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Abstract

Background

Accumulating evidence points to overall improvements in health-related quality of life after joint replacement for osteoarthritis. Some patients, however, do not appear to benefit from joint replacement. This study investigates health outcomes of patients who underwent hip or knee replacement surgery.

Methods

Linked survey and administrative data were used to compare the health-related quality of life of individuals who underwent surgery (surgical group) with that of their contemporaries who did not (comparison group), adjusting for other determinants of health. Weighted multivariate linear regression analyses were conducted.

Results

When the results were adjusted for other covariates known to be associated with health, the surgical group reported lower functional health (post-operative) than did the comparison group. Differences ranged from 6% lower functional health among hip replacement patients diagnosed with osteoarthritis to 21% lower functional health for those with hip fractures. Among surgical patients with osteoarthritis, co-morbid conditions and being underweight were associated with lower post-operative functional health.

Interpretation

This study is a unique application of linked data to the study of health outcomes of joint replacement at the population level. Outcomes of joint replacement differed by the initial diagnosis or reason for the surgery. For patients with osteoarthritis, poorer post-operative health outcomes were associated with co-morbidities and with being underweight.

Keywords

arthroplasty, databases, data collection, health status, hip fractures, hospital records, osteoarthritis

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Joint (hip and knee) replacement can provide substantial relief to people suffering from pain and limited mobility. In Canada, approximately 23,000 hip replacements and 38,400 knee replacements were conducted in 2006/2007.¹ The rate at which these procedures were performed more than doubled between 1995/1996 and 2005/2006, with even sharper increases between 2004/2005 and 2006/2007.² The rising rate is partially a reflection of an aging population; the recent acceleration is likely related to the identification of joint replacement among the five priority areas selected for meaningful reductions in waiting times.³

Accumulating evidence points to the health benefits of joint replacement for *osteoarthritis*, including reduced pain and greater mobility, which improve health-related quality of life.⁴⁻⁹ But despite generally positive results, some patients do not appear to benefit from these procedures.¹⁰ Recent reviews by Jones et al. indicated that 15% to 30% of arthroplasty patients reported little or no improvement in health-related quality of life after surgery.^{11,12} However, the generalizability of most outcome studies is limited, as they were based on selected samples representing specific geographic regions, institutions, clinical sites, and/or providers.

The evidence is less clear about the effectiveness of hip replacement for *hip fracture* patients. Considerable disagreement remains about the best course of treatment, depending on factors such as age, type of fracture and condition of the hip.¹³⁻¹⁵ While surgery is almost always indicated for such patients, the indications for type of surgery are less clear for some subtypes of hip fracture.¹⁵ Some studies report higher rates of infection and mortality after hip replacement, compared with alternative procedures such as internal fixation.¹⁶⁻¹⁸ Other studies report lower rates of re-operation and comparable hip function and health-related quality of life in the long term.^{18,19}

A population approach to health outcomes yields information about the results of care obtained in various settings, representing a wide range of patients, providers and health care institutions. Most previous research in this area has relied either on survey data, which offer only limited information about health care services received, or on administrative data, which often lack information about health outcomes and about patient characteristics that may explain why some fare better than others.

This study takes an innovative, population-based approach to the analysis of health outcomes using linked survey and administrative data. Responses to the 2000/2001 Canadian Community Health Survey (CCHS) were linked with administrative data from the Hospital Morbidity Database (HMDB) on the use of inpatient acute-care services. Linkage of these two datasets makes it possible to take advantage of the strengths of each.

The primary objective is to study patients' health outcomes after hip and knee replacement: specifically, whether those who have these procedures (surgical group) return to the average health status of their peers (comparison group). Combining patient-based information from the CCHS and from the HMDB allows for an investigation of a wide range of factors hypothesized to be associated with outcomes of care, as identified in the Health Outcome Framework developed by Statistics Canada and the Canadian Institute for Health Information.²⁰

The second, more data-driven, objective is to examine the potential of linked data for the analysis of health outcomes of specific surgical interventions. This will provide some policy perspective on gains to be made in future data investments, for example, surveys of patients who have undergone surgical interventions.

