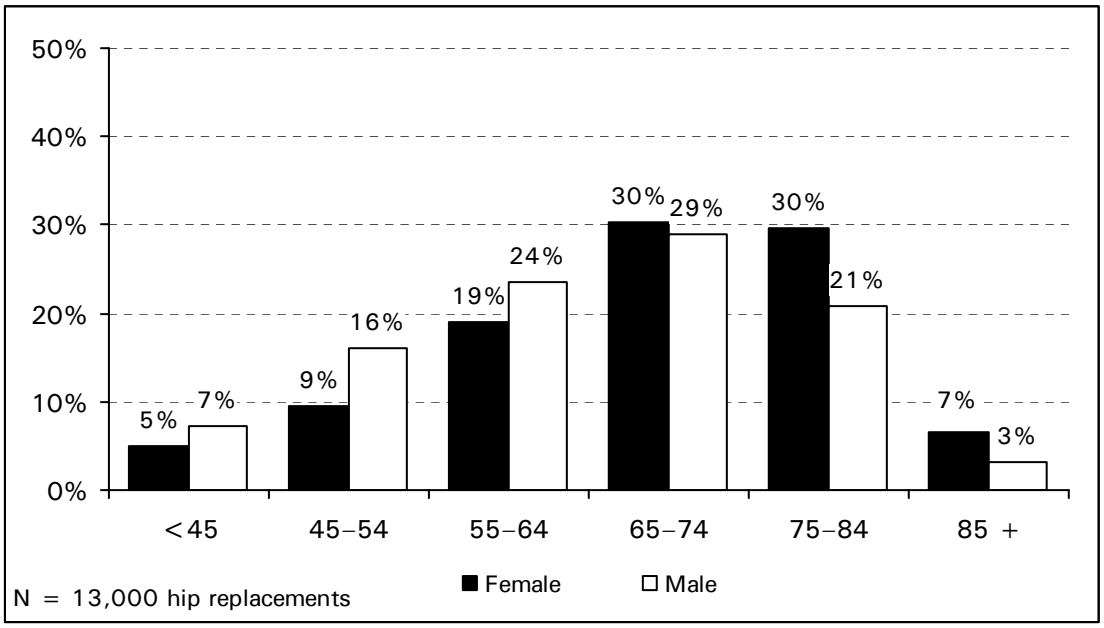
Figure 16. Hip and Knee Replacements by Age Group, CJRR, 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2005–2006.

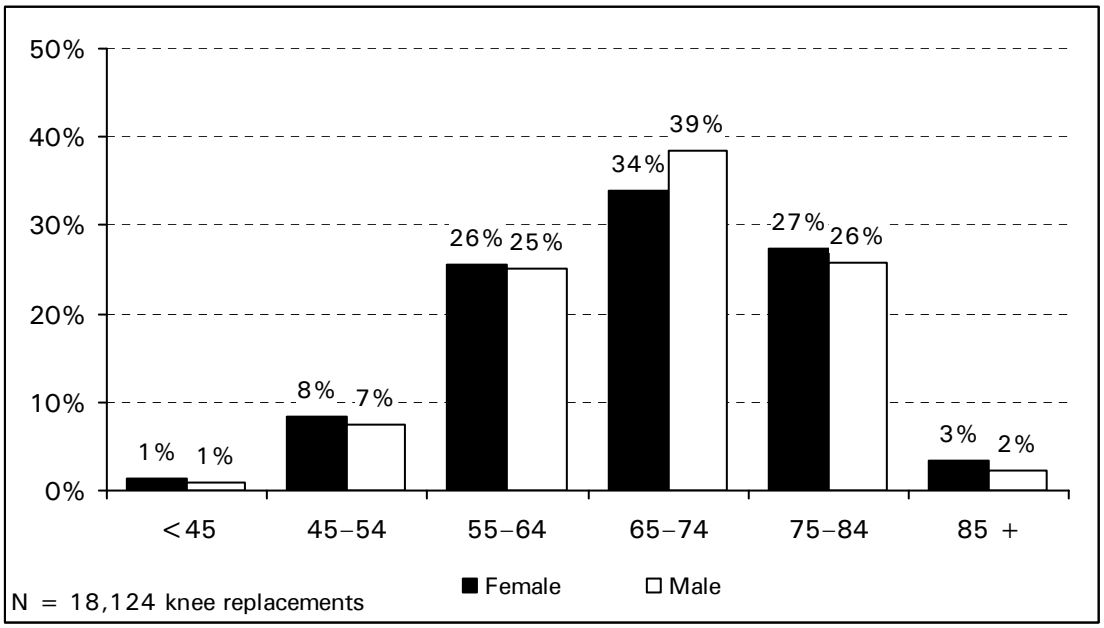
Among hip replacements recipients, females were significantly ($p < 0.0001$) older than their male counterparts, while amongst knee replacement recipients there was no significant difference in age distribution between the sexes (figures 17 and 18).

Figure 17. Age Distribution by Sex for Hip Replacement Recipients, CJRR, 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2005–2006.

Figure 18. Age Distribution by Sex for Knee Replacement Recipients, CJRR, 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2005–2006.

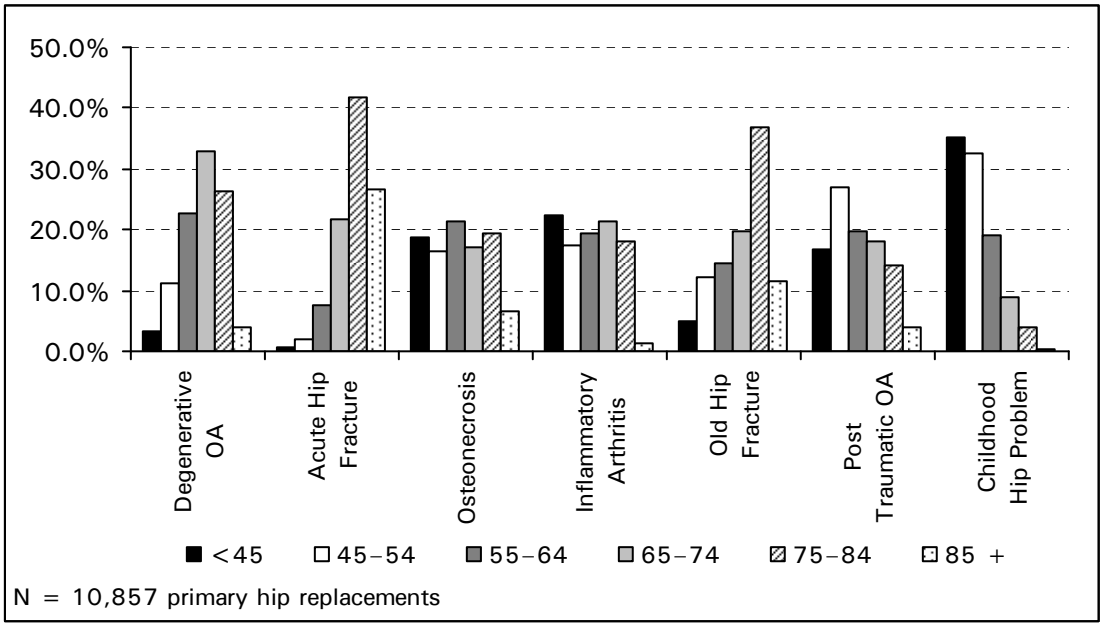
Indication for Primary Joint Replacement

Primary Hip Replacement

For primary hip replacements, surgeons were asked to record *only* the *most responsible* diagnosis groupings applicable to patients. In 2005–2006, degenerative osteoarthritis (OA) was the most common responsible diagnosis indicated for elective primary hip replacements (81%) in the CJRR, followed by osteonecrosis and acute fracture (5%) and inflammatory arthritis (3%).

While degenerative OA appears as the predominant diagnosis in all age groups, the responsible diagnoses differs between various age groups. Hip replacement patients who were 65 to 74 years old represented the highest proportion of degenerative OA; patients who were 75 to 84 years old represented the highest proportion of acute and old hip fractures; and patients who were 45 to 54 years old represented the highest proportion of post-traumatic OA. Furthermore, patients who were under the age of 55 years represented the highest proportion of childhood hip problems. Osteonecrosis and inflammatory arthritis diagnoses were evenly distributed across various age groups (Figure 19).

Figure 19. Age Distribution by Responsible Diagnosis, Primary Hip Replacements, CJRR, 2005–2006



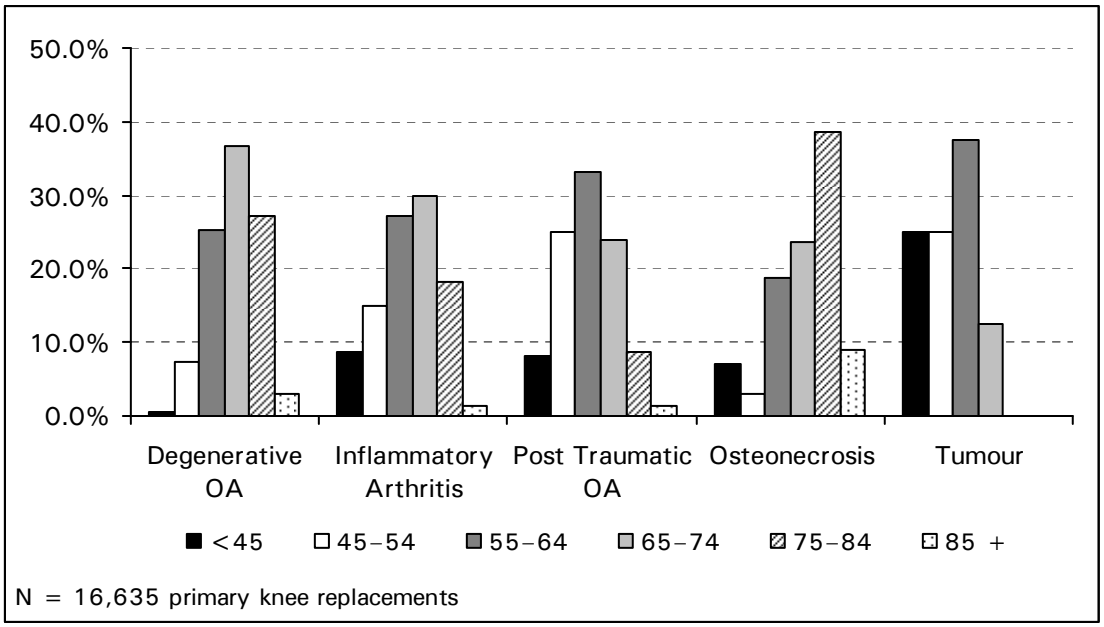
Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2005–2006.

Primary Knee Replacement

For primary knee replacements, surgeons were asked to record *only* the *most responsible* diagnosis groupings applicable to patients. Among all primary knee replacements performed in 2005–2006, degenerative OA was indicated as the most commonly reported responsible diagnosis (93%), followed by inflammatory arthritis (4%) and post-traumatic osteoarthritis (2%).

While degenerative OA is seen as the predominant diagnosis in all age groups, there is considerable variation in the distribution of the other diagnoses between various age groups. Knee replacement patients who were 65 to 74 years old represented the highest proportion of degenerative OA and inflammatory arthritis; patients who were 55 to 64 years old represented the highest proportion of post-traumatic OA and tumour; and patients who were 75 to 84 years old represented the highest proportion of osteonecrosis (Figure 20).

Figure 20. Age Distribution by Responsible Diagnosis, Primary Knee Replacements, CJRR, 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2005–2006.

Body Mass Index

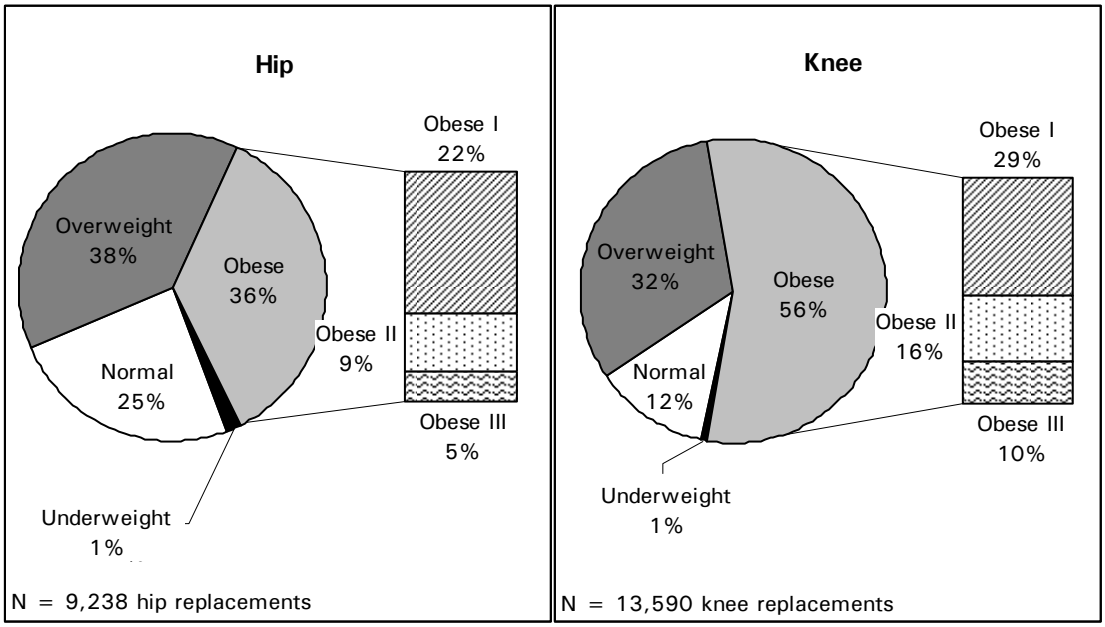
Studies have shown that obesity is one of the influencing factors associated with OA.[8, 9] Since OA is the leading diagnosis for primary joint replacements,[10] examination of body mass index (BMI) among hip and knee replacement patients is of importance. BMI is calculated as weight (in kilograms) divided by the height (in metres) squared.[11]

Based on international standards citing differentiations between "sub-groups" within the obese category, patients reported to the CJRR were assigned the following BMI categories: under 18.5 (underweight); 18.5–24.9 (normal weight); 25.0–29.9 (overweight); 30.0–34.9 (obese, class I); 35.0–39.9 (obese, class II); 40.0 and higher (obese, class III).[12, 13, 14]

Calculations for BMI values for the 2005–2006 period were available for 71% (n = 9,238) of hip replacement and 75% (n = 13,590) of knee replacement patients in the CJRR.

For hip and knee replacements, patients classified as belonging to the obese class 1 category represented the highest proportion of recipients in 2005–2006 (22% for hip and 29% for knee) (Figure 21).

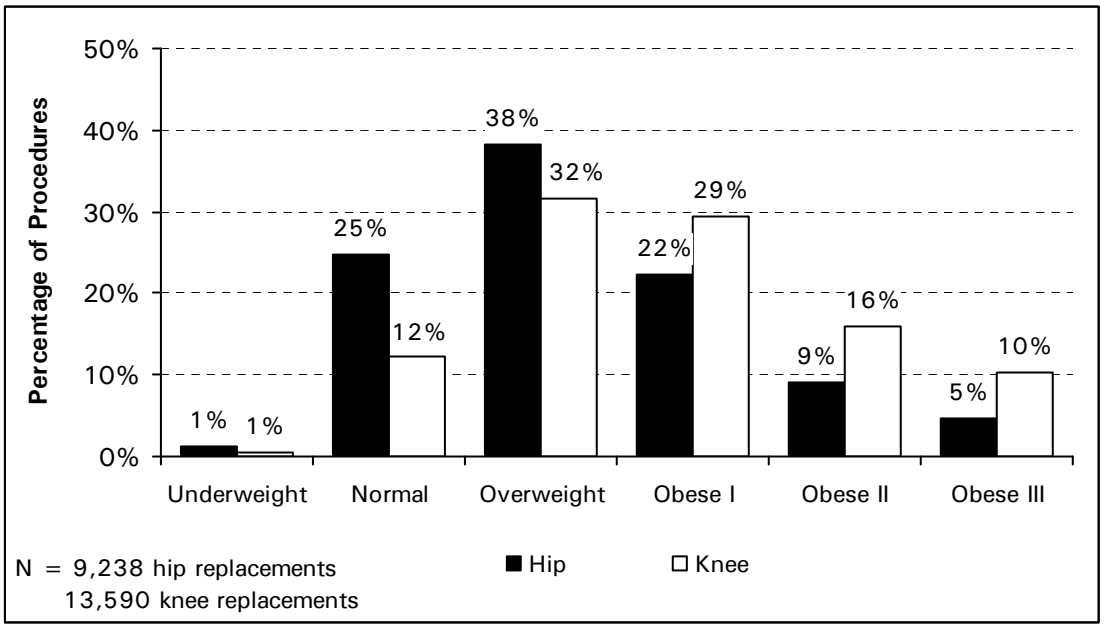
Figure 21. Hip and Knee Replacement Recipients by BMI Categories, CJRR, 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2005–2006.

While both hip and knee replacement patients in 2005–2006 were seen to have a high proportion who were obese and overweight, knee replacement recipients were found to be significantly more overweight or obese compared to hip replacement recipients (87% versus 74% combined, ($p < 0.0001$) (Figure 22). The proportion of patients in the underweight category who underwent either hip or knee replacements was negligible ($\leq 1\%$).

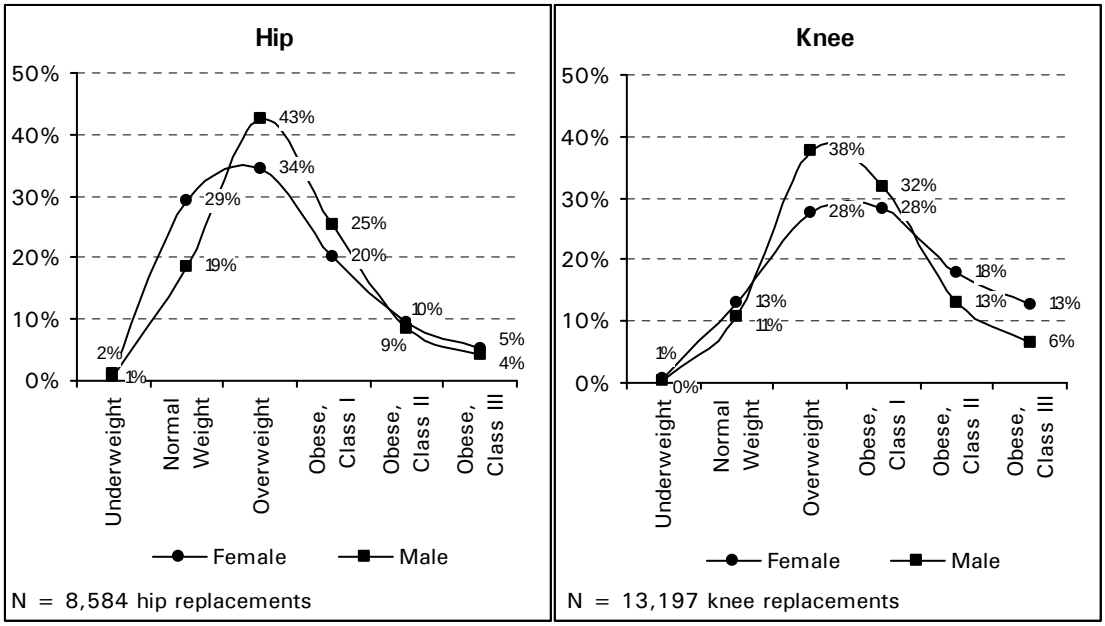
Figure 22. Hip and Knee Replacement Recipients by BMI Category, CJRR, 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2005–2006.

For hip replacements, significantly more males than females were observed to be overweight or obese (class I); similarly, for knee replacements. However, the reverse was observed for the obese class II and III groups, where more females than males were obese ($p < 0.001$) (Figure 23).

Figure 23. Relationship Between Sex and BMI, by Joint Replacement Type, CJRR, 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2005–2006.

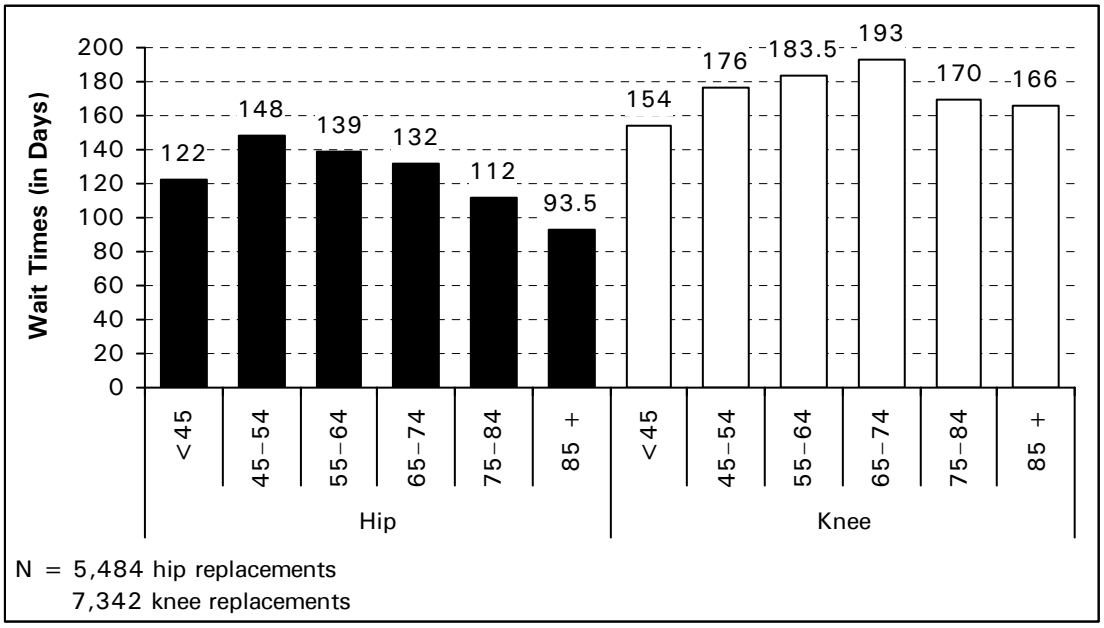
Wait Times

There is considerable interest in the amount of time that Canadians wait for various surgical procedures, including hip and knee replacement surgery. For the first time in Canada, we report on wait times for joint replacements, based on information provided by participating surgeons in the CJRR.[i] Wait times[ii] for joint replacement surgery in Canada varied for primary hip and knee replacements. Over the course of 2005–2006, in the CJRR, patients who were scheduled to undergo hip replacements waited significantly ($p < 0.0001$) shorter lengths of time relative to those who were scheduled to undergo knee replacements (median wait times of 127 days versus 182 days respectively).