Methods

Data source

The data are from the Canadian Community Health Survey (CCHS)

and the Hospital Morbidity Database (HMDB). The CCHS is a nationally representative cross-sectional survey that collects information about Canadians' health status and use of health care. Cycle 1.1 was conducted in 2000/2001 with a sample size of 131,535.²¹ The survey covers approximately 98% of the population aged 15 or older living in private dwellings.

The HMDB is a national administrative database representing all inpatient acute hospital admissions. It contains information on dates of admission and separation, up to sixteen ICD-9 diagnoses identifying the reason(s) for the stay, and up to ten procedure codes (based on ICD-9/-10 codes²²) indicating interventions during the stay.

Study sample

To identify the "surgical group" (those who had joint replacement surgery), data from cycle 1.1 of the CCHS were linked to HMDB data covering the five years before the survey (1995/1996 to 2000/2001) using probabilistic data linkage techniques based on health insurance number, sex, date of birth and postal code.^{23,24} The analyses included only respondents who agreed to have their survey information linked to administrative data. The Statistics Canada Policy Committee approved the linkage. To address potential bias introduced by non-linkers, new survey weights were derived. The analyses excluded CCHS

respondents from Quebec, because data provided to Statistics Canada by Quebec for the HMDB have scrambled health insurance numbers, which make it impossible to link administrative records and survey responses.

Hospital stays were included in the analysis only if they were coded with a first surgical intervention indicating hip or knee replacement (Table 1). Some individuals had more than one acute inpatient admission with the relevant procedure codes. In these cases, the hospital event closest to the survey date was retained for analysis; subsequent admissions were dropped. No attempt was made to differentiate revisions from primary replacements; individuals (n=16) who stayed in hospital for these surgeries both before and after their CCHS interview were excluded. As well, hospital stays that occurred within the six months before the CCHS interview were excluded, because in these cases, answers to the survey questions about health status would reflect the post-operative recovery/rehabilitation period rather than full recovery. The sample was limited to CCHS respondents aged 40 or older because joint replacement at younger ages is rare and generally has different precursors and causes.

The "comparison group" consisted of CCHS respondents aged 40 years or older who had not had joint replacement in the five years before their interview (n=58,667).

Analytical techniques

Univariate analyses and weighted multivariate linear regression were used to compare the health status of individuals who had joint replacement surgery ("surgical group") with those who did not ("comparison group"), controlling for factors associated with post-operative health status. The same variables were then modelled to identify factors associated with health status among surgical patients diagnosed with osteoarthritis. Small sample sizes prevented similar analyses for the other diagnostic groups. Analyses were conducted with Stata software using the

Table 1
Procedure and diagnosis codes used to identify surgery groups

Surgery group	Procedure code	Diagnosis code
Hip replacement with osteoarthritis	935, 936	715
Hip replacement with fracture	935, 936	820, 821
Knee replacement with osteoarthritis	934 (ICD-9)	715
Complications of surgery (hip/knee)	934, 935, 936	996, 997, 998, 999
Other diagnoses (hip/knee)	934, 935, 936	All other diagnoses

xi: regression procedure. Special linkage weights were developed by Statistics Canada to adjust the linked data for those who did not consent to link and those who could not be linked because the information required for linkage was insufficient.

Variables

Health outcome measure

The primary health outcome measure is the health utility index (HUI), a multidimensional preference-based measure of health status^{25,26} that has been used in studies of population health²⁷⁻²⁹ and in clinical settings,³⁰ including among joint replacement patients. The HUI has a theoretical range between -0.3 (living in a state worse than death) and 1 (perfect health). It is intended to capture an individual's functional health status across eight dimensions: vision, hearing, speech, dexterity, cognition, emotion, mobility and pain. The two latter dimensions are particularly relevant for individuals undergoing hip and knee replacement surgery. A difference of 0.03 in the HUI is considered clinically significant.²⁹

Independent variables

The CCHS includes demographic information (age, sex, marital status, province of residence), socio-economic variables (household income, education), and risk factors that are hypothesized to be related to health status (presence of chronic conditions, body mass index, smoking). Education refers to the highest level attained by the respondent: less than secondary graduation; secondary graduation or some postsecondary, and postsecondary graduation. Household income, adjusted for household size, was measured in quintiles.