Wait times differed significantly ($p < 0.0001$) between males and females. The median wait time for females who underwent a hip replacement was 15 days shorter than for males (120 days versus 135 days). For knee replacement surgeries, there was no significant difference noted in wait times between males and females.

No significant difference was noted in the relationship between age and wait times for knee replacements. In contrast, for hip replacement surgeries, wait times were significantly shorter for recipients who were 75 years of age and older than they were for other age groups (Figure 24).

Figure 24. Wait Times (in Days) by Age Groups for Hip and Knee Replacement Recipients, CJRR, 2005–2006

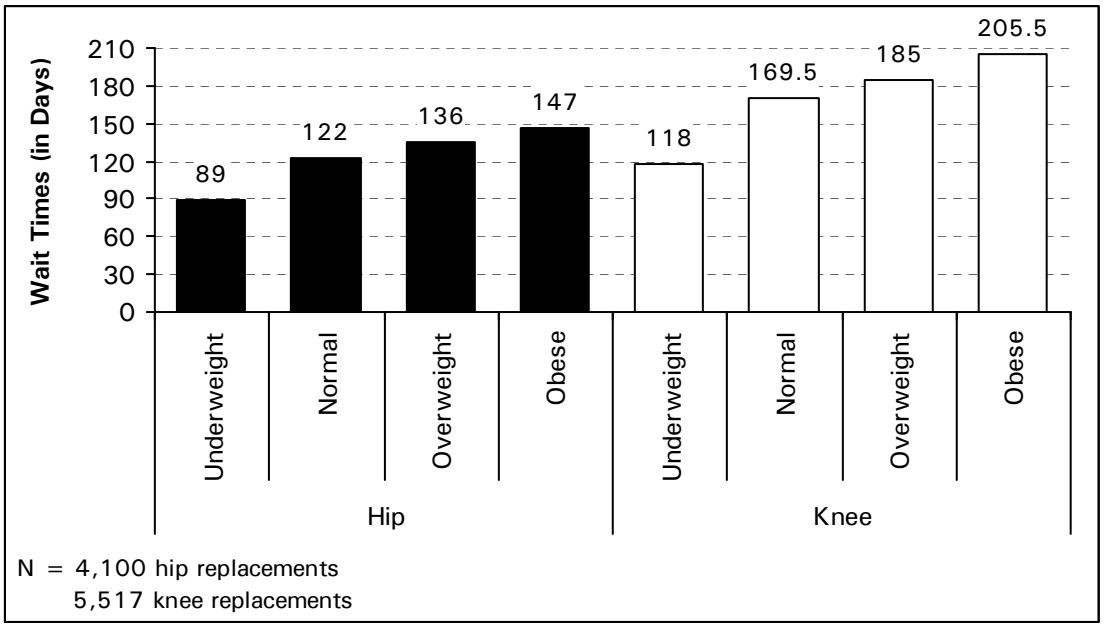


Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2005–2006.

i. More than 50% of the joint replacement cases in the CJRR had wait times information reported.
ii. As measured from the time an orthopedic surgeon made a decision, with a patient's consent, for surgery to the time when the actual surgery occurred (definition for wait times may vary by province).

Wait times for patients of various BMI categories were found to be significantly different ($p < 0.0001$). Escalating BMI was associated with longer wait times regardless of the type of joint replacement (hip or knee) a patient underwent (Figure 25).

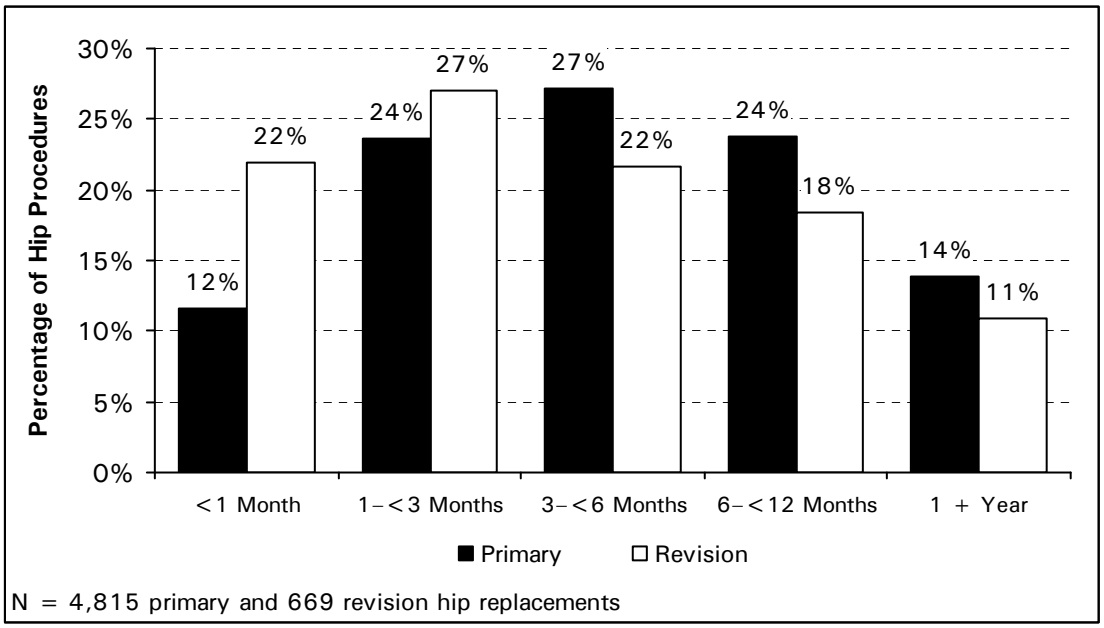
Figure 25. Relationship Between Wait Time (in Days) and BMI, by Joint Replacement, CJRR, 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2005–2006.

For hip replacement surgery, patients requiring a revision had significantly ($p < 0.0001$) shorter wait times than those requiring primary hip replacement (median of 91 days versus 132 days, respectively) (Figure 26). From the time the decision for surgery was made, 63% of patients underwent planned primary hip replacement in less than six months, followed by 24% of patients who had their primary hip replacement between 6 and 12 months. Meanwhile, 71% of patients had their revision done within six months from the time a decision for surgery was determined.

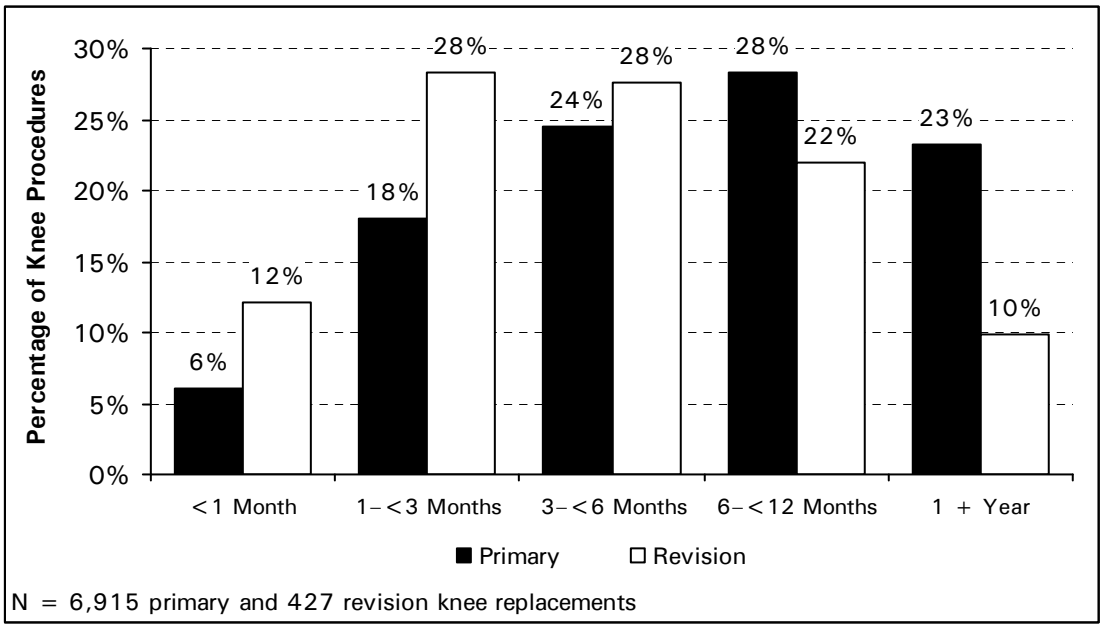
Figure 26. Wait Time (Days) Associated With Hip Replacement Procedures; Primary Versus Revision, CJRR, 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2005–2006.

Knee replacement revision recipients had significantly ($p < 0.0001$) shorter wait times than primary knee replacement recipients (median wait time of 112 versus 187 days respectively). From the time the decision for surgery was made, 48% of patients underwent planned primary knee replacement in less than six months, followed by 28% of patients who had their primary knee replaced between 6 and 12 months. Sixty-eight percent of patients had their revision performed within six months from the time a decision for surgery was made (Figure 27). In 2005–2006, recipients of primary knee replacements using a uni-compartmental approach (UKA) waited a median of 225 days.

Figure 27. Wait Time (Days) Associated With Knee Replacement Procedures; Primary Versus Revision, CJRR, 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2005–2006.

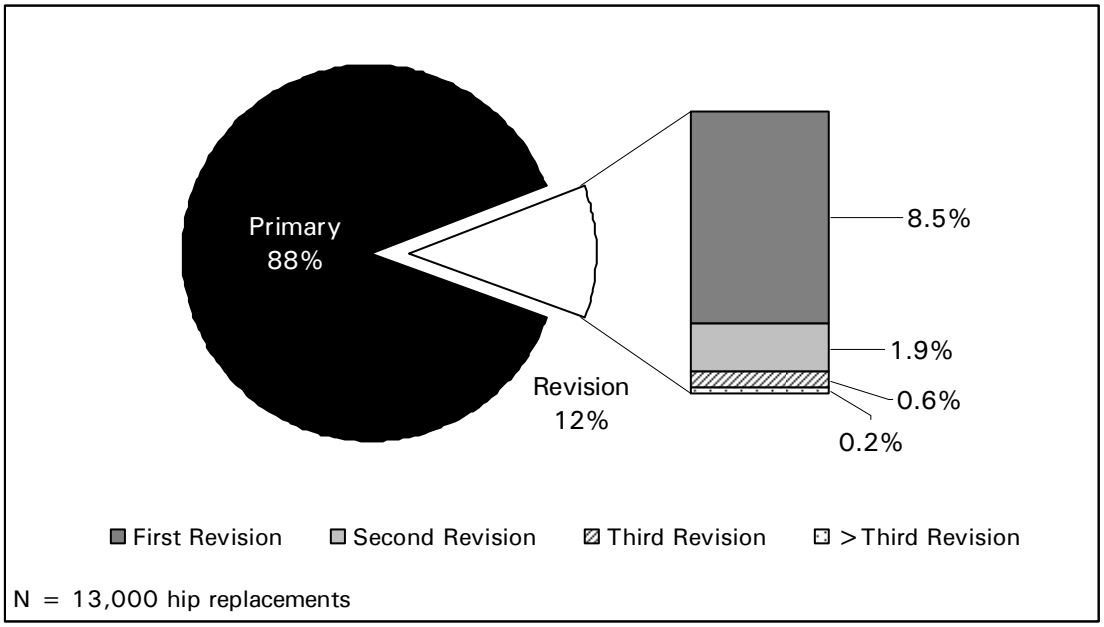
Surgical and Clinical Characteristics of Joint Replacement Surgeries Reported in CJRR

Type of Joint Replacement (Primary Versus Revision)

Primary Hip Replacement

Of all hip replacements reported in 2005–2006, 88% of surgeries involved primary replacements (Figure 28).

Figure 28. Hip Replacements, CJRR, 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2005–2006.

Since 2002–2003, a steady increase in the number of primary hip replacements has outpaced the growth in hip revisions in the CJRR by 15%. The cumulative increase was 52% for primary hip procedures. For hip revision, the increase over the four years was 37% (Table 12).

Table 12. Hip Replacements by Type of Surgery, 2002–2003 to 2005–2006

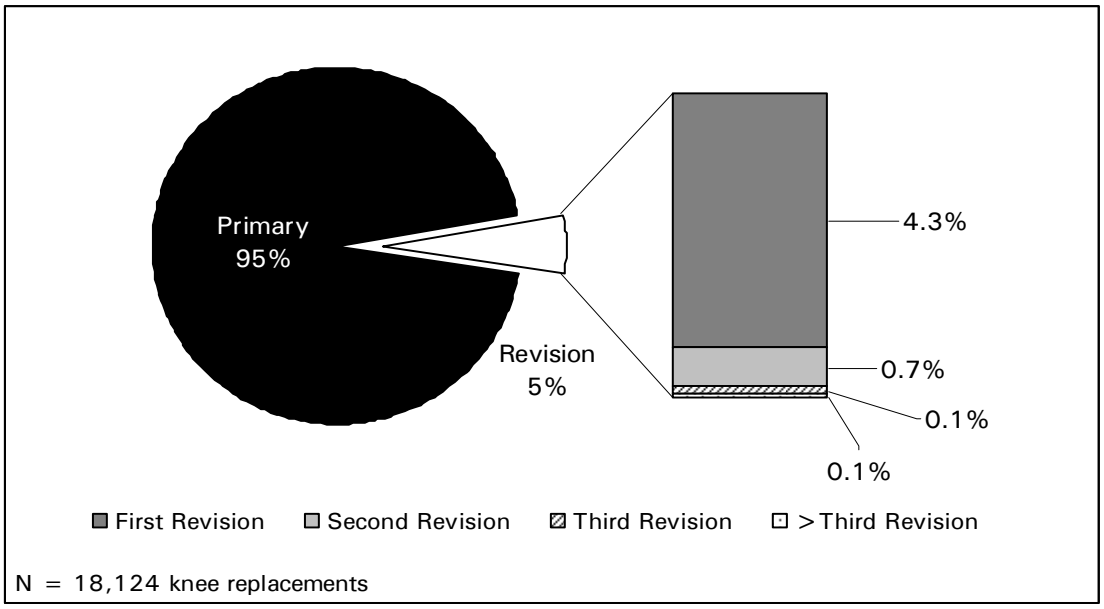
Type of Replacement	2002–2003		2003–2004		2004–2005		2005–2006		3-Year Increase
	N	%	N	%	N	%	N	%	%
Primary	7,520	87	10,154	87	12,687	88	11,430	88	52
Revision	1,111	13	1,555	13	1,691	12	1,521	12	37
First revision	804	9	1,123	10	1,247	9	1,094	8	36
Second revision	224	3	306	3	316	2	248	2	11
Third revision	65	1	80	1	80	1	83	1	28
>Third revision	18	0	46	0	48	0	32	0	78
Excision	4	0	3	0	11	0	8	0	100
Not Stated	14	0	17	0	44	0	41	0	193
Total	**8,649**	**100**	**11,729**	**100**	**14,433**	**100**	**13,000**	**100**	**50**

Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2002–2003 to 2005–2006.

Primary Knee Replacement

Among all the knee replacements reported in 2005–2006, 95% involved primary surgeries and 5% involved revisions (Figure 29).

Figure 29. Knee Replacements, CJRR, 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2005–2006.

Increases in the number of knee replacement procedures in the CJRR between 2002–2003 and 2005–2006 were mainly driven by an increase in primary procedures (primary versus revisions increase: 78% versus 58% for knee replacement respectively) (Table 13).

Table 13. Knee Replacements by Type of Surgery, 2002–2003 to 2005–2006

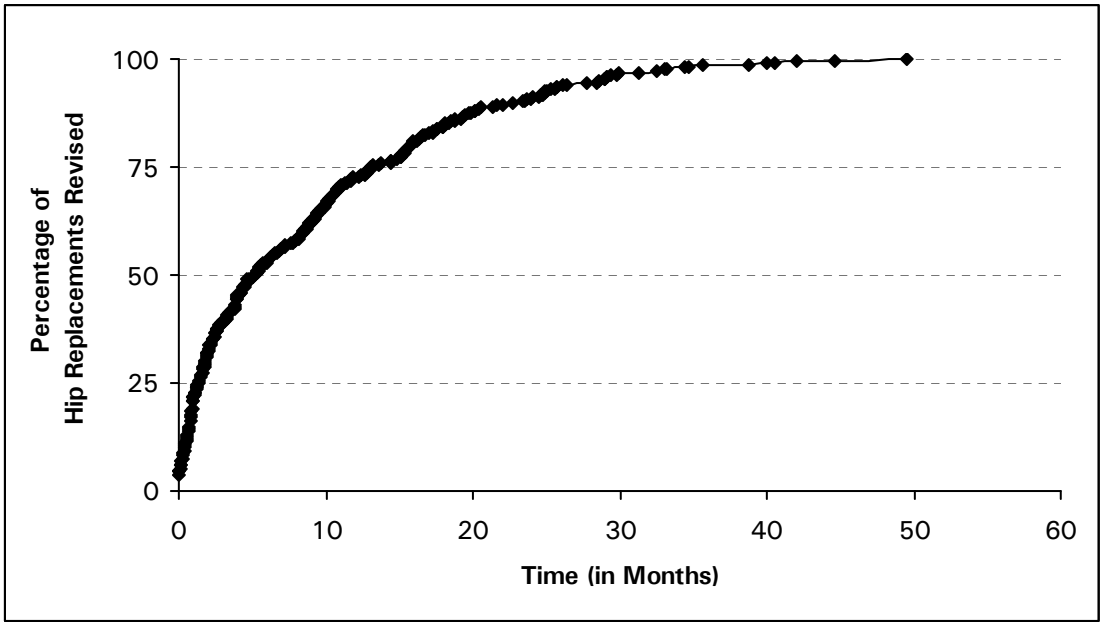
Type of Replacement	2002–2003		2003–2004		2004–2005		2005–2006		3-Year Increase
	N	%	N	%	N	%	N	%	%
Primary	9,589	94	13,905	94	17,860	94	17,082	94	78
Revision	615	6	932	6	1,132	6	973	5	58
First revision	502	5	768	5	918	5	779	4	55
Second revision	94	1	133	1	167	1	124	1	32
Third revision	13	0	21	0	30	0	20	0	54
>Third revision	6	0	10	0	17	0	13	0	117
Excision	5	0	5	0	8	0	11	0	120
Not Stated	16	0	16	0	23	0	58	0	263
Total	**10,225**	**100**	**14,858**	**100**	**19,023**	**100**	**18,124**	**100**	**77**

Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2002–2003 to 2005–2006.

Hip Revisions

Of the patients who required a revision, 50% had their hip revised in the first five months after their primary hip replacement. Females underwent their revision sooner than their male counterparts (4.6 months versus 5.6 months respectively) (Figure 30).

Figure 30. Cumulative Proportion of Revision Hip Replacements, CJRR, May 2001 to March 2006

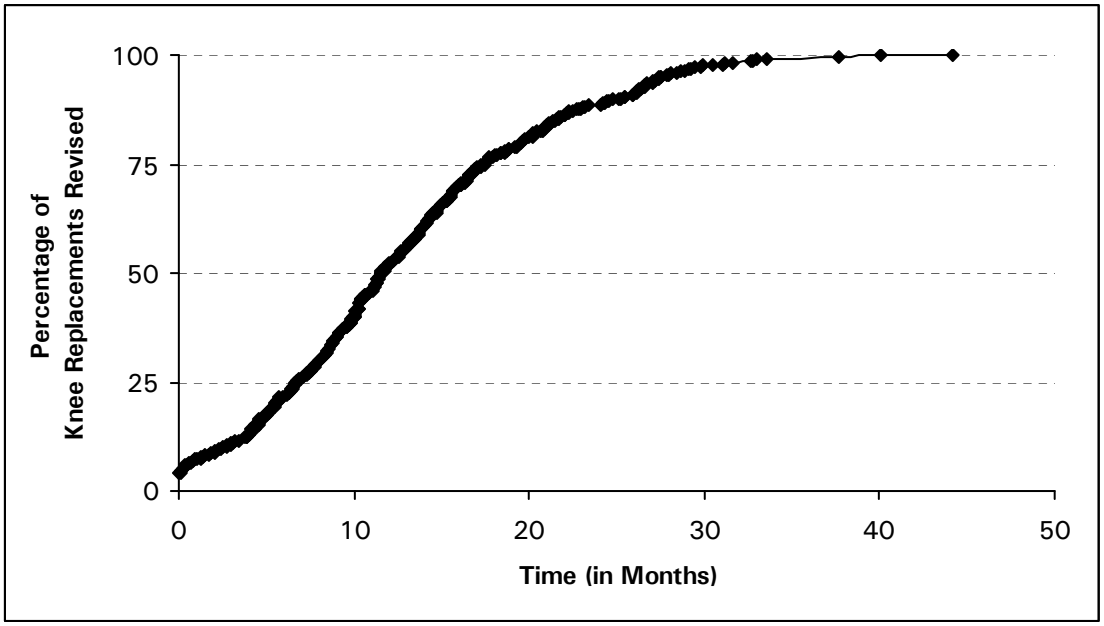


Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, May 2001 to March 2006.

Knee Revisions

Of the patients who required a revision subsequent to their primary knee replacement, 50% had the revision performed in the first 11.5 months following the primary knee replacement (Figure 31).

Figure 31. Cumulative Proportion of Knee Replacement Revisions, CJRR, July 2001 to April 2007

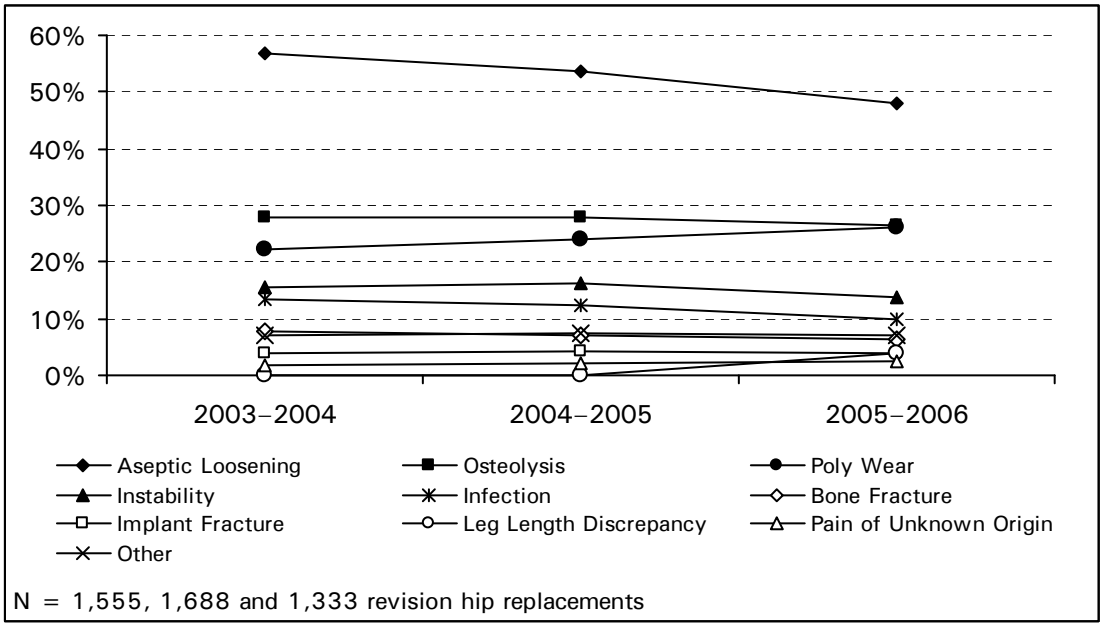


Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, July 2001 to March 2006.

Reasons for Hip Revision

Aseptic loosening (48%), followed by osteolysis (27%), poly wear (26%) and instability (14%) were leading reasons reported for a revision of a primary hip replacement in 2005–2006 (Figure 32).

Figure 32. Reasons Reported for Revising Hip Replacements, 2003–2004 to 2005–2006

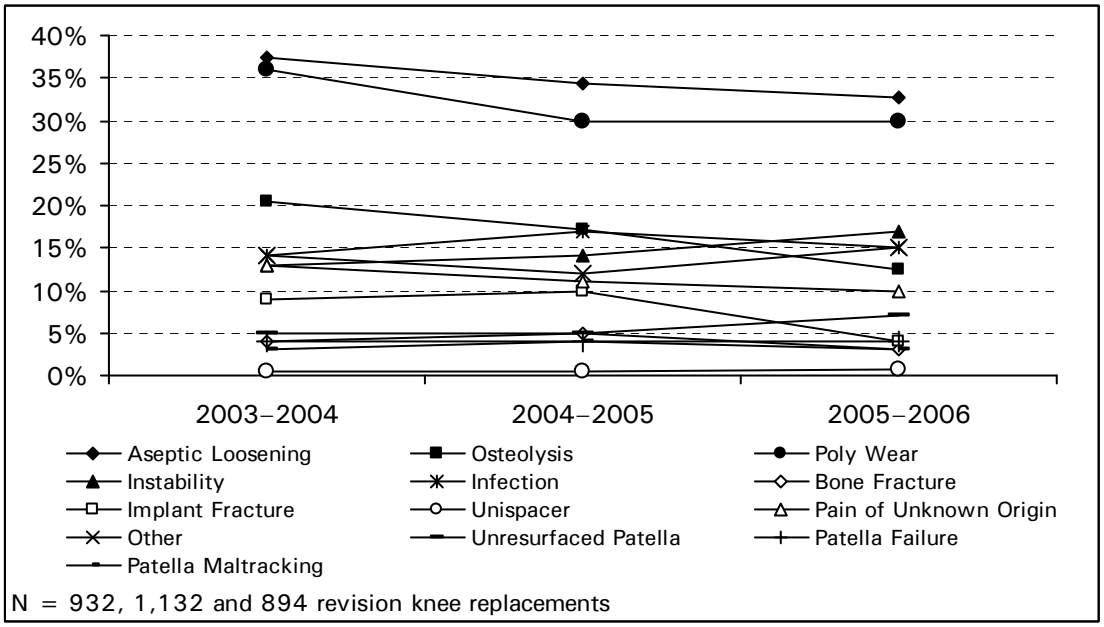


Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2005–2006.

Reasons for Knee Revision

Among all the knee replacements reported in 2005–2006, 5% were revisions (Figure 29). The most common reason reported for knee replacement revisions in 2005–2006 was aseptic loosening (33%), followed by poly wear (30%) and instability (17%) (Figure 33). The proportion of revisions done because of osteolysis has decreased significantly ($p = 0.009$) from the last year, from 18% to 12%.

Figure 33. Reasons Reported for Revising Knee Replacements, 2003–2004 to 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2005–2006.

Classification of Surgical Types for Joint Replacements

Hip Replacement

A hip replacement may involve a total arthroplasty or a partial (hemi-arthroplasty). Total arthroplasty entails replacing all three natural parts (ball, socket, and bone shaft) with a prosthetic device. Hemi-arthroplasty may be monopolar (where only the femoral head and stem are replaced) or bipolar (where the femoral head and stem and the acetabular compartment, but not the acetabular insert/liner, are replaced). When resurfacing (bone-conservative method) of the hip joint is performed, it may entail full resurfacing (replacing the femoral head and acetabular compartment) or hemi-resurfacing (replacing only the femoral head).

In the CJRR, the vast majority of hip arthroplasties, both primary and revision, involved total arthroplasties (91% for primary and 77% for revision) (Table 14).

See Appendix B for the method used to define these types of surgeries.

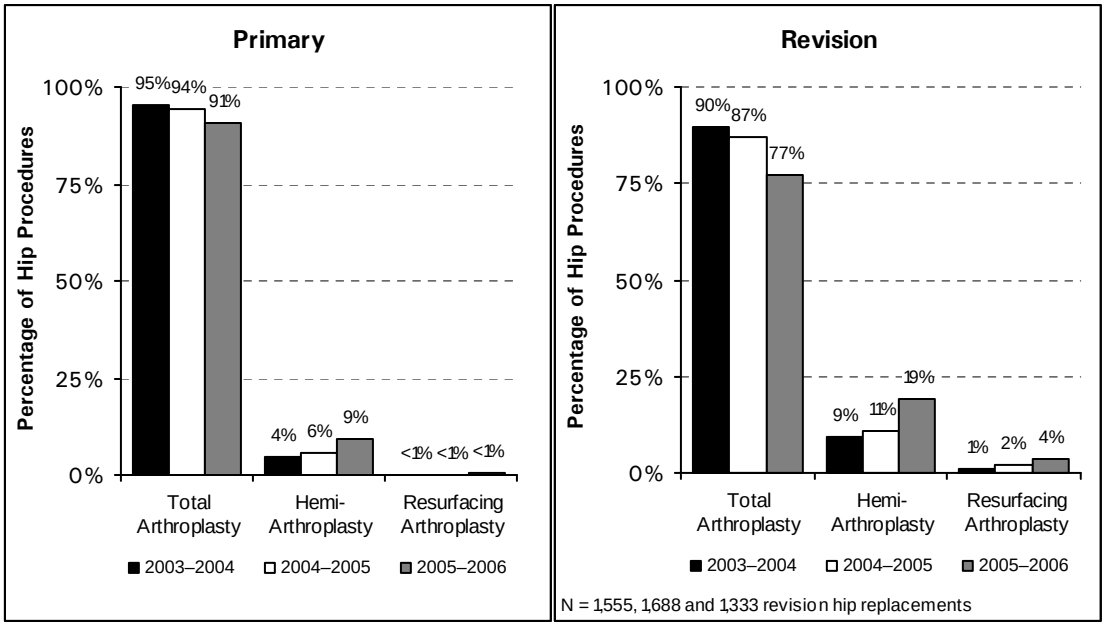
Table 14. Hip Replacements by Type of Surgery, 2005–2006

Type of Replacements	Total Arthroplasty	Hemi Arthroplasty		Resurfacing Arthroplasty	
		Monopolar	Bipolar	Full	Hemi
Primary HA	91%	4%	5%	<1%	<1%
Revision HA	77%	15%	4%	2%	2%
All HA	90%	5%	5%	<1%	<1%

Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2005–2006.

Over the past three years, procedures involving hemi-arthroplasty have increased, while procedures involving total hip arthroplasty have decreased, especially with revisions ($p < 0.0001$) (Figure 34). The proportion of total arthroplasties used in revision procedures has decreased by 10% compared to the previous year (87% in 2004–2005).

Figure 34. Trends in Type of Hip Arthroplasty, CJRR, 2003–2004 to 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2003–2004 to 2005–2006.

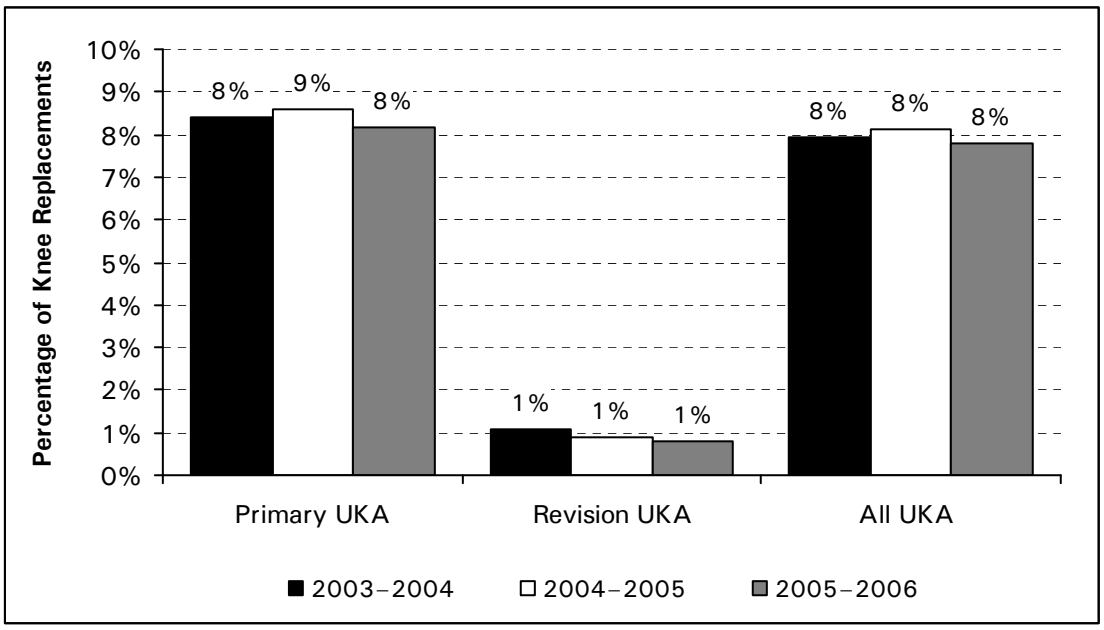
Knee Replacement

Knee replacement surgery may involve a total knee replacement, uni-compartmental arthroplasty (UKA) or patellofemoral replacement. A total knee arthroplasty involves replacing all three compartments of the knee (medial, lateral, and patellofemoral compartments).

UKA involves replacing one or both of the medial and lateral compartments. UKA may be performed in patients who have only limited knee arthritis. The procedure consists of replacing only one side of the knee joint. A uni-compartmental approach allows the other compartment and all ligaments to remain intact. By retaining the remaining normal compartments of the knee, it is hypothesized that the joint may function more naturally.[15, 16] Patellofemoral replacement involves replacing the patellofemoral component—the joint between undersurface of the knee cap (patella) and the femur.

In the CJRR, the UKA procedure rates have remained steady over the past three years (UKA procedures accounted for 8% to 9% of primary replacements and total knee replacements accounted for 91% to 92%) (Figure 35).

Figure 35. UKAs—Primary and Revisions as a Proportion of All Knee Replacements, CJRR, 2003–2004 to 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2003–2004 to 2005–2006.

Joint Replacement Surgical Approach

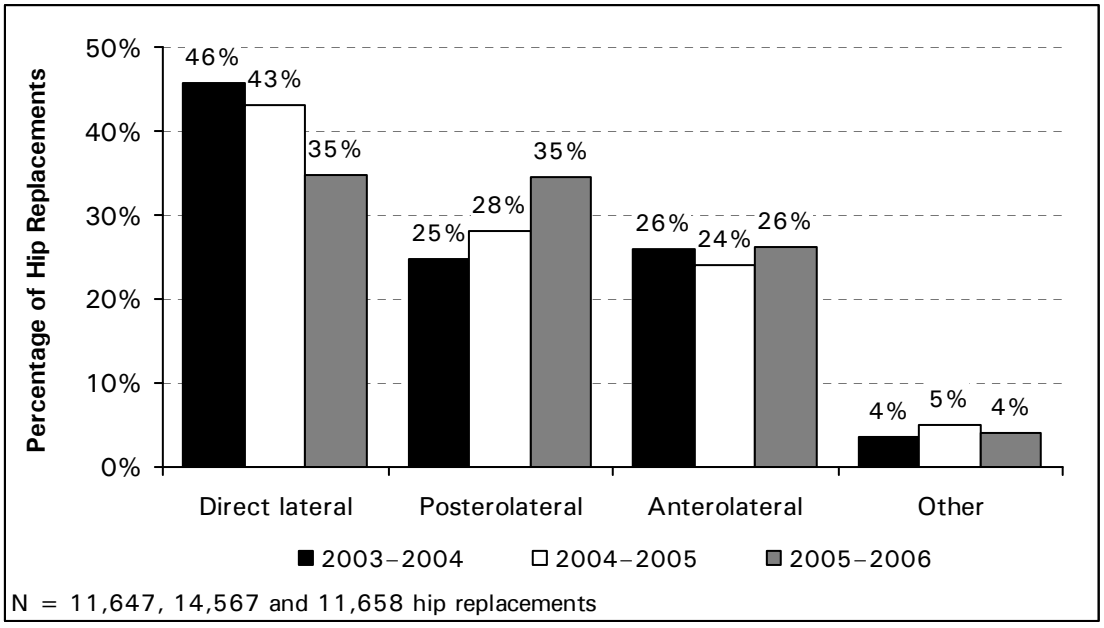
Hip and knee replacement surgery may be undertaken using either a conventional approach or a minimally invasive approach.

A conventional hip replacement involves a standard incision of 25–40 cm in length, while a minimally invasive hip replacement involves a shorter incision of < 10 cm in length.[17] Conventional hip surgical approaches include posterolateral, anterolateral, anterior (that is, Smith-Peterson), direct lateral or transgluteal (that is, Hardinge), and lateral transtrochanteric (that is, Charnley).[18, 19, 20] A conventional knee replacement involves a standard incision, 20 to 30 cm in length, while a minimally invasive knee replacement involves a shorter incision, 10 to 12 cm in length.[21]

Conventional Surgical Approach

Significant trends ($p < 0.0001$) were noted among the type of conventional surgical approaches used for hip arthroplasties over the three years studied (2003–2006, Figure 36). Over this time, the use of a direct lateral approach for hip arthroplasty declined, from 46% to 41% to 35%, while the use of a posterolateral surgical approach for hip arthroplasty rose by 10%. The Smith-Peterson and two-incision approaches (anterior surgical approach, captured under "other") were each used in less than 1% of surgeries.

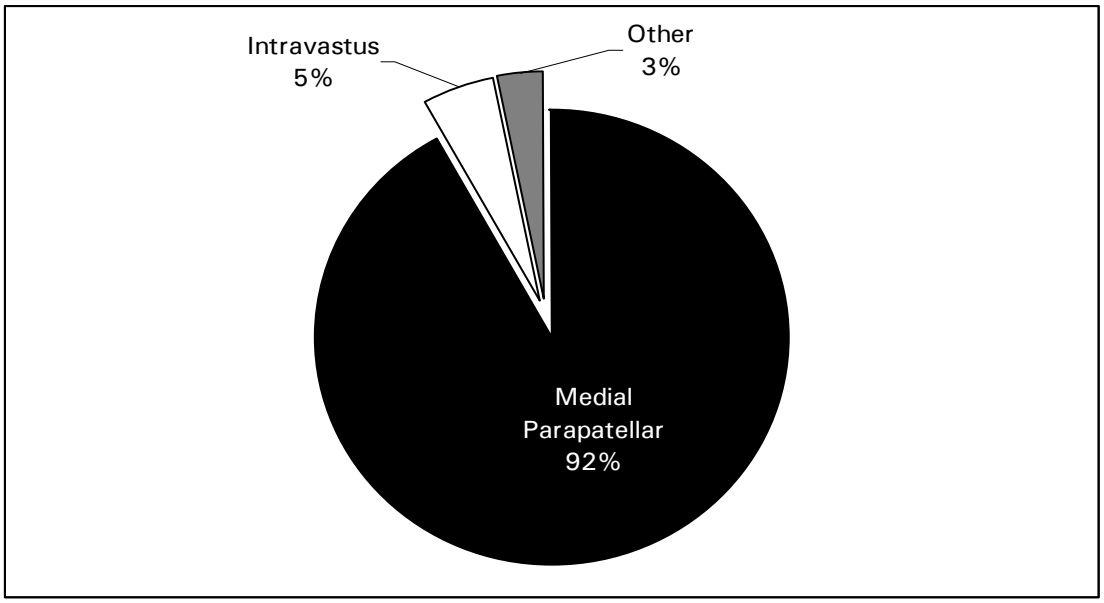
Figure 36. Surgical Approach for Hip Replacements, 2003–2004 to 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2003–2004 to 2005–2006.

The use of conventional surgical approaches in knee replacement surgeries has remained consistent over the past three years. Among the knee replacements reported in the CJRR over the 2005–2006 period, 92% of the procedures were done with a medial parapatellar approach and 5% of the procedures were done with an intravastus approach (Figure 37).

Figure 37. Knee Replacements by Surgical Approach, CJRR, 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2005–2006.

Minimally Invasive Surgery Surgical Approach

In 2005–2006, one-tenth of the hip replacement and one-eighth of the knee replacement procedures were reported using minimally invasive surgery in the CJRR. Minimally invasive surgery is an emerging surgical technique used for both hip and knee replacement procedures and is the subject of this annual report's focused chapter. For comprehensive information about the use of minimally invasive surgery reported in CJRR for hip and knee replacement procedures, please see the special focused chapter of this report.

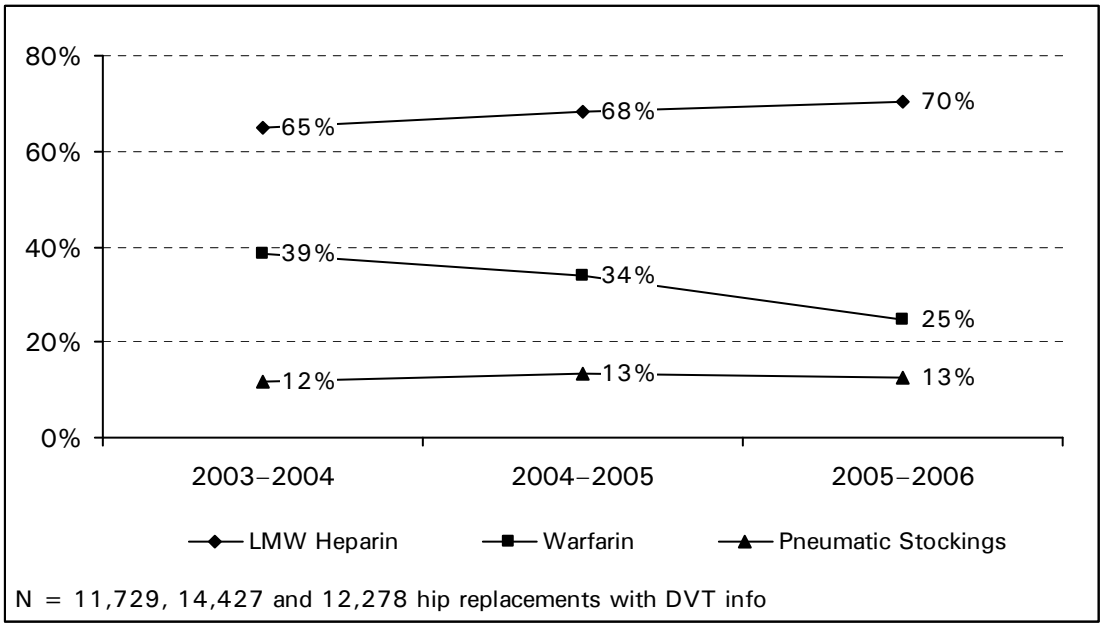
Joint Replacements and Deep Vein Thrombosis (DVT)

One of the major risks facing patients who undergo orthopedic surgery in the lower extremities is a complication called deep vein thrombosis (DVT), a form of venous thromboembolic disease. In response to this potential risk, pharmacologic prophylaxis such as aspirin, warfarin and heparin are used as DVT prophylactic (prevention) therapy.