The CCHS collects information about chronic conditions including arthritis, diabetes, chronic obstructive pulmonary disease, asthma, hypertension, stroke, heart conditions, chronic pain, cancer and depression. Individuals were classified by the number chronic conditions they reported as diagnosed by a health professional and lasting

more than six months. Body mass index (BMI) was based on self-reported height and weight (weight in kilograms/height in metres squared). Smoking status was categorized as never smoked, former smoker, or current smoker based on self-reported smoking habits.

The surgical cohort was divided into diagnostic groups according to the reason for joint replacement as indicated by the most responsible diagnosis code on the hospital separation record for the surgical procedure: osteoarthritis, fracture (hip replacements), complications (specific ICD codes indicating complications of a surgical intervention), or other (for example, cancer, rheumatoid arthritis). This classification reflects the hypothesis that post-operative recovery differs depending on the reason for the surgery. Individuals undergoing joint replacement due to fractures, for example, experience a different trajectory of care and outcomes, given that the surgery is in response to an acute event.³¹

Results

Descriptive

A total of 598 individuals had a hip or knee replacement sometime between six months and five years before their CCHS cycle 1.1 interview (Table 2).

Table 2
Distribution of surgery groups, by surgical procedure and diagnosis, respondents aged 40 or older to 2000/2001 Canadian Community Health Survey, Canada excluding Quebec

Surgical procedure and diagnosis	Number	%
Total	598	100.0
Hip replacement		
Osteoarthritis	177	29.5
Fracture	52	8.7
Knee replacement (osteoarthritis)	239	40.0
Hip or knee replacement with/resulting from complications	63	10.5
Hip or knee replacement with other diagnoses (for example, cancer, arthritis)	67	11.2

Sources: 2000/2001 Canadian Community Health Survey; Hospital Morbidity Database.

What is already known on this subject?

- The rate at which hip and knee replacements are performed has increased sharply since 1995/1996.
- Despite generally positive results, some patients report little or no improvement in health-related quality of life after joint replacement.

What does this study add?

- This study is the first population-based analysis of the health outcomes of joint replacement using linked survey and administrative data at the national level in Canada.
- People aged 40 to 79 who underwent joint replacement reported lower post-operative functional health than did the comparison group.
- Among surgical patients with osteoarthritis, co-morbid conditions and being underweight were associated with lower post-operative functional health.
- Linked survey and administrative data show promise for assessing outcomes of health care interventions.

Osteoarthritis was the most common diagnosis among both hip and knee replacement patients: 29.5% and 40.0%, respectively. Hip fractures accounted for 8.7% of the cohort. Almost equal percentages had a joint replaced with or resulting from complications (10.5%), or with other diagnoses such as cancer or rheumatoid arthritis (11.2%).

The surgical group was, on average, older than the comparison group (47.3% versus 10.3% were aged 75 or older) and more likely to be female (63.4% versus 51.6%) and to have co-morbidities (89.7% versus 52.4%) (Table 3).

Average (unadjusted) health status, measured by the HUI, was 0.615 for

Table 3
Selected characteristics of surgery and comparison groups, respondents aged 40 or older to 2000/2001 Canadian Community Health Survey, Canada excluding Quebec