In 2005–2006, 97% of hip replacement and 99% of knee replacement patients received DVT prophylactic treatment. Since 2003–2004, three types of DVT prophylactic pharmacologic agents have been used consistently:

- low molecular weight (LMW) heparin—the most commonly used among hip and knee replacement recipients (70% and 68% respectively in 2005–2006) with significantly increased use over time ($p<0.0001$);
- Warfarin (25% each in 2005–2006) with significantly decreased use over time ($p<0.0001$); and
- pneumatic stockings, with steady use over time at 13% and 11% respectively (figures 38 and 39).

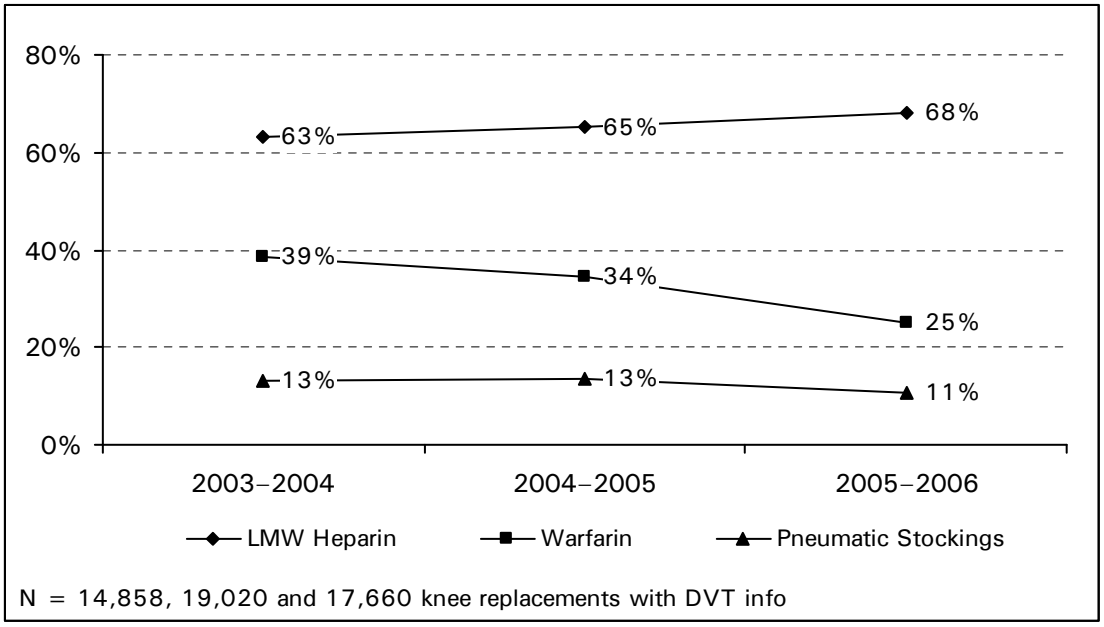
Figure 38. DVT Preventive Agents, Hip Replacements, 2003–2004 to 2005–2006



Note:
Percentages by year total more than 100%, as more than one DVT preventive agent may be used.

Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2003–2004 to 2005–2006.

Figure 39. DVT Preventive Agents, Knee Replacements, 2003–2004 to 2005–2006



Note:
Percentages by year total more than 100%, as more than one DVT preventive agent may be used.

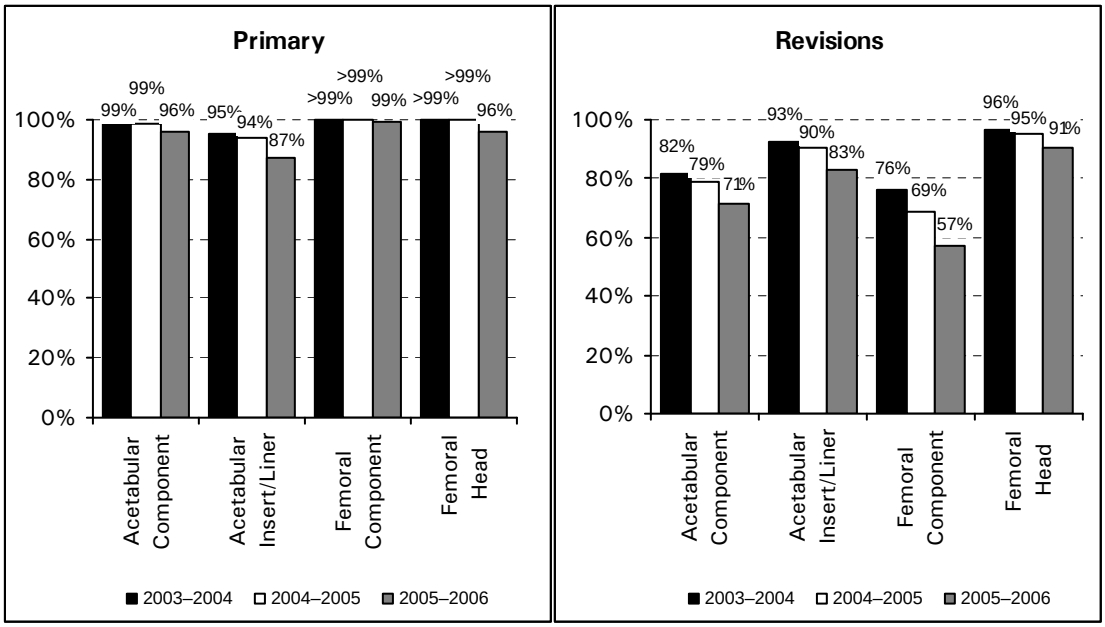
Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2003–2004 to 2005–2006.

Joint Replacement Prosthesis Characteristics

Component Types Implanted for Hip Replacement Surgeries

There are four basic components used for hip replacement surgeries. These include acetabular component, acetabular insert/liner, femoral component and femoral head. All components of the naturally occurring bone joint were significantly more likely to be replaced during primary hip replacements than during revisions (Figure 40). With hip replacement revisions, replacement of the femoral head was the most common surgical procedure (91%) while replacement of the femoral stem/ component was the least common (57%) (Figure 40).

Figure 40. Compartments Inserted or Replaced by Primary and Revision Hip Arthroplasty, CJRR, 2003–2004 to 2005–2006

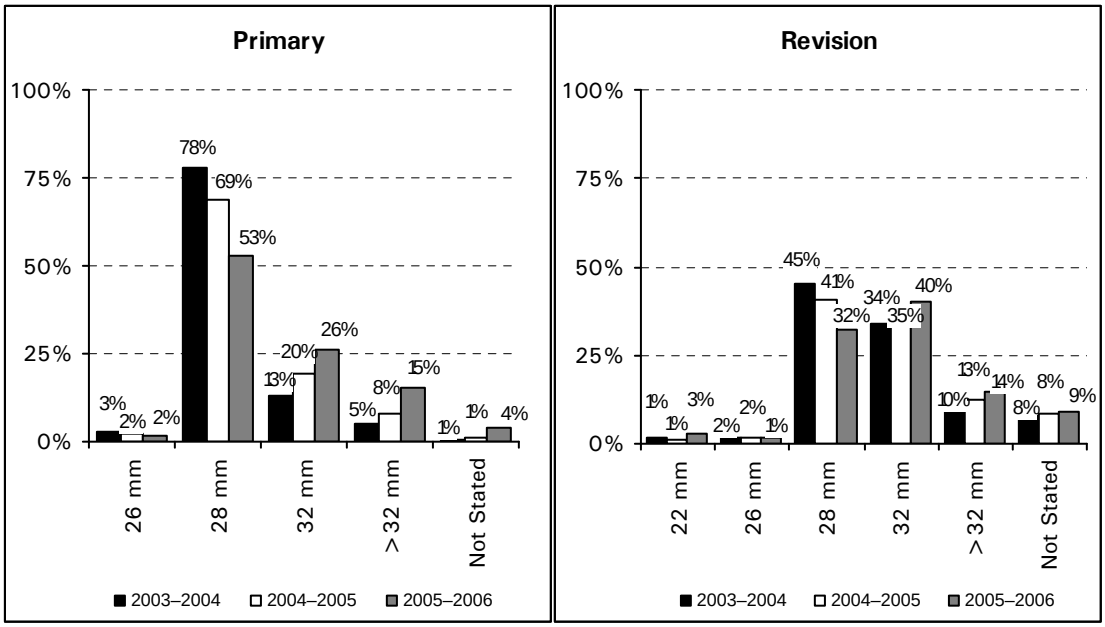


Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2003–2004 to 2005–2006.

Size of Femoral Head Implanted for Hip Replacement Surgery

The stability and durability of hip reconstruction is dependent on many factors, including the design and size of prosthetic components. In the CJRR, a femoral head size of 28 mm was most commonly used for hip replacement (primary and revision: 53% and 32% respectively), followed by a femoral head size of 32 mm (primary and revision: 26% and 40%). Of note, there is a significantly increasing trend in the use of 32 mm femoral heads, and a decreasing trend in the use of 28 mm femoral heads. Similar patterns are noted for primary and revision hip replacement procedures (Figure 41).

Figure 41. Size of Femoral Head Used for Primary and Revision Hip Replacements, CJRR, 2003–2004 to 2005–2006

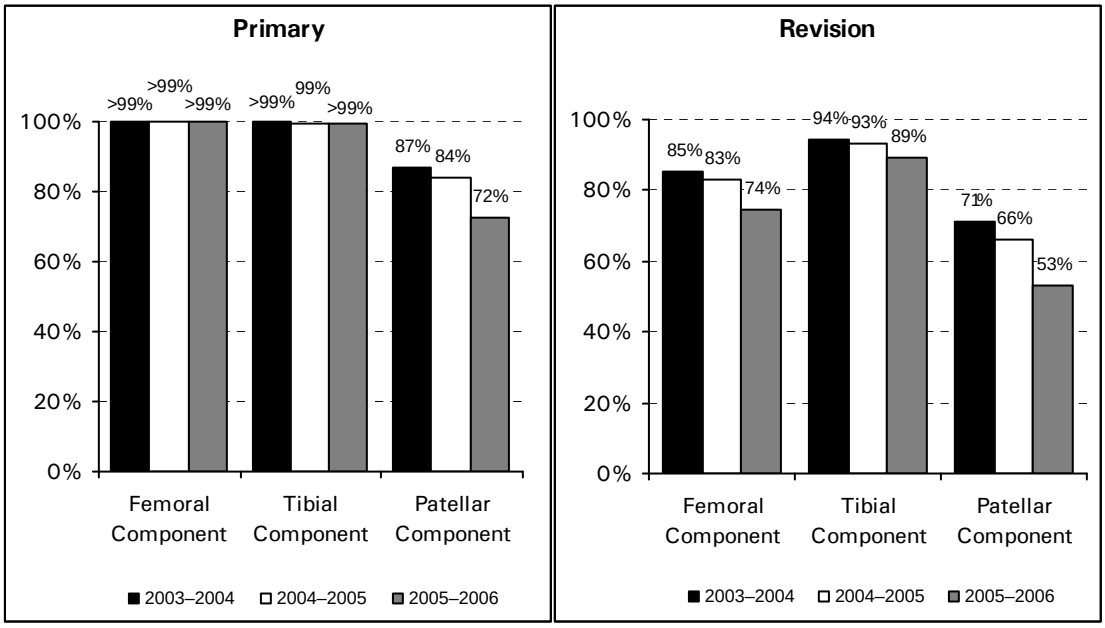


Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2003–2004 to 2005–2006.

Component Types Implanted for Knee Replacement Surgeries

There are three basic components used for knee replacement surgeries. These include femoral component, tibial component and patellar component. Among primary knee replacements reported, over 99% of the cases involved replacing the femoral and tibial compartments. In 2005–2006, with knee replacement revisions, replacement of the tibial component was the most common procedure (89%), followed by the femoral component (74%).

Figure 42. Knee Replacement Components by Primary and Revision Knee Arthroplasties, CJRR, 2003–2004 to 2005–2006

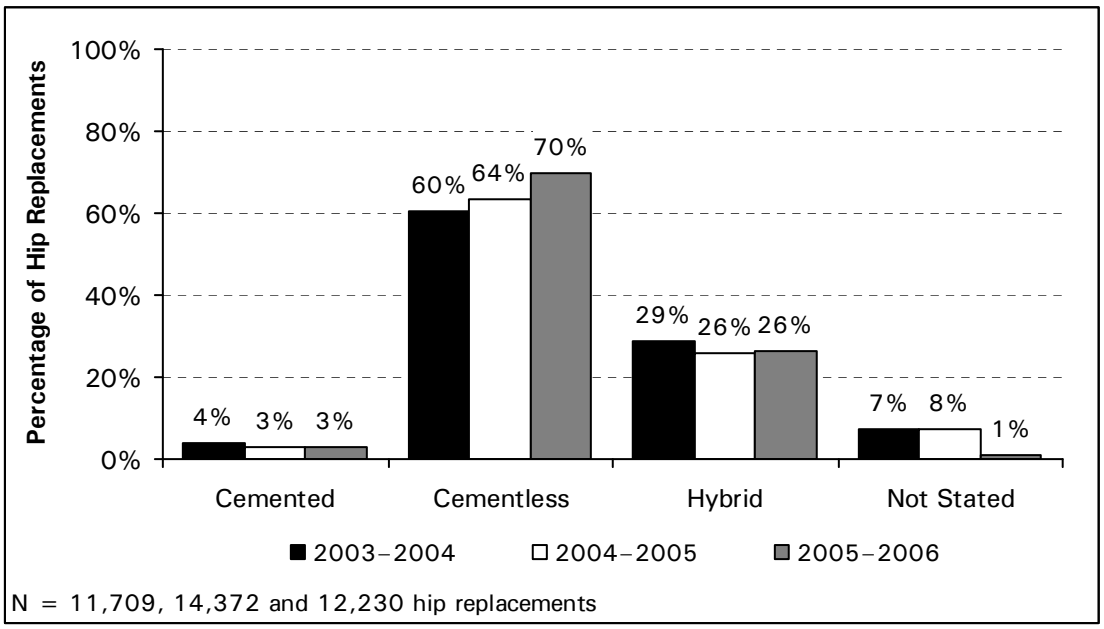


Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2003–2004 to 2005–2006.

Fixation Method in Joint Replacement Surgeries

In 2005–2006, cementless (70%) was the most common form of fixation method used for hip replacement (primary and revision) procedures, followed by hybrid (26%) (Figure 43). Between 2003–2004 and 2005–2006, there was an increasing use of the cementless fixation method for hip replacement procedures ($p < 0.0001$).

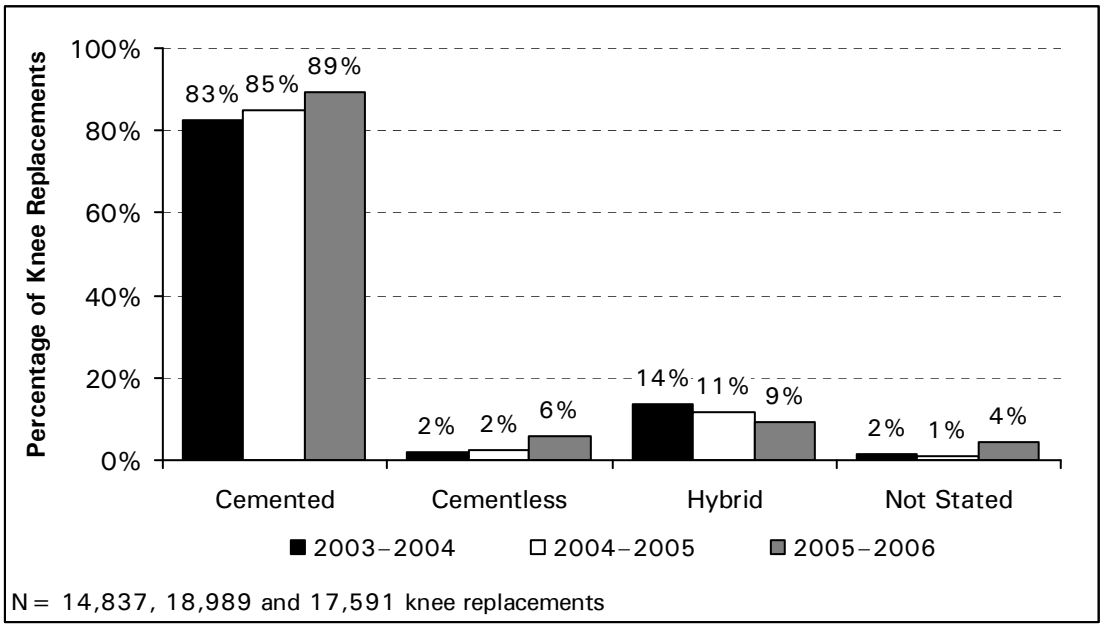
Figure 43. Fixation Method for Hip Replacement Procedures, CJRR, 2002–2003 to 2004–2005



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2003–2004 to 2005–2006.

Among all knee replacements reported to CJRR in 2005–2006, cemented (89%) was the most common form of fixation method used, followed by hybrid (9%) (Figure 44). Between 2003–2004 and 2005–2006, there was a significant increasing trend ($p < 0.0001$) of a cemented fixation method. In 2005–2006, fixation methods in primary and revision knee arthroplasties were similar.

Figure 44. Fixation Methods for Knee Replacement Procedures, CJRR, 2003–2004 to 2005–2006

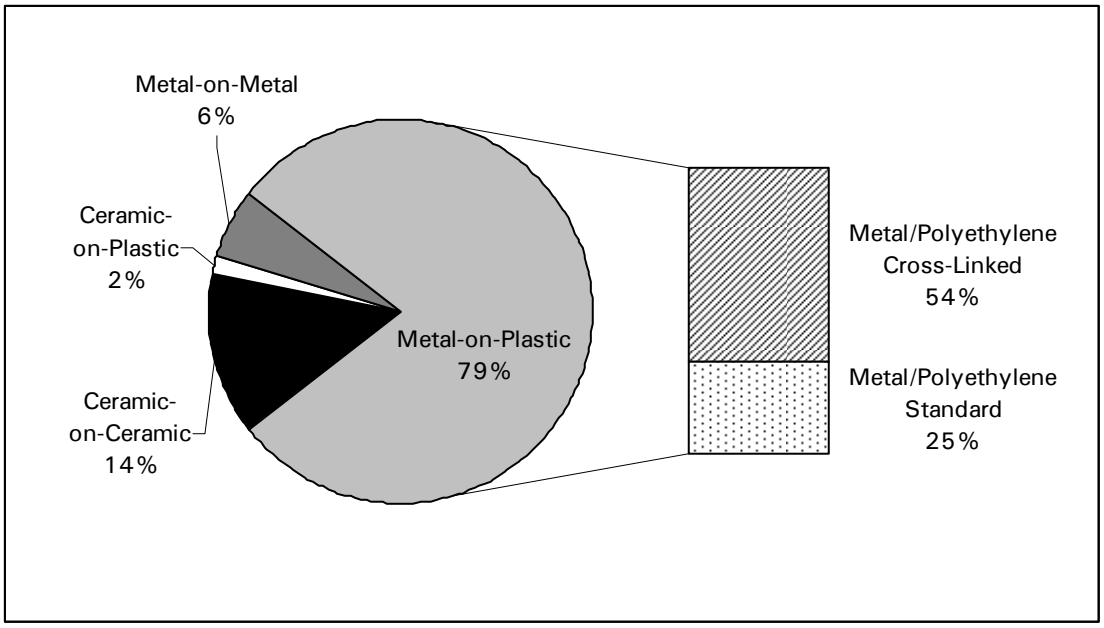


Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2003–2004 to 2005–2006.

Bearing Surfaces for Hip Replacements

Although various combinations of femoral head and acetabular liner materials were used in performing hip replacement procedures, the most common bearing surface was metal-on-plastic (79%), primarily cobalt chrome/cross-linked polyethylene (Figure 45). There is a significantly ($p < 0.0001$) increasing trend in using cobalt chrome/cross-linked polyethylene over cobalt chrome/polyethylene standard (Figure 46).

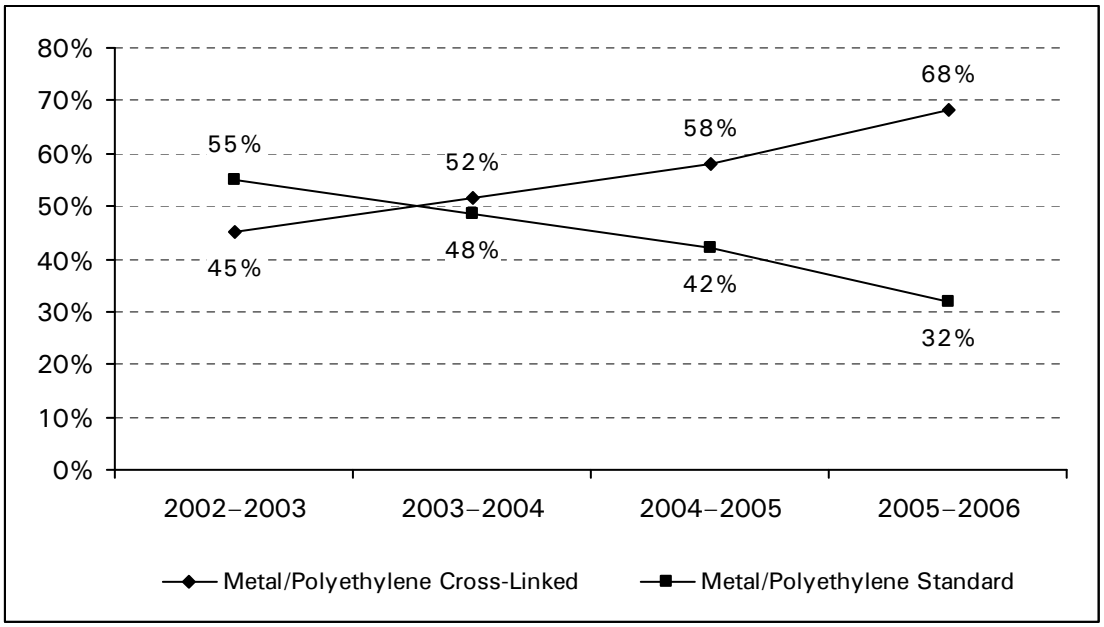
Figure 45. Bearing Surfaces for Hip Replacements, 2005–2006



Note:
The denominator for percentages calculation excludes records with no information available on bearing surfaces.

Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2005–2006.

Figure 46. Types of Metal-on-Plastic Bearing Surfaces, Hip Replacements, 2002–2003 to 2005–2006



Note:
The denominator for percentages calculation excludes records with no information available on bearing surfaces.

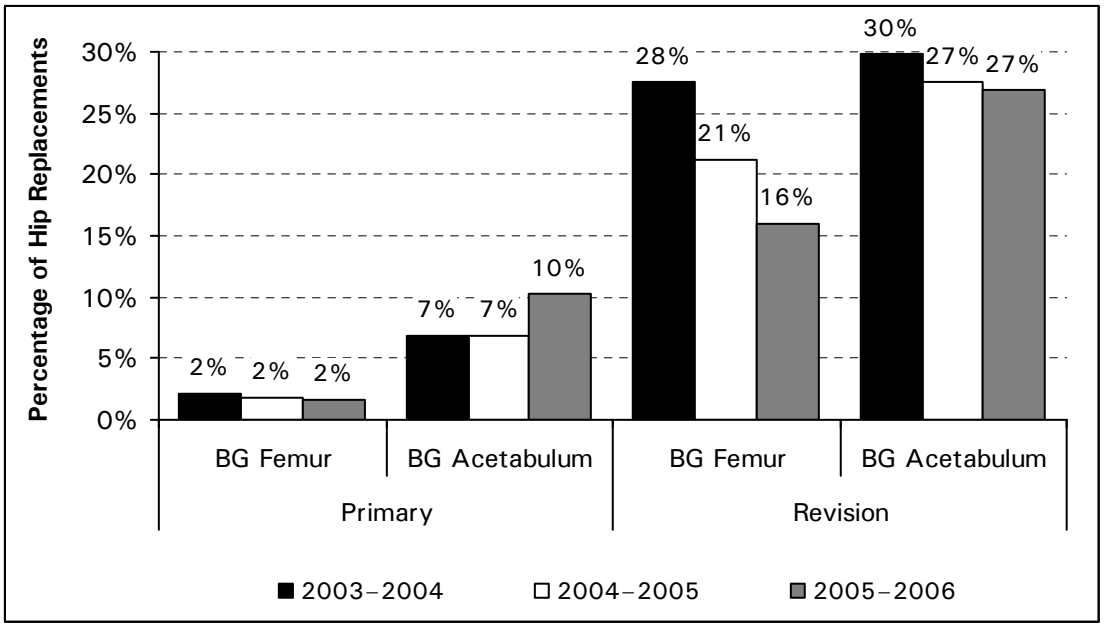
Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2002–2003 to 2005–2006.

Bone Graft Use in Joint Replacement Surgeries

Collection of information on bone graft (BG) use began in 2003–2004, with data captured regarding BG use on the femur and acetabulum for hip replacements. As in the previous years, in 2005–2006, grafts were used more frequently for revision procedures than for primary replacements.

For hip replacement revisions, BG transplantation on the femur was higher for revisions (16%), as compared to primary procedures (2%). For revision procedures, 27% used grafts on the acetabulum, compared to 10% for primary procedures (Figure 47).

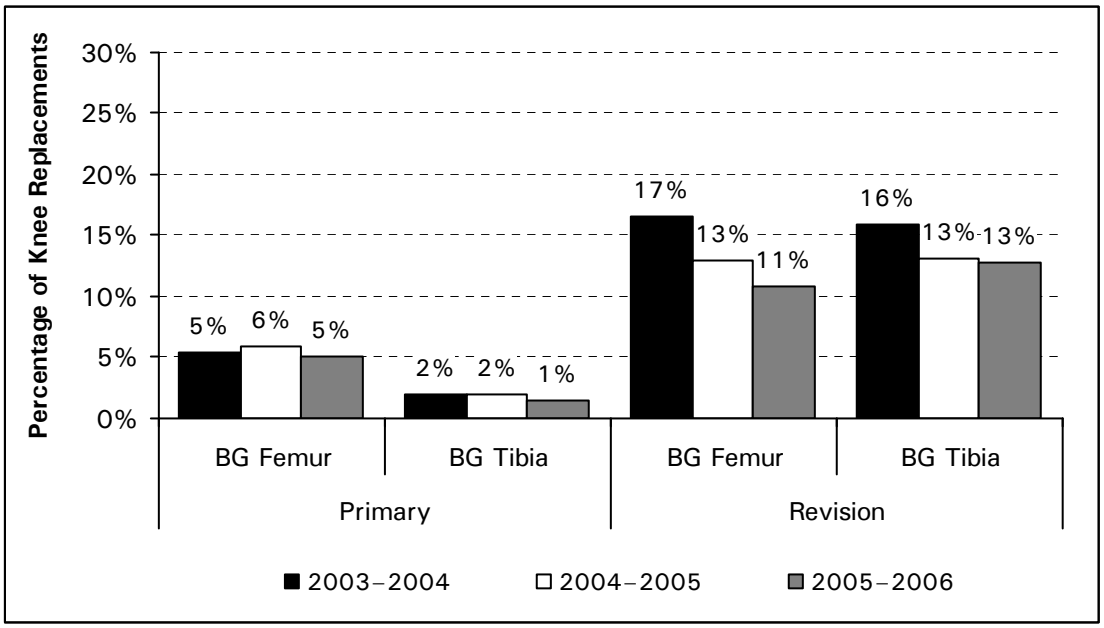
Figure 47. BG Use for Hip Replacements, 2003–2004 to 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2003–2004 to 2005–2006.

For knee replacement procedures in 2005–2006, bone grafts on the femur and tibia were more frequently used among revisions (24%) than among primary replacements (6%). Femur bone grafts were transplanted in 11% of the revisions and in 5% of the primary knee replacements; tibia bone grafts were transplanted in 13% of the revisions and in 1% of the primary knee replacements (Figure 48).

Figure 48. BG Use for Knee Replacements, 2003–2004 to 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2003–2004 to 2005–2006.

Summary of Findings

Knee replacement recipients had significantly higher BMI than hip replacement recipients. With escalating BMI, an increase in wait times was observed regardless of the type of joint replacement (hip or knee). Among the hip and knee replacement recipients, BMI in the obese class I (BMI between 30.0 and 34.9) category represented the largest proportion (22% and 29% respectively) in 2005–2006.

Degenerative OA was indicated as the most common responsible diagnosis for elective primary hip (81%) and knee (93%) replacements.

Overall in 2005–2006, Canadians waited a significantly shorter period of time for hip replacement surgeries (median 127 days) than for knee replacements (median 182 days). Furthermore, wait times for hip and knee replacement revisions were significantly shorter than for primary hip and knee replacements (91 days and 112 days; 132 days and 187 days respectively).

For patients requiring a revision subsequent to their primary hip or knee replacement, 50% had their hip revised in the first five months and 50% had their knee revised in the 11.5 months following their primary replacement.

Focus on Minimally Invasive Surgery

Overview

Minimally invasive surgery is a relatively new approach for a variety of surgical interventions. Over the past several decades, total hip and total knee joint replacements have been among the most successful orthopedic procedures, and with a continuing focus on improving surgical technique there has been heightened interest in using minimally invasive surgery to accomplish this. Minimally invasive surgery, by virtue of its definition, is a procedure performed through a shortened skin incision, and is a modified version of the conventional approach in hip and knee replacement. For total knee replacement through minimally invasive surgery, the incision is 10.9 to 14.0 cm (compared to 19.8 to 30.5 cm for a conventional approach). For total hip replacement using minimally invasive surgery, the surgical incision ranges from 7.6 to 10.2 cm—about a third of that used in the conventional approach (20.3 to 25.4 cm).[22] The goals of implementing minimally invasive surgery are to minimize surgical trauma, blood loss, scarring, and length of stay in hospital, while maximizing analgesia and promoting more effective rehabilitation and overall recovery.[21]

This chapter provides a profile of patients undergoing minimally invasive surgery, delineating demographic and clinical characteristics and considerations. As well, the wait times reported for this group of patients are explored in comparison to wait times for the conventional approach. Finally, revision rates are reported for patients undoing their joint replacement procedure through a minimally invasive approach.

The outcomes associated with the use of minimally invasive surgery currently have mixed results reported in the literature.[23, 24, 25, 26, 27, 28] The goal of this chapter is to provide new and comprehensive analyses through CJRR data to enhance the understanding of minimally invasive surgery, both from a clinical and a policy perspective, as an alternative surgical approach for hip and knee replacement procedures in Canada.

Minimally Invasive Surgery in CJRR

The CJRR began collecting national information related to minimally invasive surgery on April 1, 2003. Primary hip and knee replacement procedures (81,131) conducted between April 1, 2003 and March 31, 2006, recorded in the CJRR, were used for the analysis of minimally invasive procedures in Canada. Of the 81,131 primary joint replacements, 33,545 (41.4%) were classified as primary hip replacement and 47,586 were classified as primary knee replacement.

The minimally invasive approach was reported in 10.0% of cases.[iii] In this analysis, records with missing information pertaining to surgical approach, date of birth, sex, or surgical date were excluded. In total, 30,127 primary hip replacement and 41,467 primary knee replacement procedures were examined, using descriptive and logistic regression analyses.

iii. Surgical approach information was missing in 11.6% of the cases.

Analytic Methods

A full description of the analytic techniques and limitations is included in Appendix D. For this chapter, descriptive and quantitative analyses, including an analysis of the characteristics of those patients who receive them, were used to increase understanding of the use of minimally invasive techniques for hip and knee replacement procedures in Canada. In addition, longitudinal analyses were undertaken to provide early information about revisions related to minimally invasive techniques in the patient population (those who have had minimally invasive surgery primary joint replacement). Factors related to knee and hip replacement procedures were examined separately, using eight variables: primary diagnosis, body mass index (BMI), surgery date, age at surgery, sex, province, category of patient residence (urban–rural), and neighbourhood income.

For the purposes of this analysis, 8,044 joint replacement procedures using a minimally invasive approach are examined (4,212 hip, 3,832 knee).

Minimally Invasive Surgery and Total Knee Replacement

Overall, a conventional surgical method (standard incision) was used in the vast majority of knee replacement procedures in the CJRR (90.8%). For this analysis, 3,832 primary knee replacement procedures using minimally invasive surgery were examined.

In an effort to understand patterns of patient selection, minimally invasive knee replacement cases reported to the CJRR were examined in association with eight factors: age, sex, BMI, diagnosis, province, fiscal year in which the procedure was performed, community size, and neighbourhood income quintile.

Patient Characteristics

Age

Age was seen to be an important and statistically significant ($p < 0.01$) factor in the use of a minimally invasive approach in knee replacement surgery.

The highest number of minimally invasive procedures (and conventional approach procedures) was performed in the 65-to-74-year age group, with 1,304 procedures. This figure accounts for 8.5% of all knee replacement procedures performed in this age group and 34% of all minimally invasive knee procedures overall (all ages). Patients in the 55-to-64-year age group accounted for the second-highest number (1,188) of minimally invasive procedures, while this age group accounted for the third-highest number of conventional approach procedures (Table 15).

As patients age, the likelihood of undergoing a minimally invasive procedure decreases. Patients under the age of 44 years were seen to be the most likely to undergo the procedure (odds ratio [OR] of 1.646), followed by those in the 45-to-54-year age group (OR = 1.345). Patients 75 years of age and older were the least likely to have minimally invasive surgery used for their knee replacement procedure (OR = 0.457) (Appendix E, Table E-1).

Sex

The analysis found a statistically significant difference in the use of minimally invasive surgery for males and females ($p < 0.01$). While females represent 61.2% of all primary knee replacement procedures performed, they have a lower proportion of minimally invasive procedures than their male counterparts (8.5% and 10.5% respectively). A similar statistically significant ($p < 0.01$) but less definitive pattern was seen with hip replacements.

The sex distribution pattern pertaining to minimally invasive and conventional-knee replacement procedures between 2003–2004 and 2005–2006 was consistent, with males having increased odds of undergoing knee replacement through a minimally invasive approach as opposed to females.

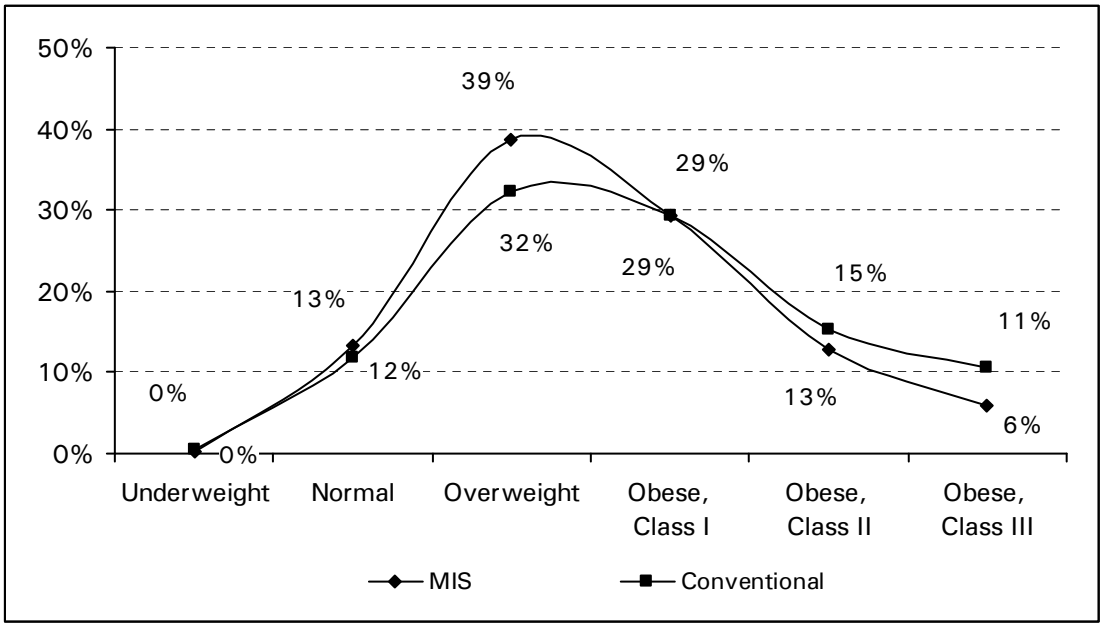
Females undergoing knee replacement surgery had 17.3% lower odds of having a minimally invasive approach used compared to male patients ($p < 0.01$).

BMI

As a proportion of all procedures performed (conventional and minimally invasive), patients in the obese category represented the highest proportion (48%), followed by individuals in the overweight BMI category ($25 \leq BMI < 30$) (Table 15).

Compared to conventional knee replacement recipients, minimally invasive knee replacement recipients weighed significantly (< 0.0001) less (Figure 49).

Figure 49. BMI Categories for Conventional Knee Replacements and Minimally Invasive Knee Replacements, 2003–2004 to 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2003–2004 to 2005–2006.

Of the group of patients who had a knee replacement using a minimally invasive approach, patients with BMI ≥ 30 (obese) accounted for the largest (35%) proportion, followed by patients classified as overweight (25 ≤ BMI < 30) (28%) (Table 15).

Patients in the normal and overweight BMI groups were found to have nearly similar and higher odds of undergoing surgery using a minimally invasive approach (OR = 1.010).

Diagnosis

Degenerative osteoarthritis (OA) was the leading diagnostic indication (95%) for receiving a knee replacement procedure using a minimally invasive approach.

A highly significant difference ($p < 0.01$) was noted between diagnosis and the approach in surgical intervention (minimally invasive versus conventional). Out of all patients with a specific diagnosis, those with osteonecrosis or tumour represented the leading diagnostic reason for having a knee replacement with minimally invasive surgery (15.8% compared to 9.6% for OA). Those with osteonecrosis or tumour had 93% higher odds of having minimally invasive surgery, compared to those with degenerative OA ($p < 0.1$).

Trends Over Time

Over a three-year period (2003–2004, 2004–2005 and 2005–2006), the frequency of minimally invasive knee replacements increased by 38% (Table 15). As a proportion of all knee replacement procedures, a statistically significant increase in the use of a minimally invasive procedure was seen in 2005–2006 ($p < 0.01$) (Table 15).

Table 15. Knee Replacements by Surgical Approach: Minimally Invasive and Conventional, Number and Percent

Factors	Minimally Invasive Approach		Conventional Approach		P Value (Chi-Sq Test)
	Counts	Percentage	Counts	Percentage	
Total	**3,832**	**9.2**	**37,635**	**90.8**	
Age Groups (Years)					
< 44	68	14.4	405	85.6	< .01
45–54	456	14	2,807	86	
55–64	1,188	12	8,748	88	
65–74	1,304	8.5	14,107	91.5	
75 +	816	6.6	11,568	93.4	
Sex					
Male	1,685	10.5	14,407	89.5	< .01
Female	2,147	8.5	23,228	91.5	
BMI					
Underweight (0 > BMI < 18.5)	7	5.4	123	94.6	< .01
Normal weight (18.5 ≥ BMI < 25)	375	9.9	3,405	90.1	
Overweight (25 ≥ BMI < 30)	1,090	10.6	9,215	89.4	

Factors	Minimally Invasive Approach		Conventional Approach		P Value (Chi-Sq Test)
	Counts	Percentage	Counts	Percentage	
Obese (30 ≥ BMI)	1,344	7.8	15,873	92.2	
Unknown	1,016	10.1	9,019	89.9	
Diagnosis Groups					
Degenerative osteoarthritis	3,658	9.6	34,638	90.4	<.01
Osteonecrosis/tumour	54	15.8	288	84.2	
Inflammatory arthritis	57	3.3	1,680	96.7	
All other diagnoses	63	5.8	1,029	94.2	
Province of Residence					
Atlantic provinces*	504	9.7	4,680	90.3	<.01
Quebec	520	11.4	4,060	88.6	
Ontario	790	4.7	16,128	95.3	
Manitoba	260	11.1	2,087	88.9	
Saskatchewan	216	8.1	2,452	91.9	
Alberta	596	12	4,377	88	
British Columbia†	946	19.7	3,851	80.3	
Fiscal Years					
2003	923	7.4	11,593	92.6	<.01
2004	1,412	8.3	15,620	91.7	
2005	1,497	12.6	10,422	87.4	
Neighbourhood Income					
Lowest quintile	523	7.5	6,464	92.5	<.01
Second quintile	674	8.5	7,232	91.5	
Third quintile	648	8.7	6,832	91.3	
Fourth quintile	715	9.6	6,704	90.4	
Highest quintile	804	10.4	6,900	89.6	
Unknown	468	11.8	3,503	88.2	
Community Size					
Urban fringe	94	8.8	979	91.2	<.01
Rural fringe inside CMA	262	9.3	2,558	90.7	
Urban area outside CMA	299	7.5	3,674	92.5	
Rural area outside CMA	448	7.9	5,256	92.1	
Secondary urban core	22	5.1	411	94.9	
Urban centre	2,333	9.6	22,083	90.4	
Unknown	374	12.3	2,674	87.7	

Notes:
Percentages presented pertain to rows and not columns.
* Atlantic provinces include Newfoundland and Labrador, Prince Edward Island, Nova Scotia and New Brunswick.
† British Columbia includes counts for the Northwest Territories, Nunavut and the Yukon.

Minimally Invasive Surgery and Total Hip Replacement

Overall, a conventional surgical method (standard incision) was used in the vast majority of hip replacement procedures in the CJRR (86.0%). For this analysis, 4,212 primary hip replacement procedures that used minimally invasive were examined.

Of the minimally invasive hip replacement procedures analyzed, 99% were primary arthroplasties and 1% were revisions.

In an effort to understand patterns of patient selection, minimally invasive hip replacement cases reported to the CJRR were examined in association with eight factors: age, sex, BMI, diagnosis, province, fiscal year in which the procedure was performed, community size and neighbourhood income quintile.

Patient Characteristics

Age

Hip replacement performed through the use of minimally invasive surgery was seen predominantly in CJRR patients younger than 65 years of age. Of the 4,212 hip replacements with a minimally invasive approach, 70% were patients younger than 75 years of age (Table 16). Within the oldest age group (75 years and older), the odds of having a minimally invasive procedure for joint replacement were 10.4% lower than for those between the ages of 55 and 64.