Characteristic	Surgery group		Comparison group	
	Number	%	Number	%
Total	598	100.0	57,493	100.0
Demographic				
Age group				
40 to 64	116	19.4	42,881	74.6
65 to 74	199	33.3	8,699	15.1
75 or older	283	47.3	5,912	10.3
Sex				
Men	219	36.6	27,820	48.4
Women	379	63.4	29,673	51.6
Marital status				
Married/Common-law	377	63.0	42,448	73.8
Widowed	163	27.2	5,221	9.1
Separated/Divorced	28	4.6	5,608	9.8
Never married	31	5.2	4,155	7.2
Region				
Newfoundland and Labrador, Prince Edward Island, Nova Scotia, New Brunswick	60	10.0	6,104	10.6
Ontario	307	51.3	29,063	50.6
Manitoba, Saskatchewan	55	9.2	5,127	8.9
Alberta, British Columbia	176	29.5	17,200	29.9
Socio-economic				
Education				
Less than secondary graduation	280	46.9	14,717	25.6
Secondary graduation/Some postsecondary	121	20.3	15,351	26.7
Postsecondary graduation	190	31.7	26,791	46.6
Household income quintile				
Lowest	20	3.4	1,797	3.1
Lower-middle	52	8.7	3,577	6.2
Middle	190	31.8	10,933	19.0
Upper-middle	180	30.2	17,659	30.7
Highest	78	13.1	17,118	29.8
Health/Lifestyle				
Number of chronic conditions				
None	62	10.4	27,369	47.6
One	155	26.0	15,837	27.5
Two	172	28.8	8,831	15.4
Three	124	20.8	3,794	6.6
Four	50	8.4	1,319	2.3
Five	31	5.2	276	0.5
Six or more	F	F	53	0.1
Body mass index (BMI)				
Underweight	33	5.6	3,268	5.7
Normal	188	31.4	22,305	38.8
Overweight	219	36.7	20,920	36.4
Obese	145	24.2	9,708	16.9
Smoking				
Never	236	39.4	18,420	32.0
Former	309	51.7	26,100	45.4
Current	52	8.7	12,828	22.3
Mean Health Utility Index	0.615	...	0.844	...

... not applicable

F too unreliable to be published (coefficient of variation 16.6% to 33.3%)

Source: 2000/2001 Canadian Community Health Survey; Hospital Morbidity Database.

Table 4
Adjusted[†] difference in Health Utility Index between surgical and comparison groups, by surgical procedure and diagnosis, respondents aged 40 or older to 2000/2001 Canadian Community Health Survey, Canada excluding Quebec

Surgical procedure (diagnosis)	Coefficient	95% confidence interval	
		from	to
Hip (osteoarthritis)	-0.056*	-0.086	-0.025
Hip (fracture)	-0.209*	-0.265	-0.153
Knee (osteoarthritis)	-0.089*	-0.115	-0.063
Hip or knee (complications)	-0.075*	-0.126	-0.024
Hip or knee (other)	-0.164*	-0.214	-0.115
No surgery

[†] adjusted for demographic, socio-economic and health/life-style characteristics

* significantly different from "no surgery" (p<0.01)

... not applicable

Sources: 2000/2001 Canadian Community Health Survey; Hospital Morbidity Database.

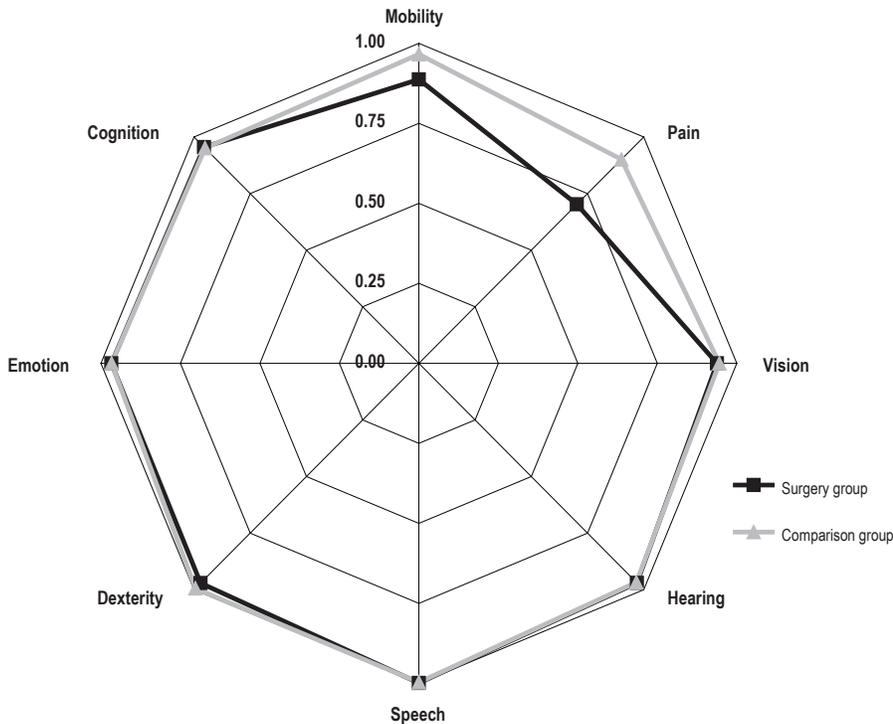
the surgical group and 0.844 for the comparison group (Table 3). The differences were mostly in the dimensions of mobility and pain, as shown, for example, on a radar plot for those age 65 to 74 (Figure 1). The pattern was similar for the other age groups and when the fracture group was removed from the analysis (data not shown).