When controlled for seven other factors (sex, BMI, diagnosis group, province, fiscal years, neighbourhood income quintile, and community size) there was no significant difference noted between the likelihood of a specific age group receiving a minimally invasive procedure in Canada (Appendix E, Table E-2).

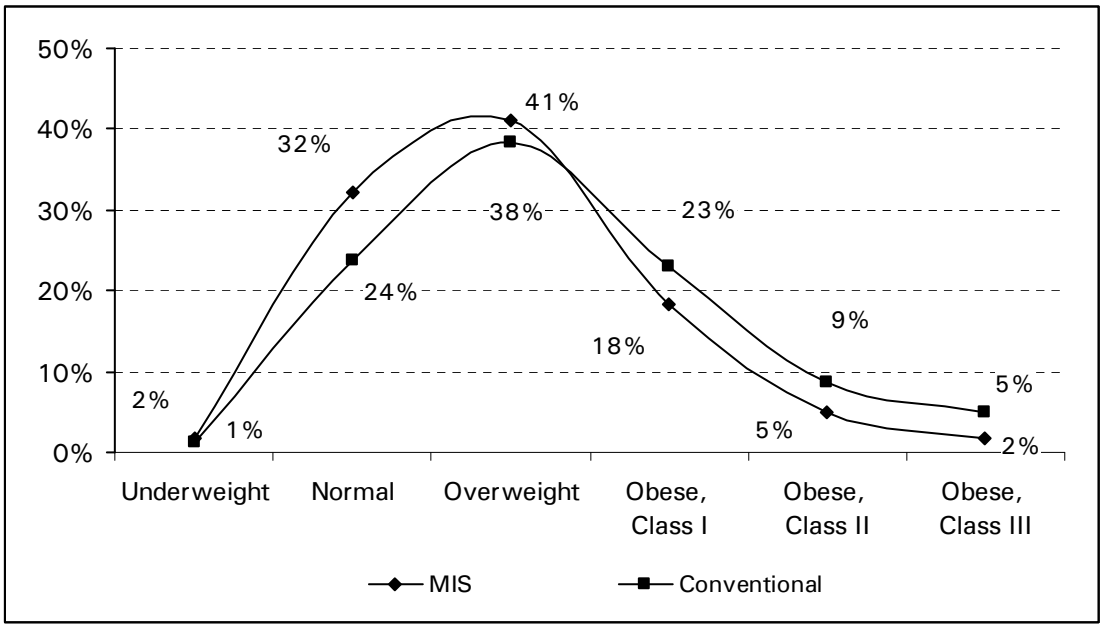
Sex

Overall, minimally invasive hip replacement counts were higher for females (2,305). However, females undergoing a hip replacement had a lower proportion of minimally invasive approach cases (13.5%) than males undergoing a hip replacement (14.7%) (Table 16). Overall, the odds of undergoing a minimally invasive procedure favoured males, with females having 11% reduced odds of undergoing the less invasive procedure ($p = 0.001$).

BMI

Patients selected for minimally invasive hip replacement weighed significantly (<0.0001) less than those selected for conventional hip replacement (Figure 50). Twenty-five percent of patients who underwent a hip replacement using minimally invasive were obese (Table 16).

Figure 50. BMI Categories for Conventional Hip Replacements and Minimally Invasive Hip Replacements, 2003–2004 to 2005–2006



Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2003–2004 to 2005–2006.

In relation to the conventional approach patients who underwent hip replacement, in the obese and overweight categories 9.3% and 14.2% ($p<0.01$) respectively underwent a minimally invasive replacement procedure.

BMI is inversely related to the odds of having a minimally invasive hip replacement, with those in the obese category (BMI≥30) having odds of undergoing a minimally invasive procedure that were 51% less than those within the "normal" range. Similarly, the odds of a patient in the "overweight" BMI category undergoing a minimally invasive procedure were 23% less than patients in the "normal" range. Those patients who were categorized as underweight had similar odds of receiving minimally invasive as those in the normal BMI group.

Compared to conventional hip replacement recipients, minimally invasive hip replacement recipients weighed significantly less (<0.0001).

Diagnosis

In the CJRR analysis, degenerative OA was the predominant diagnosis (83%, $p<0.01$), followed by osteonecrosis for minimally invasive hip replacements (Table 16).

When the adjusted effects of primary diagnosis on the use of minimally invasive were analyzed, patients with inflammatory arthritis had 6% higher odds of undergoing a minimally invasive approach to hip replacement as compared to those with OA (OR = 1.063, $p < 0.0001$).

Trends Over Time

In 2005–2006, a minimally invasive approach was used in 17.2% of hip replacement procedures reported to the CJRR. This is an increase over the baseline year of 2003–2004, when 10.2% of hip replacements procedures in the CJRR were minimally invasive.

There is a statistically significant time effect (after controlling for other factors) whereby the odds of having a minimally invasive hip replacement procedure in each of fiscal years 2004–2005 and 2005–2006 was at least 40% higher compared to the fiscal year 2003–2004 ($p < 0.01$).

Table 16. Hip Replacements by Surgical Approach: Minimally Invasive and Conventional, Number and Percent

Factors	Minimally Invasive Approach		Conventional Approach		P Value (Chi-Sq Test)
	Counts	Percentage	Counts	Percentage	
Total	**4,212**	**14**	**25,915**	**86**	
Age Groups (Years)					
< 44	222	13.1	1,468	86.9	0.4947
45–54	513	14.3	3,083	85.7	
55–64	906	14.1	5,503	85.9	
65–74	1,322	14.3	7,917	85.7	
75 +	1,249	13.6	7,944	86.4	
Sex					
Male	1,907	14.7	11,107	85.3	0.0033
Female	2,305	13.5	14,808	86.5	
BMI					
Underweight (0 > BMI < 18.5)	52	17.5	245	82.5	< .01
Normal Weight (18.5 ≥ BMI < 25)	940	17.4	4,449	82.6	
Overweight (25 ≥ BMI < 30)	1,208	14.2	7,274	85.8	
Obese (30 ≥ BMI)	729	9.3	7,121	90.7	
Unknown	1,283	15.8	6,826	84.2	
Diagnosis Groups					
Degenerative osteoarthritis	3,503	14.4	20,835	85.6	< .01
Osteonecrosis/tumour	239	13.4	1,547	86.6	
Inflammatory arthritis	162	15.2	901	84.8	
All other diagnoses	308	10.5	2,632	89.5	

Factors	Minimally Invasive Approach		Conventional Approach		P Value (Chi-Sq Test)
	Counts	Percentage	Counts	Percentage	
Province of Residence					
Atlantic provinces*	405	10.6	3,410	89.4	<.01
Quebec	369	9.8	3,395	90.2	
Ontario	1,117	10.1	9,970	89.9	
Manitoba	276	17.9	1,262	82.1	
Saskatchewan	328	20.6	1,267	79.4	
Alberta	359	8.7	3,755	91.3	
British Columbia†	1,358	32.2	2,856	67.8	
Fiscal Years					
2003	919	10.2	8,129	89.8	<.01
2004	1,719	14.4	10,186	85.6	
2005	1,574	17.2	7,600	82.8	
Neighbourhood Income					
Lowest quintile	611	12.6	4,232	87.4	<.01
Second quintile	700	13.6	4,457	86.4	
Third quintile	700	12.8	4,775	87.2	
Fourth quintile	760	14	4,655	86	
Highest quintile	1,015	15.8	5,389	84.2	
Unknown	426	15	2,407	85	
Community Size					
Urban fringe	68	8.9	694	91.1	<.01
Rural fringe inside CMA	201	10.2	1,769	89.9	
Urban area outside CMA	366	13	2,441	87	
Rural area outside CMA	480	12.4	3,389	87.6	
Secondary urban core	24	7.3	306	92.7	
Urban centre	2,728	15	15,417	85	
Unknown	345	15.4	1,899	84.6	

Notes:
Percentages presented pertain to rows and not columns.
* Atlantic provinces include Newfoundland and Labrador, Prince Edward Island, Nova Scotia and New Brunswick.
† British Columbia includes counts for the Northwest Territories, Nunavut and the Yukon.

Geographic and Neighbourhood Variations for Minimally Invasive Joint Replacement Procedures

Provincial Variations

The use of a minimally invasive approach for joint replacement showed statistical differences between provinces within Canada. Surgeon participation in the CJRR is voluntary and likely influences the variations that are seen (see Table 17). The results do not allow a consistent conclusion about the relationship between rate of surgeon participation in the CJRR and minimally invasive provincial variations. For example, Ontario has 80% participation, yet patients in that province have the lowest odds of undergoing a minimally invasive knee replacement procedure. British Columbia has 60% surgeon participation in the registry, and patients from this province undergoing joint replacement surgery had the highest odds of undergoing a minimally invasive procedure regardless of the joint (hip or knee). Provincial variations should therefore be interpreted with caution.

There are several additional factors likely involved in the observed differences including, but not limited to: the type of hospital (teaching, community), volume of cases, availability of equipment and technical expertise, complexity of cases, and the demographics of the population.

Compared to joint replacement patients in Ontario, patients from all other provinces were found to have higher odds of having a minimally invasive knee replacement procedure. Those undergoing joint replacement surgery in British Columbia had the highest odds of having minimally invasive for both procedures (OR = 4.823, $p<0.001$ for knee; OR = 3.661, $p<0.001$ for hip).

For those undergoing knee replacements, the highest odds (after BC) of having minimally invasive were for those patients in Quebec, followed by Alberta and Manitoba.

For hip replacement patients, the highest odds (after BC) of undergoing a minimally invasive procedure were seen in Saskatchewan (OR = 2.109) followed by Manitoba (OR = 1.868).

Table 17. Minimally Invasive Knee and Hip Replacement Provincial Distribution

Province of Residence	Knee Replacements		Hip Replacements	
	Minimally Invasive Approach	Percentage	Minimally Invasive Approach	Percentage
Newfoundland	20	0.5	12	0.3
Prince Edward Island	5	0.1	6	0.1
Nova Scotia	371	9.7	354	8.4
New Brunswick	108	2.8	33	0.8
Quebec	520	13.6	369	8.8
Ontario	790	20.6	1,117	26.5
Manitoba	260	6.8	276	6.6
Saskatchewan	216	5.6	328	7.8
Alberta	596	15.6	359	8.5
British Columbia	935	24.4	1,351	32.1
Total*	**3,832**	**100.0**	**4,212**	**100.0**

Note:
* Includes counts for the Yukon, the Northwest Territories and Nunavut, which are suppressed due to small numbers.

Neighbourhood Composition Variations

For the purpose of these analyses, neighbourhood income and community size were selected as a means of defining population groups and of comparing variations of health and health care across different groups.

In the CJRR, the majority of minimally invasive hip (65%) and minimally invasive knee (61%) replacement procedures were performed on patients from an urban centre. A significant difference ($p < 0.01$) was noted when community size was examined in relation to the type of joint replacement approach used.

For hip replacement patients in the urban centre communities, the odds of undergoing minimally invasive were higher than for those in any of the other community size groups (6% to 38%) (Appendix E, Table E-2). In contrast, for patients undergoing a knee replacement, those living in a rural fringe area had slightly increased odds of having a minimally invasive approach used as compared to their counterparts residing in an urban centre. However, the difference was not statistically significantly different in most cases. For all other community types, the odds of having a minimally invasive approach to knee replacement were less than in urban centres.

When income is examined as a factor, the odds of having a minimally invasive approach for surgery are greatest in the highest income quintile (OR = 1.231 or 23% higher odds for hip; OR = 1.375 or 38% higher odds for knee) as compared to the lowest quintile ($p < 0.01$). The statistically significant difference seen is between these two groups at opposite ends of the income quintile continuum.

Wait Times; Minimally Invasive Joint Replacement Procedures

Shorter wait times were observed for recipients of minimally invasive hip replacement procedures (median of 148 days) as compared to minimally invasive knee replacement recipients, who waited a median of 211 days between when a decision was made to treat with surgery and the actual date of surgery. Similarly, wait times were shorter for recipients of conventional hip replacement as compared to recipients of conventional knee replacement (median of 127 days and 182 days respectively). Wait times significantly differed for minimally invasive procedures as compared to conventional procedures.

Outcomes; Minimally Invasive Joint Replacement Procedures

When revision surgeries were considered, patients 75 years or older experienced the highest number of hip replacement revisions, followed by those 65 to 74 years of age. The differences between the minimally invasive and the conventional approach to surgery were insignificant. For knee replacement surgery, patients aged 55 to 64 years had the most revisions performed. Again, there was no statistically significant difference between the type of surgical approach used and the revision rates (Appendix E, Table E-3).

Similar findings are found when the sex of the patient was considered. Of the minimally invasive hip replacement revisions, 53% were performed on males. There was no statistically significant difference between the number of males and females requiring revision of hip surgery. For knee revision using minimally invasive surgery, 63% were on females. Again, for knee replacement surgery, there was no statistically significant difference noted.

With revision of both hip and knee minimally invasive procedures, there were no statistically significant differences found with regard to BMI category (Appendix E, Table E-4). Among recipients requiring a revision after a minimally invasive knee replacement, those in the obese category were the most highly represented (39%). Similarly, for patients receiving a knee replacement revision via a conventional method, those in the obese category had the highest representation (44%).

The longevity of a prosthesis (how long it will last) varies between individuals, and depends on many factors that include (but are not limited to): physical condition, activity level, BMI, and surgical technique. For hip replacement minimally invasive recipients who required a revision following the primary procedure, 62% had a revision done within the first six months and 26% had a revision within the first seven to 12 months. There was no statistically significant difference between the surgical approaches in the time to revision (Appendix E, Table E-4).

For knee replacement revisions when a minimally invasive approach was used in the primary surgery, 26% underwent revision within the first six months (Appendix E, Table E-3). There was no statistically significant difference between the surgical approaches in the time to revision (Appendix E, Table E-3).

Conclusion

To date, an evolving body of literature has been developed about minimally invasive surgery. The current literature provides disparate patient selection guidelines and criteria for the consideration of minimally invasive surgery for joint replacement. Some authors stipulate a low activity demand, consideration of patient age, minimal pain at rest and a range of motion that is not severely compromised, and BMI in the acceptable or mildly overweight category[29] Others exclude patients with BMI greater than 40 and specific joint deformities,[30] while still others make no exclusion based on BMI, sex or deformity and recommend the adoption of a minimally invasive approach for all primary knee replacement procedures.[31] Obesity has been associated with degenerative changes in the knee,[32] and when surgery is required, obesity has been associated with technical difficulties, increased risk of complications and early failure of the prosthesis.[33]

Although future data are required to confirm the finding over an extended period of time, in this analysis a minimally invasive approach for hip and knee replacements was not associated with any different outcomes (proportion of revisions and time to revision) compared to those observed with conventional surgery. It will be important to further assess traditional outcomes (LOS and mortality) and to assess other qualitative outcomes, including patient quality of life and satisfaction.

As with all emerging health technologies and techniques, sound evidence is required about minimally invasive joint replacements to inform decisions about implementation, to help guide patient selection and to ultimately improve patient and system outcomes. The goal of this focused chapter is to provide a foundation of information about the CJRR experience with minimally invasive that could lead to enhanced understanding, and which ultimately can be used to improve the health and well-being of Canadians.

Discussion and Future Directions

The *Canadian Joint Replacement Registry (CJRR) 2007 Annual Report on Hip and Knee Replacements in Canada* uses data collected from several sources (including CJRR and HMDB—both maintained at CIHI) to highlight trends and regional variations for hip and knee replacement procedures in Canada. As well, the report provides detail on the nature and types of hip and knee replacement surgeries and surgical techniques used by Canadian orthopedic surgeons. This information is intended for use by decision-makers involved in managing health care systems, orthopedic surgeons and related care providers, researchers, and by the general public.

This year, in addition to continuing to present results of analyses in established areas, we present new information on joint replacement wait times. As well, we further explore BMI sub-classes, and the emerging use of new techniques, as part of the need to provide national data on continually changing practices in the orthopedic field.

Joint replacement procedures are one of the five priority areas targeted federally for meaningful reductions in wait times by 2007. As a mechanism to inform these efforts, as of April 1, 2005, CJRR began collecting data related to wait times as part of a broader CIHI initiative to collect and report on national wait time data. This year's report finds that wait times for hip replacements (median wait of 127 days) were significantly shorter than for knee replacements (median wait of 182 days). The data collected and reported by the CJRR will continue to inform these issues.

Patients who had knee replacements during 2005–2006 were found to be more likely to be overweight or obese as compared to hip replacement patients, and obese individuals were more than three times as likely to undergo joint replacement surgery, compared to those in the acceptable BMI category. New analysis in CJRR demonstrates differences in sub-groups of BMI. This report provides further information on classes of obesity as they relate to joint replacement surgery in Canada.

Minimally invasive techniques provide new approaches for hip and knee replacement surgery and have reported in the literature several hypothesized benefits for patients This report presents a focused chapter on the use of minimally invasive techniques in joint replacement surgery in Canada, in an attempt to provide a comprehensive body of evidence that clinicians and health care decision-makers can use as a basis for making decisions on emerging technologies that affect patients and the system. Such evidence is required to optimize patient outcomes and system efficiency.

CJRR is currently expanding its data collection and recruitment efforts in order to allow it to become an increasingly relevant source of health information for decision-makers. CJRR is in the process of developing a web-based data submission system, as an addition to current paper and electronic file options. Focused attention continues to be directed towards increasing CJRR participation in provinces such as Ontario and Quebec, which contribute a substantial proportion of national joint replacement data. CJRR began implementation in Ontario as of October 1, 2005, with the winding down of operations of the Ontario Joint Replacement Registry.

Future directions for CJRR include further exploration of health outcomes that reflect the ever-changing hip and knee replacement surgery experience in Canada. For instance, in this report, trends are presented in the use of minimally invasive techniques, and patellar resurfacing, which currently have mixed results reported in terms of outcomes.[34, 35, 36, 37, 38] Outcome measurement at baseline, prior to replacement surgery, will allow the CJRR to explore the role that baseline severity plays in the hospital, postoperative and longer-term outcomes for Canadian joint replacement patients.

Additionally, CJRR will be launching comparative facility specific outcomes reports in the future, which will allow facilities, regions and provinces to compare key indicators. Again, such information will support clinical practice, system management and policy.

The CJRR will play a continuing and growing role in collecting and analyzing comprehensive national data in the years ahead. As new technologies and surgical techniques emerge for joint replacements, comprehensive analyses of CJRR data will explore the spectrum of health outcomes in an effort to inform understanding of evolving implants and surgical techniques from clinical and policy perspectives.

Appendix A
Hip and Knee Replacement Coding Methodology, HMDB

Hospital Morbidity Database (HMDB)

Collection of HMDB Data

The Hospitalization Statistics chapter of the CJRR annual report contains data from the Hospital Morbidity Database (HMDB). HMDB, managed by CIHI, is a national data holding that captures administrative, clinical and demographic information on hospital discharges largely from Canadian acute care facilities. The HMDB provides national information on diagnoses, operative procedures, admission date, in-hospital length of stay and patient demographics.

The HMDB is populated by two sources: 1) a subset of the Discharge Abstract Database (DAD) data, which consists largely of acute inpatient data from most provinces in Canada; and 2) data from provinces that do not participate in the DAD. In 2005–2006, all provinces and territories submitted discharge data directly to the DAD, with the exception of Quebec. The Quebec Ministry of Health and Social Services submits data files to CIHI on an annual basis. These data files are then merged with the DAD to create the national HMDB.

Population of Reference

HMDB data reported in this document include hospitalizations for hip and knee replacements (including primary and revisions) performed in Canada, for all discharges from acute care hospitals during fiscal year 2005–2006 (April 1, 2005 to March 31, 2006). Additional years of data are also reported for trending purposes.

Patients in all age groups were included in the CJRR annual report. Patients younger than 20 years of age comprised <0.1% of the total for hip and knee replacements for fiscal years 2003–2004 through 2005–2006. Thus, inclusion of this age group is unlikely to impact overall analyses.

Hip and knee replacements performed in fiscal years 2004–2005 and 2005–2006 were identified according to ICD-10-CA/CCI codes, with the exception of Quebec which reports using the ICD-9/CCP classification. Hospitalization data prior to 2004–2005 were collected using a mixture of coding classifications (ICD-10-CA/CCI, ICD-9-CM, ICD-9/CCP). Analyses include partial and total knee replacement procedures, as the latter cannot be separated out in the CCP classification system. However, only data on total hip replacements are shown. Partial hip replacements are not included in the analyses. Counts for hip and knee replacements performed in Quebec prior to 2003–2004 may have been underestimated, as revision codes were not identifiable in the HMDB at that time.

Surgeries coded as “previous” or “abandoned” were excluded from the analyses. Also, beginning with 2001–2002 data, surgeries coded as being performed out-of-province were excluded in order to avoid double counting of cases.

Hospitalization Counts

Beginning with the 2005 CJRR annual report, counts reported are based on the number of hospitalizations. In earlier reports, counts reported were based on the number of procedures performed. The main difference between the two methodologies is due to the counting of bilateral procedures performed on the same day (that is, same operative episode). In the current methodology, if a person has more than one hip or knee replacement procedure (that is, bilateral) coded for the same hospital visit, only one hospitalization is counted. This is consistent with the reporting of procedures in the Canadian Classification of Health Interventions (CCI). Therefore, when comparisons with historical reports are made, this methodology should be kept in mind.

Geographical Reporting

With the exception of length of stay and in-hospital death analyses, provincial analyses are based on a patient's province of residence as opposed to where the procedure was performed. Patient geography was assigned based on postal code using the July 2005 Postal Code Conversion File from Statistics Canada. Patients with incomplete postal codes were included in the provincial and national counts and rate calculations. Patients with unknown residence were excluded in the counts and the age-standardized rates of provincial analyses.

In CJRR annual reports released prior to 2004–2005, patients with unknown or invalid postal codes were reported in the "Unknown" province category. The methodology was revised such that incomplete postal codes were mapped to provinces/territories using the first three digits of the postal code. Therefore, there is a significant reduction of the number of patients with an "unknown" province of residence and a corresponding increase of counts for some provinces and territories compared to previously reported data in fiscal years 1994–1995 through 2000–2001.

Contrary to the rest of the report, length-of-stay analyses are based on the province in which the procedure was performed as opposed to the province of the patients' residence. Non-Canadian residents and patients with unknown or invalid residence codes are included in this analysis.

Reporting of Age-Rate Standardized Rates

Age-standardization is a common analytical technique used to compare rates over time, as it takes into account changes in age structure across populations and time. Unless otherwise indicated, rates presented in this report are age-standardized and are reported per 100,000 of the population.

For the calculation of rates, national and provincial fiscal population estimates are used. These are based on October 1 of the given fiscal year, and are special order tabulations provided by Statistics Canada. The 1991 Canadian population was used as the standard to determine the age-standardized rates.

Counts and rates of hip and knee replacements shown over time may vary in the current report compared to previous reports. This is due to the following:

- historical counts for fiscal years 1995–1996 through 2000–2001 have been updated in the HMDB; and
- calculations for age-standardized rates are based on updated fiscal population estimates from Statistics Canada.

Codes Used to Identify Hip and Knee Replacements

In the HMDB for the fiscal period 1994 to 2000, hip or knee replacement procedures were coded using ICD-9-CM (ICD-9-CM 9th Revision—Clinical Modification) or CCP (ICD-9/CCP 9th Revision—Canadian Classification of Diagnostic, Therapeutic, and Surgical Procedures). ICD-9-CM codes were converted to CCP for the purpose of this report. Beginning in fiscal 2001, ICD-10-CA/CCI (International Statistical Classification of Diseases and Related Health Problems, 10th Revision, Canada and Canadian Classification of Health Interventions) was introduced, replacing the previous classification systems in a staggered fashion across the country. CCI provides greater specificity in the classification of hip and knee replacement procedures compared to its predecessors. In addition to providing separate codes for cemented versus uncemented procedures, it permits separation of partial versus total replacements.

The ICD-10-CA/CCI classification systems were updated in 2003–2004. New Brunswick started implementing the new version of ICD-10-CA/CCI. The provinces and territories already using ICD-10-CA/CCI for coding medical diagnoses and interventions began using the updated version of ICD-10-CA/CCI as well, while ICD-9-CM and ICD-9/CCP were still in use in Manitoba and Quebec, respectively, during this fiscal year. As a result, the 2003–2004 HMDB data file contains data in three different classification systems: ICD-9/CCP, ICD-9-CM (enhanced ICD-9/CCP) and ICD-10-CA/CCI (version 2001 and version 2003).

Manitoba began adopting the ICD-10-CA/CCI in 2004–2005, thereby completing the implementation of the new classification system in all DAD-submitting provinces/territories. As a result, all provinces and territories reported hip replacements and knee replacements in 2004–2005 and 2005–2006 using the ICD-10-CA/CCI classification system, except Quebec, which used the ICD-9/CCP coding system.

Of note, the ICD-10-CA/CCI classification systems are considerably different from the previously used ICD-9/CCP and ICD-9-CM classification systems, which were relatively comparable.

Hip Replacements

Table A-1 presents the codes used to identify hip replacements in this report. In CCI, the rubric code of interest is 1.VA.53 *Implantation of internal device, hip joint*. This rubric code is broken down into more detailed subcategories: cement spacer, single component and dual component; and for each, whether the procedure was cemented or uncemented (even more detailed components in the latter). Only the dual component prosthetic device code series is of interest to this report, as it captures total (as opposed to partial) hip replacements: 1.VA.53.LA-PN (open approach) and 1.VA.53.PN-PN (robotics-assisted approach). In CCI, revisions are identified using a supplementary code called a Status Attribute, in which Status Attribute = R identifies that the procedure is a revision. It must be noted that for fiscal years 2001 and 2002 the coding of this attribute was optional; therefore, the number of revision procedures may be underestimated. Coding of revisions is mandatory since year 2003–2004.

For hip replacement procedures coded in the CCP classification, codes of interest are 93.51 *Total hip replacements with methyl methacrylate* and 93.59 O*ther total hip replacements.* Prior to year 2000–2001, these codes also included revisions. However, after April 1, 2000, revisions of a total hip replacement *cemented with methyl methacrylate* were assigned the CCP code 93.52 and revision of a total hip replacement *uncemented* was coded 93.53. Therefore, when reporting total hip replacement procedures in this report, any of these four codes are used. It must be noted that partial hip replacement procedures are captured using the CCP code 93.69 *Other repair of hip*, which is not included in this report's analyses.

Table A-1. CCI and CCP Hip Replacement Codes*

Rubric	CCI Codes				
1.VA.53.^^ Implantation of internal device, hip joint	**Cemented**	**Uncemented**	**With bone autograft [uncemented]**	**With bone homograft [uncemented]**	**With combined bone graft and cement or paste**
Open Approach					
Dual component prosthetic device [femoral and acetabular]	1.VA.53.LA-PN-N	1.VA.53.LA-PN	1.VA.53.LA-PN-A	1.VA.53.LA-PN-K	1.VA.53.LA-PN-Q
Single component prosthetic device [femoral]	1.VA.53.LA-PM-N	1.VA.53.LA-PM	1.VA.53.LA-PM-A	1.VA.53.LA-PM-K	1.VA.53.LA-PM-Q
Robotics-Assisted Approach [e.g. telemanipulation of tools]					
Dual component prosthetic device [femoral and acetabular]	1.VA.53.PN-PN	1.VA.53.PN-PN-N	1.VA.53.PN-PN-A	1.VA.53.PN-PN-K	1.VA.53.PN-PN-Q
Single component prosthetic device [femoral]	1.VA.53.PN-PM	1.VA.53.PN-PM-N	1.VA.53.PN-PM-A	1.VA.53.PN-PM-K	1.VA.53.PN-PM-Q

Rubric	CCP Code	CCP Description
93.5—Total hip replacement	93.51	Total hip replacement, cemented
	93.59	Other total hip replacement
	93.52	Revision of total hip replacement, cemented
	93.53	Revision of total hip replacement, uncemented

Notes: (CCI Code)

1.VA.53.^^ Implantation of internal device, hip joint

Includes: Arthroplasty with implantation of prosthetic device, hip
Hemiarthroplasty with implantation of prosthetic device, hip
Replacement, hip, using prosthetic device
Reduction with fixation and implantation of prosthetic device, hip

Excludes: Implantation, prosthetic device to acetabulum alone (see 1.SQ.53.^^)

* Only dual component prosthetic device codes in CCI were considered as they refer to total, not partial, hip replacements while performing analysis of data from the Hospital Morbidity Database.

Knee Replacements

Table A-2 presents the codes of interest used to identify knee replacements for the purposes of this report. It must be noted that although CCI permits the separation of "true" total knee replacements from partial knee replacements, *all* codes in rubric 1.VG.53 were used to define total knee replacement. The decision to include partial replacements in the reporting was made to maintain comparability with provinces using the older classification systems, which do not distinguish between the two types of surgery. Table A-3 shows the split between true partial versus total knee replacements using the CCI coding system based on data from 2004–2005.

In CCP, the relevant knee replacement code was 93.41 *Geomedic and polycentric total knee replacement*, which captured primary and revision procedures together until April 2000. Afterwards, the code 93.40 was added to capture revisions of total knee replacements only, cemented or uncemented. In CCI, revisions are identified using the supplementary code "Status Attribute = R"; however, it was optional to report this code in fiscal years 2001 and 2002. Coding of revisions is mandatory since year 2003–2004. While the rest of Canada uses CCP code 93.40 to capture knee revision procedures (cemented and uncemented), CCP code 93.471 has been used in the Med-Écho since 1998 to capture knee revisions in Quebec.

Table A-2. CCI and CCP Codes for Total Knee Replacements*

Rubric	CCI Codes				
1.VG.53.^^ Implantation of internal device, knee joint	Cemented	Uncemented	With bone autograft	With bone homograft	With combined bone graft and cement or paste
Cement spacer [temporary] [impregnated with antibiotics]	1.VG.53.LA-SL-N	---	---	---	---
Dual component prosthetic device [bicondylar]	1.VG.53.LA-PN-N	1.VG.53.LA-PN	1.VG.53.LA-PN-A	1.VG.53.LA-PN-K	1.VG.53.LA-PN-Q
Single component prosthetic device [unicondylar]	1.VG.53.LA-PM-N	1.VG.53.LA-PM	1.VG.53.LA-PM-A	1.VG.53.LA-PM-K	1.VG.53.LA-PM-Q
Tri-component prosthetic device [medial, lateral and patellofemoral]	1.VG.53.LA-PP-N	1.VG.53.LA-PP	1.VG.53.LA-PP-A	1.VG.53.LA-PP-K	1.VG.53.LA-PP-Q

Rubric	CCP Code	CCP Description
93.4—Arthroplasty of the knee and ankle	93.41	Total knee replacement, (geomedic) (polycentric)
	93.40, 93.471	Revision of total knee replacement, (geomedic) (polycentric)

Notes: (CCI Code)

1.VG.53.^^ Implantation of internal device, knee joint

Includes: Arthroplasty with implantation of prosthetic device, knee
Hemiarthroplasty with implantation of prosthetic device, knee
Replacement, knee, using prosthetic device

Excludes: Patellaplasty alone using prosthetic
Replacement, patellofemoral alone

* All of these CCI codes were considered for analysis of data from the Hospital Morbidity Database, Discharge Abstract Database and National Ambulatory Reporting System in CIHI.

Table A-3. Partial and Total Knee Replacement Hospitalizations by Reporting Hospital Province (Provinces Reporting in ICD-10-CA, CCI Only)

Submitting Hospital Province	Extent of Knee Replacement Procedure					
	Partial*		Total†		All Knee Replacements (CCI)	
	Counts	Percentage	Counts	Percentage	Counts	Percentage
Newfoundland and Labrador	17	3.5	471	96.5	488	100.0
Prince Edward Island	<5	1.5	200	98.5	203	100.0
Nova Scotia	117	9.4	1,125	90.6	1,242	100.0
New Brunswick	104	9.5	990	90.5	1,094	100.0
Ontario	1,725	9.1	17,274	90.9	18,999	100.0
Manitoba	192	10.0	1,728	90.0	1,920	100.0
Saskatchewan	156	10.8	1,295	89.2	1,451	100.0
Alberta	376	9.2	3,723	90.8	4,099	100.0
British Columbia	648	12.1	4,687	87.9	5,335	100.0
Northwest Territories	<5	5.6	34	94.4	36	100.0
Yukon	0	0.0	8	100.0	8	100.0
Total	**3,342**	**9.6**	**31,535**	**90.4**	**34,875**	**100.0**

Notes:
Counts with cell size less than 5 suppressed due to privacy.
* CCI codes for partial knee arthroplasty: 1.VG.53.LA-PM, 1.VG.53.LA-SL.
† CCI codes for total knee arthroplasty: 1.VG.53.LA-PP, 1.VG.53.LA-PN.

Source: Hospital Morbidity Database, Canadian Institute for Health Information, 2005–2006.

Quebec Replacement Revision Counts Underestimated

Differences in the way revision knee replacements are coded in Quebec compared to other provinces has resulted in an underestimation of Quebec knee replacement revision procedures since 1998. In 1998, Quebec designated code 93.471 to indicate knee replacement revisions, which differs from the CCP code 93.40 that was implemented for knee replacement revisions as of April 1, 2000 for participating DAD provinces and territories (Quebec does not submit to the DAD, which is the parent database for HMDB). Code 93.471 is not part of the universe of codes reported by the CJRR. Also, it has not been identifiable previously in HMDB, as the fifth digit was routinely truncated during HMDB data processing. As a result, CCP codes reported as 93.471 were incorrectly processed as 93.47 *Other repair of the knee*. As of 2004–2005 data, all instances of CCP code 93.471 on the raw Quebec data file from Med-Écho were converted to CCP code 93.40 prior to appending Quebec data to HMDB at CIHI.

There were 374 knee replacement revision procedures performed in Quebec in 2005–2006, 335 in 2004–2005, 314 in 2003–2004, 282 in 2002–2003, 255 in 2001–2002, 240 in 2000–2001, 171 in 1999–2000, and 184 in 1998–1999. The knee revision procedures performed in Quebec from 1998–1999 to 2002–2003 were provided by Med-Écho, and the counts for 2003–2004 through 2005–2006 were retrieved from CIHI's HMDB.

Appendix B
Hip and Knee Replacement Coding Methodology, CJRR

Canadian Joint Replacement Registry (CJRR)

The Surgical and Clinical Characteristics section of the report is based on data collected through the CJRR. The methodology used in this section is presented below.

Collection of CJRR Data

The CJRR is a national registry that collects information on primary and revision hip and knee replacement surgeries performed in Canada. Data are submitted to the CJRR on a voluntary basis by participating surgeons from provinces across Canada through standardized data collection forms. Four facilities submitted data electronically in 2005–2006. From July 2003 through September 2005, data from Ontario were submitted through the Ontario Joint Replacement Registry (OJRR). Since October 2005, data from Ontario surgeons are submitted to the CJRR.

All data undergo standardized edit checks to maximize data quality. For further information on CJRR data and coverage, please see the section entitled About the Canadian Joint Replacement Registry.

Population Reference Period

Surgical and clinical data presented in this report are based on hip and knee replacement surgeries and revisions performed in Canadian acute care hospitals. Data are presented on a fiscal year basis (2002–2003 to 2005–2006) with the main focus on 2005–2006 data (April 1, 2005 and March 31, 2006). Fiscal year is defined by the data of surgery recorded on the CJRR forms. In instances in which surgery date was not available, admission date was used as a proxy.

Surgical data from orthopedic surgeons presented in this report may be updated in future reports. The CJRR continues to accept data beyond the deadline for the reporting period; thus, the information presented from this data source may be incomplete. Data from 2002–2003 through 2004–2005 shown in this report reflect updated numbers compared to the 2005 CJRR annual report.

Geographical Reporting

For the clinical and surgical data presented in this report, the reported province is based on where the procedure was performed, not where the patient resided.

Undercoverage

A limitation of the CJRR data reported is undercoverage, as not all eligible surgeons participate in the CJRR. The overall surgeon participation rate in the CJRR as of March 31, 2006 was 70%, with rates varying by province. Furthermore, it is not known whether each participating surgeon has submitted all procedures. Response bias is possible, but is not quantifiable.

For further information on CJRR participation and coverage, please see the section entitled About the Canadian Joint Replacement Registry.

Procedures

Cases are counted by number of procedures. If a patient had a bilateral procedure, it counts as two procedures in the CJRR.

Data Element Notes

Minimally Invasive Surgery

CJRR began collecting minimally invasive surgical information in 2003–2004.

Revisions and DVT Prevention

When recording revision joint replacement procedures, surgeons were asked to indicate *one or more* reasons for revision from a list provided. Similarly, surgeons were asked to record one or more methods of DVT prevention. Since more than one option is possible for both elements, percents shown in the report for reasons for revision and DVT prevention may not sum to 100%.

Note that the data submitted by one facility indicate replacements by primary or revision procedure but provide no information on the type of revision (first revision, second revision). Thus, the counts for revision procedures are higher than the sum of counts for types of revisions.

Excisions

Information on excision procedures was not provided by two facilities for 2005–2006 data; thus, there may be undercounting of excisions.

Components Replaced

Throughout this report the term "components replaced" refers to components replacing existing artificial implants, as in the case of revision procedures.

Body Mass Index (BMI)

BMI is calculated as: weight (in kilograms) divided by height (in metres) squared.

Based on international standards, patients were assigned to the following BMI categories: under 18.5 (underweight); 18.5–24.9 (normal weight); 25.0–29.9 (overweight); 30.0–34.9 (obese, class I); 35.0–39.9 (obese, class II); 40.0 and higher (obese, class III).

Statistical Analysis and Tests of Significance

Survival analysis measured the duration of time until a revision occurred. The cumulative distribution function curves presented in the report plot percent of revisions performed as a function of time. Survival analysis for hip procedures was performed by tracking patients who had a primary and a subsequent revision recorded in the CJRR between May 2001 and March 2006. For knee procedures, survival analysis was performed on patients who had a primary and revision procedure between July 2001 and March 2006.

The Wilcoxon test, a nonparametric method, was performed to test the association between sex and the time between the primary and the first revision, for both hips and knees.

Throughout the analyses presented in the report, statistical testing employed t-tests to compare the average between two groups, Chi-square correlation tests and Mantel-Haenszel tests for trends, and nonparametric methods to compare medians.

Wherever the term "significant" is used in this report, a two-sided statistical test (t-test or Chi-square, as appropriate) was performed and the result was statistically significant at the 0.05 level.

Appendix C
Definition of Hip and Knee Replacements in the CJRR

Hip Replacement (Arthroplasty)

The definition, or algorithm, for the categories and subcategories of hip replacement (arthroplasty) procedures is based on combining information on replacing the four compartments involved as shown below in Table C-1.

Table C-1. Algorithm Used to Define Hip Arthroplasty Types

Type of Arthroplasty	Femoral Stem	Femoral Head	Acetabular Component	Acetabular Insert/Liner
Total Arthroplasty	Yes	Yes	Yes	Yes
Hemi-Arthroplasty				
1. Monopolar	Yes	Yes	No	No
2. Bipolar	Yes	Yes	Yes	No
Resurfacing Arthroplasty				
1. Full resurfacing	No	Yes	Yes	No
2. Hemi-Resurfacing	No	Yes	No	No

Knee Replacement (Arthroplasty)

There are two different types of knee replacement captured in this report. *Total knee replacement* involves the replacement of all three compartments of the knee (medial, lateral and patellofemoral compartments). *Uni-compartmental knee replacement* involves replacing one or both of the medial and lateral compartments.

Appendix D
Methodological Notes for Minimally Invasive Surgery Focused Chapter

Data Sources and Methodology

Data Sources

Primary hip and knee replacement procedures (81,131) conducted between April 1, 2003 and March 31, 2006 and reported in the CJRR were used for the analysis of the chapter *Focus on Minimally Invasive Surgery for Primary Joint Replacements in Canada*. The CJRR has collected information related to minimally invasive surgery nationally since April 1, 2003. However, some data from Ontario were excluded due to incompleteness and unavailability at the time the analysis for this section was undertaken. Therefore, reporting of the overall counts may vary from those discussed in the Surgical and Clinical Characteristics section of this annual report.

Of the 81,131 primary joint replacements, 33,545 cases were classified as primary hip replacement and 47,586 cases were classified as primary knee replacement. Minimally invasive stratification was done by identification of a surgical approach filter; 10.0% of the cases represented use of a minimally invasive surgical approach and 11.6% of the cases had missing information on surgical approach. Of the minimally invasive hip replacement cases, 10.0% had missing data, while 12.7% of the minimally invasive knee replacement cases had missing data. Missing surgical approach information was evenly distributed across provinces and facilities.

To simplify this analysis, cases with missing information pertaining to surgical approach, date of birth, sex and surgical date were excluded. In total, 30,127 primary hip replacement and 41,467 primary knee replacement cases were used for the descriptive and logistic regression analyses for this section.

For conventional surgical method and non-conventional surgical method (such as minimally invasive surgery), associated revisions were tracked through longitudinal data covering the April 1, 2003 to March 31, 2006 period. This particular section of the study examined patient characteristics such as age, sex, diagnosis, province and time duration before a revision of a primary (hip and knee) replacement was needed. In total, 260 hip replacement and 273 knee replacement cases were studied. This sample of cases may not be representative of all revision cases performed in Canada, as submission of information to the CJRR is on a voluntary basis.

Collection of wait time information for hip and knee replacement procedures in Canada began April 1, 2005, on a voluntary basis. As a result, wait times analysis for minimally invasive procedures in this section only includes cases holding a complete set of wait time data; this represents 50% of all hip replacements (792/1,574) and 42% of all knee replacements (626/1,497) reported in the CJRR.

Methods

Knee and hip replacements are modeled separately. There are eight factors included in the generation of the analytical model: primary diagnosis, body mass index (BMI), year of surgery date, age at surgery, sex, province, area of patient residence (urban–rural) and neighbourhood income.

Primary diagnosis categories were collapsed into four main groups for both hip and knee replacements: (1) degenerative osteoarthritis, (2) inflammatory arthritis, (3) osteonecrosis and tumour, and (4) other.

BMI[11] was calculated by using patient's height and weight information collected in the CJRR. Four categories of BMI as defined in the Canadian weight classification system are used in this chapter. These include: underweight (BMI less than 18.5); normal weight (BMI = 18.5 to 24.9); overweight (BMI = 25 to 29.9) and obese (BMI = 30 and over).

Year of surgery date encapsulates hip and knee procedures performed at any point over the course of three consecutive fiscal year periods: 2003–2004, 2004–2005 and 2005–2006.

Patient age at surgery is represented through use of five categories: 0–44, 45–54, 55–64, 65–74 and 75+. Patient sex is dichotomized into male and female groups. Those for which sex is categorized as "other" were excluded due to small size.