Multivariate regression analysis

Overall, the surgical group reported lower functional health than did the comparison group, when the results were adjusted for other covariates hypothesized to be associated with health (Table 4). The results, however, varied by diagnosis. Joint replacement patients with a primary diagnosis of osteoarthritis "regained" more health, reporting 6% (hip replacement) and 9% (knee replacement) less functional health compared with the control group, whereas the hip fracture group reported 21% less functional health.

Among joint replacement patients with *osteoarthritis*, several other factors were significantly associated with post-operative health status (Table 5). Their functional health decreased with each

Figure 1
Mean (unadjusted) Health Utility Index scores, by attribute, for surgery and comparison groups, aged 65 to 74, to 2000/2001 Canadian Community Health Survey, Canada excluding Quebec



Source: 2000/2001 Canadian Community Health Survey; Hospital Morbidity Database.

additional chronic condition (13% less). Those who were underweight reported 24% less functional health, compared with “normal” weight individuals. Former smokers reported more functional health (7%), compared with those who never smoked.

Discussion

This is the first population-based analysis of health outcomes of joint replacement using linked survey and administrative data at the national level in Canada. Unlike studies based solely on administrative health data, the availability of health-related quality of life information (HUI) in the survey data allowed a more direct assessment of health outcomes on a range of patients, in a variety of care settings and providers.

On average, individuals who underwent joint replacement surgery were not restored to a level of functional level compared with a similar population group. As expected, the results varied by type of diagnosis, from 6% (hip replacement) and 9% (knee replacement) lower functional health among those with a diagnosis of osteoarthritis to 21% lower functional health among the hip fracture group. After surgery, patients with fractures do not “regain” health to the same degree as the osteoarthritis group. This finding supports evidence about the outcomes of treatment for hip fractures. Hip fracture has been associated with excess mortality, compared with the general population³² and compared with other hip replacement recipients.³³ As previously observed, the evidence about the effectiveness of joint replacement for hip fracture patients is mixed. Other

consequences of hip fractures may adversely affect patients’ health-related quality of life. It is likely that the fracture itself has a negative impact on their health trajectory; for example, the hospital stay itself can result in changes in functional status.³⁴⁻³⁶ Fractures among the elderly are as much a cause as a consequence of frailty, representing a closer to terminal event in the process of health decline.^{37,38}

The linked database made it possible to explore a range of factors associated with health outcomes of joint replacement among a nationally representative population. The results indicate that, among people with osteoarthritis who underwent joint replacement, being underweight and having co-morbid conditions were associated with poorer post-operative health. Although sex, age and marital status also seemed to be associated with poorer health, the results did not attain statistical significance, likely because of the small sample size. These results are consistent with other findings that point to a variety of factors associated with outcomes of joint replacement,^{39,40} including co-morbid conditions⁴¹ and lack of social support.⁴² These associations may indicate the expected effectiveness of joint replacement, in terms of health status, for individuals with osteoarthritis.

The better health of former smokers, compared with those who never smoked, was unanticipated. However, former smokers include both recent and long-time quitters, the latter of whom often achieve health status and adopt health care practices similar to those of non-smokers.^{43,44} In fact, some evidence suggests that long-time quitters are more likely than non-smokers to believe in the efficacy of modifying other risk factors.⁴⁵ It is possible, then, that former smokers (at least, long-time quitters) have adopted other healthy lifestyles, such as greater physical activity, that improve their overall health.