To investigate provincial differences with minimally invasive procedures, patient residential codes were grouped into seven provinces: Atlantic provinces (Newfoundland and Labrador, Prince Edward Island, Nova Scotia, and New Brunswick), Quebec, Ontario, Manitoba, Saskatchewan, Alberta, and British Columbia (includes Yukon and Northwest Territories).

Patient level data (patient's residence postal code) on primary hip and knee procedures, reflecting the April 1, 2003 to March 31, 2006 period and obtained from the CJRR, were used to link with Statistic Canada's Postal Code Conversion File[39] data, updated in July 2006, to draw urban–rural distinctions as well as neighbourhood income estimates.

According to Statistic Canada's guideline, the urban–rural type consists of six categories: (1) urban center, (2) urban fringe, (3) rural fringe inside census metropolitan area (CMA), (4) urban area outside CMA, (5) rural area outside CMA and (6) secondary urban core. The census population counts for the urban core must be at least 100,000 to form a CMA. The urban fringe is defined as urban areas that are located within the CMA but are not contiguous to the urban core. Rural fringe is defined as rural areas within the CMA.

Categories of neighbourhood income were generated using the 2001 census data and are presented in the form of quintiles. Although the neighbourhood income category captures a lesser level of granularity, it allows for a broader understanding of the potential impact of socioeconomic status on access to care or clinical decisions pertaining to minimally invasive hip and knee replacement procedures in Canada.

A descriptive analysis was performed using a two-way frequency (crosstab) of each factor against the outcome variable—use or non-use of minimally invasive procedures. This analysis provides insight into proportions of minimally invasive procedures in relation to eight factors: primary diagnosis, BMI, year of surgery, age group, sex dichotomy, province, area of patient residence (urban or rural), and neighbourhood income. A chi-square test with contingency table was used to examine the statistical difference in proportion.

A descriptive analysis on type of hip and knee replacement methods (minimally invasive and conventional) is presented to provide background information for readers, but the conventional method was not used in the logistic regression models.

To further analyze the data, logistic regression models were used to determine the effect of a given factor after controlling for other factors. All factors, regardless of their statistical importance, were included in the logistical model.

In this study, the dependent variable is minimally invasive procedure, which is a binary variable. The independent variables include age at surgery, sex, BMI, province, primary diagnosis, year of surgeries, area of patient residence (urban–rural) and neighbourhood income. Logistic models were run separately for knee and hip respectively.

The LOGISTIC procedure was employed using SAS version 9, which sets the default to PARAMETER = EFFECT in its CLASS statement. The design variables for the reference group are set to -1. The maximum likelihood estimates are LOG (odds). For the purpose of this analysis, the PARAMETER = REFERENCE was specified. Thus, the design variables for the reference group were set to 0 and the maximum likelihood estimates showing in this report were LOG (odds ratio).

Cut-off points for independent variables were determined based on the frequency distribution patterns seen in the descriptive analysis. Missing data were coded as "unknown."

With logistic regression models, the default or comparative value for each factor was selected based on the following criteria: (i) clinical significance (for example, degenerative osteoarthritis as the default for diagnosis grouping); (ii) relative proportion grouping size (that is, age 55–64 as default for age at surgeries); and (iii) interpretation ease (that is, urban center for urban–rural type and the lowest neighbourhood income quintile for income categories).

The outputs of the logistic regression models are presented as odds ratios and confidence interval estimates. An odds ratio is defined as a ratio estimate of the number of times an event of interest occurs to the number of times that it does not.[40] Interval estimates of odds ratios are used to determine if odds ratios are statistically significant. If the confidence intervals contain the value of 1, then the odds ratio is considered not significant.

To simplify the interpretation of outputs resulting from logistic regression, the logistic regression model on hip replacements is a main effect model and does not count on interaction terms and random effects among facilities and surgeons.

A descriptive analysis with one-way frequency was employed to analyze minimally invasive surgery related revision rates. Procedures identified as revisions by submitting surgeons were selected for the analysis. A revision may indicate the need to replace or remove all or some of the artificial prosthetic components previously inserted.

A longitudinal analysis was conducted to identify and link revisions that were done subsequent to a primary arthroplasty between April 1, 2003 and March 31, 2006. The primary and revision procedures were matched using patient identifiers (that is, sex, health card number, birth date), type of joint (that is, hip or knee) and location of joint replaced (left or right side).

To understand the longevity of primary joint replacements, surgery dates were used to measure the time lapse between primary joint replacement and an associated revision for both conventional and non-conventional surgical methods. For example, a difference between the surgery date of the unilateral primary hip or knee replacement and the surgery date of the corresponding unilateral revision was calculated.

Patients of all age groups (0 to 85+) were analyzed and grouped into 5 main age categories (0–44, 45–54, 55–64, 65–74 and 75+) to avoid residual disclosure due to small cell sizes.

A descriptive analysis on wait times information for hip and knee replacements provides a "snapshot" of the wait time queue experienced by patients from the time the decision for surgery was made to the time of surgery date for a minimally invasive procedure. Wait times are reported in either medians or inter-quartiles. The median represents a mid-point of wait time experienced by 50% of hip and knee replacement patients in the queue. The inter-quartile range represents the time period between the second quarter (Q2) and third quarter (Q3) (between the 25th and 75th percentiles) that patients are in queue waiting for a joint replacement.

Data Limitations: Due to undercoverage issues and limited samples for minimally invasive patients with a revision, results presented should not be generalized to all hip and knee joint anthroplasties performed in Canada.

Appendix E
Minimally Invasive Focused Chapter Tables

Table E-1. Estimates of Undergoing Knee Replacements With Minimally Invasive Surgery Against Eight Factors: Age, Sex, BMI, Diagnosis Group, Province, Fiscal Year, Neighbourhood Income Category and Community Size

Factors Influencing Minimally Invasive Surgery	Maximum Likelihood Estimate	Standard Error of Estimate	Chi-Square p Value	Odds Ratio Estimates	95% Wald Confidence Limits	
					Lower CL	Upper CL
Age Group (Years)						
<44 vs. 55–64*	0.498	0.143	0.000	1.646	1.244	2.178
45–54 vs. 55–64*	0.296	0.061	<.0001	1.345	1.193	1.517
65–74 vs. 55–64*	-0.435	0.044	<.0001	0.647	0.594	0.705
75+ vs. 55–64*	-0.783	0.050	<.0001	0.457	0.415	0.504
Sex						
Female vs. male*	-0.190	0.036	<.0001	0.827	0.771	0.887
BMI						
Obese vs. normal weight*	-0.394	0.065	<.0001	0.674	0.594	0.765
Overweight vs. normal weight*	0.010	0.066	0.880	1.010	0.888	1.149
Underweight vs. normal weight*	-0.678	0.402	0.091	0.507	0.231	1.115
Unknown vs. normal weight*	-0.401	0.068	<.0001	0.670	0.586	0.766
Diagnosis Group						
Inflammatory arthritis vs. degenerative OA*	-1.351	0.139	<.0001	0.259	0.197	0.340
Osteonecrosis/tumour vs. degenerative OA*	0.657	0.156	<.0001	1.929	1.420	2.620
Other diagnosis vs. degenerative OA*	-0.940	0.135	<.0001	0.391	0.300	0.509
Province of Residence						
Alberta vs. Ontario*	0.973	0.060	<.0001	2.645	2.353	2.974
Atlantic vs. Ontario*	0.809	0.064	<.0001	2.245	1.982	2.543
British Columbia vs. Ontario*	1.573	0.056	<.0001	4.823	4.324	5.380
Manitoba vs. Ontario*	0.866	0.077	<.0001	2.376	2.043	2.765
Quebec vs. Ontario*	1.009	0.064	<.0001	2.742	2.421	3.106
Saskatchewan vs. Ontario*	0.650	0.084	<.0001	1.916	1.623	2.261

Factors Influencing Minimally Invasive Surgery	Maximum Likelihood Estimate	Standard Error of Estimate	Chi-Square p Value	Odds Ratio Estimates	95% Wald Confidence Limits	
					Lower CL	Upper CL
Time (Fiscal Year)						
Fiscal 2004 vs. 2003*	0.037	0.045	0.408	1.038	0.950	1.134
Fiscal 2005 vs. 2003*	0.293	0.047	<.0001	1.341	1.223	1.470
Neighbourhood Income						
Second quintile vs. lowest quintile*	0.148	0.062	0.017	1.160	1.026	1.310
Third quintile vs. lowest quintile*	0.146	0.063	0.021	1.157	1.022	1.309
Fourth quintile vs. lowest quintile*	0.220	0.062	0.000	1.246	1.103	1.407
Highest quintile vs. lowest quintile*	0.318	0.061	<.0001	1.375	1.221	1.548
Unknown vs. lowest quintile*	0.383	0.101	0.000	1.467	1.204	1.787
Community Size						
Rural area outside of CMA vs. urban centre*	-0.263	0.058	<.0001	0.769	0.686	0.862
Rural fringe vs. urban centre*	0.009	0.072	0.897	1.009	0.877	1.162
Secondary urban core vs. urban centre*	-0.433	0.225	0.054	0.649	0.418	1.008
Urban area outside of CMA vs. urban centre*	-0.230	0.066	0.000	0.795	0.698	0.904
Urban fringe vs. urban centre*	-0.017	0.114	0.880	0.983	0.786	1.230
Unknown vs. urban centre*	-0.165	0.103	0.109	0.848	0.694	1.037

Note:

* Reference group; analyzed against eight variables: age, sex, BMI, diagnosis group, province, fiscal year, neighbourhood income category, and community size.

Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2003–2004 to 2005–2006.

Table E-2. Estimates of Undergoing Hip Replacements With Minimally Invasive Surgery Against Eight Factors: Age, Sex, BMI, Diagnosis Group, Province, Fiscal Year, Neighbourhood Income Category and Community Size

Factors Influencing Minimally Invasive Surgery	Maximum Likelihood Estimate	Standard Error of Estimate	Chi-Square p Value	Odds Ratio Estimates	95% Wald Confidence Limits	
					Lower CL	Upper CL
Age Group (Years)						
<44 vs. 55–64*	-0.045	0.085	0.595	0.956	0.809	1.129
45–54 vs. 55–64*	-0.001	0.062	0.992	0.999	0.885	1.129
65–74 vs. 55–64*	0.009	0.048	0.856	1.009	0.917	1.109
75+ vs. 55–64*	-0.109	0.050	0.027	0.896	0.813	0.988
Sex						
Female vs. male*	-0.116	0.035	0.001	0.890	0.830	0.954
BMI						
Obese vs. normal weight*	-0.710	0.056	<.0001	0.492	0.441	0.549
Overweight vs. normal weight*	-0.262	0.050	<.0001	0.769	0.698	0.848
Underweight vs. normal weight*	0.022	0.164	0.893	1.022	0.741	1.410
Unknown vs. normal weight*	-0.167	0.052	0.001	0.846	0.764	0.937
Diagnosis Group						
Inflammatory arthritis vs. degenerative OA*	0.061	0.092	0.505	1.063	0.888	1.273
Osteonecrosis/tumour vs. degenerative OA*	-0.118	0.075	0.117	0.889	0.767	1.030
Other diagnosis vs. degenerative OA*	-0.469	0.066	<.0001	0.626	0.549	0.713
Province of Residence						
Alberta vs. Ontario*	-0.273	0.066	<.0001	0.761	0.668	0.866
Atlantic vs. Ontario*	0.026	0.067	0.699	1.026	0.900	1.171
British Columbia vs. Ontario*	1.298	0.050	<.0001	3.661	3.320	4.037
Manitoba vs. Ontario*	0.625	0.076	<.0001	1.868	1.610	2.167
Quebec vs. Ontario*	-0.211	0.068	0.002	0.810	0.708	0.926
Saskatchewan vs. Ontario*	0.746	0.075	<.0001	2.109	1.820	2.443

Factors Influencing Minimally Invasive Surgery	Maximum Likelihood Estimate	Standard Error of Estimate	Chi-Square p Value	Odds Ratio Estimates	95% Wald Confidence Limits	
					Lower CL	Upper CL
Time (Fiscal Year)						
Fiscal 2004 vs. 2003*	0.368	0.045	<.0001	1.444	1.323	1.577
Fiscal 2005 vs. 2003*	0.470	0.048	<.0001	1.600	1.457	1.757
Neighbourhood Income						
Second quintile vs. lowest quintile*	0.105	0.061	0.086	1.111	0.985	1.253
Third quintile vs. lowest quintile*	0.033	0.061	0.589	1.034	0.917	1.166
Fourth quintile vs. lowest quintile*	0.127	0.061	0.037	1.135	1.008	1.279
Highest quintile vs. lowest quintile*	0.208	0.058	0.000	1.231	1.100	1.378
Unknown vs. lowest quintile*	-0.009	0.106	0.933	0.991	0.806	1.219
Community Size						
Rural area outside of CMA vs. urban centre*	-0.143	0.058	0.013	0.867	0.774	0.971
Rural fringe vs. urban centre*	-0.384	0.080	<.0001	0.681	0.582	0.798
Secondary urban core vs. urban centre*	-0.375	0.215	0.081	0.687	0.451	1.047
Urban area outside of CMA vs. urban centre*	-0.059	0.062	0.347	0.943	0.835	1.065
Urban fringe vs. urban centre*	-0.475	0.133	0.000	0.622	0.479	0.806
Unknown vs. urban centre*	-0.120	0.109	0.268	0.887	0.717	1.097

Note:

* Reference group; analyzed against eight variables: age, sex, BMI, diagnosis group, province, fiscal year, neighbourhood income category and community size.

Source: Canadian Joint Replacement Registry, Canadian Institute for Health Information, 2003–2004 to 2005–2006.

Table E-3. Number and Percentage of Revisions Subsequent to Primary Knee Replacements via Minimally Invasive Surgery and Conventional Approach Against Six Variables: Age, Sex, BMI, Fiscal Year, Province and Time to Revision

Factors	Minimally Invasive Approach		Conventional Approach		p Value (Chi Sq Test)
	Counts	Percentage	Counts	Percentage	
Total	**57**	**100.0**	**216**	**100.0**	
Age Group (Years)					
Younger than 55	14	24.6	32	14.8	0.2018
55–64	19	33..3	62	28.7	
65–74	16	28.1	80	37.0	
≥75	8	14.0	42	19.5	
Sex					
Male	21	36.8	95	44.0	0.3321
Female	36	63.2	121	56.0	
BMI					
Underweight	-	-	-	-	0.6502
Normal weight	<5	7.0	17	7.8	
Overweight	17	29.8	47	21.8	
Obese	22	38.6	94	43.5	
Unknown	14	24.6	58	26.9	
Fiscal Year					
2003	<5	3.5	18	8.3	0.0351
2004	19	33.3	97	44.9	
2005	36	63.2	101	46.8	
Province of Residence					
Atlantic provinces	17	29.8	49	22.7	0.0041
Quebec	6	10.5	34	15.7	
Ontario	5	8.8	68	31.5	
Manitoba	5	8.8	18	8.3	
Saskatchewan	<5	7.0	5	2.3	
Alberta	10	17.5	25	11.6	
British Columbia	10	17.5	17	7.9	
Time to Revision*					
≤6 months	15	26.3	43	20.3	0.4986
7–12 months	16	28.1	74	34.9	
>12 months	26	45.6	95	44.8	

Notes:
Percentages presented pertain to columns and not rows.
* Counts exclude outliers.

Table E-4. Number and Percentage of Revisions Subsequent to Primary Hip Replacements via Minimally Invasive Surgery and Conventional Approach Against Six Variables: Age, Sex, BMI, Fiscal Year, Province and Time to Revision

Factors	Minimally Invasive Approach		Conventional Approach		p Value (Chi Sq Test)
	Counts	Percentage	Counts	Percentage	
Total	**43**	**100.0**	**217**	**100.0**	
Age Group (Years)					
Younger than 55	9	20.9	48	22.1	0.9817
55–64	9	20.9	41	18.9	
65–74	11	25.6	60	27.6	
≥75	14	32.6	68	31.4	
Sex					
Male	23	53.5	105	48.4	0.5410
Female	20	46.5	112	51.6	
BMI					
Underweight	<5	2.3	2	0.9	0.2886
Normal weight	9	20.9	34	15.7	
Overweight	12	27.9	47	21.7	
Obese	8	18.6	76	35.0	
Unknown	13	30.2	58	26.7	
Fiscal Year					
2003	<5	4.7	36	16.6	0.0987
2004	15	34.8	77	35.5	
2005	26	60.5	104	47.9	
Province of Residence*					
Atlantic provinces	<5	6.9	48	22.1	
Quebec	7	16.2	40	18.4	
Ontario	10	23.3	35	16.1	
Manitoba	<5	6.9	25	11.5	
Saskatchewan	5	11.6	5	2.3	
Alberta	<5	2.3	28	12.9	
British Columbia	14	32.6	36	16.6	
Time to Revision†					
≤6 months	26	61.9	133	62.7	0.3597
7–12 months	11	26.2	39	18.4	
>12 months	5	11.9	40	18.9	

Notes:
Percentages presented pertain to columns and not rows.
* Chi-square values not applicable as 21% of cells have counts less than 5.
† Counts exclude outliers.

Appendix F
Glossary

Glossary

Bearing Surfaces
Bearing surfaces refer to the type of material used for the hip prostheses (that is, femoral and acetabulum). Surface types include cobalt chrome, stainless steel, metal, ceramic alumina, polyethylene standard and polyethylene cross-linked etc.

Body Mass Index (BMI)
Body mass index (BMI) is a relationship between weight and height that is associated with body fat and health risk. The equation is BMI = body weight in kilograms/height in meters squared.

Bone Graft
A bone graft is surgery to place new bone into spaces around a broken bone or in between holes and defects in bone. The new bone can be taken from the patient's own healthy bone (this is called an autograft) or from frozen, donated bone (allograft).

Deep Vein Thrombosis (DVT)
DVT is a condition in which there is a blood clot in a deep vein (a vein that accompanies an artery). DVT mainly affects the veins in the lower leg and the thigh. It involves the formation of a clot (thrombus) in the larger veins of the area. This clot may interfere with circulation, and may break off and travel through the bloodstream (embolize). A resulting embolus can lodge in the brain, lungs, heart, or other area, causing severe damage to that organ.

Fixation Method
Hip and knee joint prostheses are replaced with or without cement as needed, to securely position the joint and allow for natural bone growth. Three major categories for fixation methods used were analyzed for both hip and knee replacements: cemented, uncemented and hybrid techniques. These were defined as:

- cemented if the components involved (femoral and acetabular for hip and femoral and tibial for knee) were cemented
- uncemented if none of the components (femoral and acetabular for hip and femoral and tibial for knee) was cemented
- hybrid if one component was cemented and the other was not.

Hip Arthroplasty
This surgery is performed to replace all or part of the hip joint with an artificial device. The hip is essentially a ball and socket joint, linking the "ball" at the head of the thigh bone (femur) with the cup-shaped "socket" in the pelvic bone. A total hip prosthesis is surgically implanted to replace the damaged bone within the hip joint.

The total hip prosthesis consists of three parts:

- a cup that replaces the hip socket. The cup is usually plastic, although some centres are trying other materials, such as ceramic and metal;
- a metal or ceramic ball that replaces the head of the femur; and
- a metal stem that is attached to the shaft of the bone to add stability to the prosthesis.

A "hemi-arthroplasty," can be monopolar (in which only the femoral head and stem are replaced) or bipolar (in which the femoral head and stem and the acetabular component, but not the acetabular insert/liner, are replaced).

When resurfacing only of the hip joint is performed, it may be full resurfacing (in which both the femoral head and acetabular component are replaced) or hemi-resurfacing (in which only the femoral head is replaced).

Hip Resurfacing (Surface Replacement)
Surface replacement is a bone-conserving alternative to total hip replacement in order to restore normal joint movements and ensure joint stability.[14]

Knee Arthroplasty
Knee joint replacement is surgery to replace a painful damaged or diseased knee joint with an artificial joint. The orthopedic surgeon makes a cut over the affected knee. The patella (knee cap) is moved out of the way, and the ends of the femur (thigh bone) and tibia (shin bone) are cut to fit the prosthesis. The undersurface of the knee cap is cut to allow for placement of an artificial component.

Knee Arthroplasty (UKA)
A uni-compartmental knee arthroplasty is used when only one side/compartment (medial, lateral or patellofemoral) of the knee is diseased or damaged and needs to be replaced with an artificial joint prosthesis.

Minimally Invasive Surgery
Minimally invasive surgery is an emerging surgical approach applied to most surgical specialties, including orthopedic surgery. The technique allows for reduction of the size of the incision and for minimizing trauma to the soft tissues; however, minimally invasive arthroplasty, or joint replacement, still involves the cutting of bone, realigning the soft tissue mechanism that supports the joint and placing the implant. A more accurate term describing the minimally invasive approach is considered to be "modification of standard approaches."

Most Responsible Diagnosis
The principal or primary diagnosis relating to the patient's admission to the hospital is reported on the discharge abstract that is submitted to CIHI. The most responsible diagnosis captures the direct reason for the patient's admission to the hospital. This helps to define the exact cause or reason for a patient's hip or knee replacement procedure.

Patella Surfacing
As part of knee joint replacement surgery, patella surfacing/resurfacing is not applicable to uni-compartmental knee replacement procedures.

Primary Replacement
A primary replacement is the first replacement procedure in which the natural bone is replaced with an artificial joint prosthesis.

Revision

Revisions are modifications or replacements made to an existing artificial hip or knee joint prosthesis/component. A revision procedure may be necessary when an existing old or worn-out hip or knee component needs to be removed and replaced with a new or improved prosthesis. This may include the removal of one or more hip or knee components as necessary.

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