Limitations

This study has several limitations. First, the sample size is small—the analysis pertains only to joint replacement patients

Table 5
Linear regression coefficients relating selected characteristics to Health Utility Index, joint replacement patients with osteoarthritis, respondents aged 40 or older to 2000/2001 Canadian Community Health Survey, Canada excluding Quebec

Characteristic	Coefficient	95% confidence interval	
		from	to
Demographic			
Age group			
40 to 64 [†]
65 to 74	0.064	-0.016	0.143
75 or older	-0.078	-0.163	0.007
Sex			
Men [†]
Women	-0.055	-0.117	0.007
Marital status			
Married/Common-law [†]
Widowed	0.055	-0.015	0.125
Separated/Divorced	0.074	-0.069	0.217
Never married	-0.136	-0.282	0.010
Region			
Newfoundland and Labrador, Prince Edward Island, Nova Scotia, New Brunswick	0.094	-0.007	0.195
Ontario	-0.007	-0.071	0.058
Manitoba, Saskatchewan	0.041	-0.068	0.150
Alberta, British Columbia [†]
Socio-economic			
Education			
Less than secondary graduation	0.000	-0.070	0.070
Secondary graduation/Some postsecondary	0.034	-0.054	0.122
Postsecondary graduation [†]
Household income			
Lowest	-0.105	-0.325	0.115
Lower-middle	-0.129	-0.260	0.002
Middle	-0.042	-0.137	0.053
Upper-middle	-0.072	-0.165	0.021
Highest [†]
Health/Lifestyle			
Number of chronic conditions	-0.134*	-0.157	-0.112
Body Mass Index (BMI)			
Underweight	-0.243*	-0.429	-0.057
Normal [†]
Overweight	0.047	-0.028	0.122
Obese	0.024	-0.056	0.105
Smoking			
Never [†]
Former	0.074*	0.015	0.133
Current	0.011	-0.119	0.141

[†] reference category

* significantly different from "no surgery" (p<0.05)

... not applicable

Sources: 2000/2001 Canadian Community Health Survey; Hospital Morbidity Database.

who were respondents to the 2000/2001 CCHS. Subsequent studies may benefit from ongoing efforts at Statistics Canada to link several waves of the CCHS to hospital administrative data. This limitation, however, is counterbalanced by gains in generalizability—the data represent the Canadian population, not a single hospital or a single health insurance provider or even a single province.

Second, because the sample is restricted to the household population, it does not represent outcomes of joint replacement among residents of institutions such as long-term care facilities.

Finally, the study does not directly measure the change in health status before and after surgery. Rather, it compares the post-operative health status of surgical patients to a population comparison group. This approach assumes that the surgery was intended to restore patients to a level of health similar to that of their contemporaries. However, a negative finding does not necessarily signal the absence of a gain in health-related quality of life as a result of the surgery.

Conclusion

This study is a unique application of linked data to the study of health outcomes after a health care intervention, namely, joint replacement. The data allow for a population approach to the assessment of health outcomes, taking into account a range of factors. The outcomes of joint replacement differ depending on the initial diagnosis or reason for the surgery. In particular, patients with osteoarthritis who are underweight or have co-morbid conditions may be susceptible to poorer outcomes. Linked data show promise for studying outcomes of health care interventions, especially interventions that are common and are well-documented in administrative records. ■

References

- Canadian Institute for Health Information. *Surgical Volume Trends, 2008 - Within and Beyond Wait Time Priority Areas*. Ottawa: Canadian Institute for Health Information, 2008.
- Canadian Institute for Health Information. *Hip and Knee Replacements in Canada 2007, Annual Report*. Ottawa: Canadian Institute for Health Information, 2008.
- Canadian Intergovernmental Conference Secretariat. *A 10-Year Plan to Strengthen Health Care*. Available at: <http://www.scics.gc.ca/cinfo04/800042005_e.pdf>. Accessed June 6, 2008.
- Hawker G, Wright J, Coyte P, et al. Health-related quality of life after knee replacement. *Journal of Bone and Joint Surgery* 1998; 80(2): 163-73.
- Jones CA, Voaklander DC, Johnston DW, Suarez-Almazor ME. Health related quality of life outcomes after total hip and knee arthroplasties in a community based population. *Journal of Rheumatology* 2000; 27(7): 1745-52.
- Laupacis A, Bourne R, Rorabeck C, et al. The effect of elective total hip replacement on health-related quality of life. *Journal of Bone and Joint Surgery* 1993; 75(11): 1619-26.
- Fitzgerald JD, Orav EJ, Lee TH, et al. Patient quality of life during the 12 months following joint replacement surgery. *Arthritis Care and Research* 2007; 51: 100-9.
- Ethgen O, Bruyere O, Richy F, et al. Health-related quality of life in total hip and total knee arthroplasty. A qualitative and systematic review of the literature. *Journal of Bone and Joint Surgery* 2004; 86-A(5): 963-74.
- Montin L, Leino-Kilpi H, Suominen T, Lepisto J. A systematic review of empirical studies between 1966 and 2005 of patient outcomes of total hip arthroplasty and related factors. *Journal of Clinical Nursing* 2008; 17(1): 40-5.
- Wylde V, Dieppe P, Hewlett S, Learmonth ID. Total knee replacement: Is it really an effective procedure for all? *Knee* 2007; 14(6): 417-23.
- Jones CA, Beupre LA, Johnston DW, Suarez-Almazor ME. Total joint arthroplasties : Current concepts of patient outcomes after surgery. *Clinics in Geriatric Medicine* 2005; 21: 527-41.
- Jones CA, Beupre LA, Johnston DW, Suarez-Almazor ME. Total joint arthroplasties: current concepts of patient outcomes after surgery. *Rheumatic Diseases Clinics of North America* 2007; 33(1): 71-86.
- Bhandari M, Devereaux PJ, Tornetta P et al. Operative management of displaced femoral neck fractures in elderly patients. An international study. *Journal of Bone and Joint Surgery* 2005; 87A (9): 2122-30.
- Healy WL, Iorio R. Total hip arthroplasty. Optimal treatment for displaced femoral neck fractures in elderly patients. *Clinical Orthopaedics and Related Research* 2004; 429: 43-8.
- Lyons AR. Clinical outcomes and treatment of hip fractures. *The American Journal of Medicine*, 1997; 103: 51S-64S.
- Hsiu Su BS, Aharonoff GB, Hiebert R, et al. In-hospital mortality after femoral neck fracture: Do internal fixation and hemiarthroplasty differ? *The American Journal of Orthopedics* 2003; 32(3): 151-5.
- Sikand M, Wenn R, Moran CG. Mortality following surgery for undisplaced intracapsular hip fractures. *Injury, International Journal of Care for the Injured* 2004; 35: 1015-9.
- Bhandari M, Devereaux PJ, Swiontkowski MF, et al. Internal fixation compared with arthroplasty for displaced fractures of the femoral neck: A meta-analysis. *Journal of Bone and Joint Surgery* 2003; 85A(8): 1673-81.
- Blomfeldt R, Tornkvist H, Ponzer S et al. Comparison of internal fixation with total hip replacement for displaced femoral neck fractures. *The Journal of Bone and Joint Surgery* 2005; 87-A(8): 1680-8.
- Statistics Canada and Canadian Institute for Health Information. *A Framework for Health Outcome Analysis: Diabetes and Depression Case Studies*. Ottawa: Canadian Institute for Health Information, 2008.
- Beland Y. Canadian Community Health Survey—methodological overview. *Health Reports* (Statistics Canada, Catalogue 82-003) 2002; 13(3): 9-14.
- Statistics Canada. *Health Person Oriented Information – External Linkage Production Report (Data Years F1991-F2005)*. Ottawa: Health Statistics Division, 2007 (internal document)
- Nadeau C. *Linking HPOI 1992-2005 to CCHS*. Ottawa: Statistics Canada, Household Survey Methods Division (internal document).
- Statistics Canada. *Generalized Record Linkage Software*. Available at: <http://gensys-sysgen/DesktopDefault.aspx?lang=en&tabid=106>.
- Feeney D, Furlong W, Torrence GW, et al. Multiattribute and single-attribute utility functions for the health utilities index mark 3 system. *Medical Care* 2002; 40(2): 113-28.
- Feeny D, Furlong W, Boyle M, et al. Multi-attribute health status classification systems. *Health Utilities Index. Pharmacoeconomics* 1995; 7(6): 490-502.
- Erickson P, Kendall EA, Anderson JP, et al. Using composite health status measures to assess the nation's health. *Medical Care* 1989; 27(suppl 3): S66-76.
- Luo N, Johnson JA, Shaw JW, et al. Self-reported health status of the general adult U.S. population as assessed by the EQ-5D and Health Utilities Index. *Medical Care* 2005; 43(11): 1078-86.
- Kopec JA, Williams JI, To T, et al. Cross-Cultural comparisons of health status in Canada using the Health Utilities Index, ethnicity and health. *Ethnicity and Health* 2001; 6(1): 41-50.
- Grootendorst P, Feeny D, Furlong W. Health Utilities Index Mark 3: evidence of construct validity for stroke and arthritis in a population health survey. *Medical Care* 2000; 38(3): 290-9.
- Su H, Aharonoff GB, Hiebert R, et al. In-hospital mortality after femoral neck fracture: do internal fixation and hemiarthroplasty differ? *American Journal of Orthopedics* 2003; 32 (3): 151-5.
- Richmond J, Aharonoff GB, Zuckerman JD, et al. Mortality risk after hip fracture. *Journal of Orthopaedic Trauma*, 2003; 17 (1): 53-6.
- Canadian Institute for Health Information. *Hip and Knee Replacements in Canada 2005, Annual Report*. Ottawa: Canadian Institute for Health Information, 2006.
- Creditor MC. Hazards of hospitalization of the elderly. *Annals of Internal Medicine* 1993; 118: 219-23.
- Covinsky KE, Palmer RM, Fortinsky RH, et al. Loss of independence in activities of daily living in older adults hospitalized with medical illnesses: Increased vulnerability with age. *Journal of the American Geriatrics Society* 2003; 51: 451-8.
- Friedman SM, Mendelson DA, Bingham KW, McCann RM. Hazards of hospitalization: Residence prior to admission predicts outcomes. *The Gerontologist* 2008; 48: 537-41.
- Cree M, Yang Q, Sclater A, et al. Continuity of care and health decline associated with a hip fracture. *Journal of Aging and Health* 2002; 14(3): 385-98.
- Wolinsky FD, Fitzgerald JF, Stump TE. The effect of hip fracture on mortality, hospitalization and functional status: A prospective study. *American Journal of Public Health* 1997; 87 (3): 398-403.

39. Young NL, Cheah D, Waddell JP, Wright JG. Patient characteristics that affect the outcome of total hip arthroplasty: a review. *Canadian Journal of Surgery* 1998; 41:188-95.
40. Jones CA, Beaupre LA, Johnston DW, Suarez-Almazor ME. Total joint arthroplasties: current concepts of patient outcomes after surgery. *Rheumatic Diseases Clinics of North America* 2007; 33(1): 71-86.
41. Lübbecke A, Katz JN, Perneger TV, Hoffmeyer P. Primary and revision hip arthroplasty: 5-year outcomes and influence of age and comorbidity. *Journal of Rheumatology* 2007; 34(2): 394-400.
42. Escobar A, Quintana JM, Bilbao A, et al. Effect of patient characteristics on reported outcomes after total knee replacement. *Rheumatology* 2007; 46(1): 112-9.
43. Wilkins K, Shields M, Rotermann M. Smokers' use of acute care hospital – A prospective study. *Health Reports (Statistics Canada, Catalogue 82-003)* 2009; 20(4): 1-9.
44. Arvidsson S, Arvidsson B, Fridlund B, Bergman S. Health predicting factors in a general population over an eight-year period in subjects with and without chronic musculoskeletal pain. *Health and Quality of Life* 2008; 6: 98.
45. Halpern MT, Warner KE. Differences in former smokers' beliefs and health status following smoking cessation. *American Journal of Preventive Medicine* 1994; 10(1): 31-7.