Infection after cholecystectomy, hysterectomy or appendectomy

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Abstract

Objectives

This article uses patient-linked data to focus on hospitalization with post-operative infection following cholecystectomy, hysterectomy or appendectomy. The average number of hospital days and the costs of readmission are also estimated.

Data source

Data for surgeries in fiscal years 1997/98, 1998/99 and 1999/00 are from the Health Person-Oriented Information Database.

Analytical techniques

Bivariate tabulations were used to estimate the percentage of patients hospitalized with post-operative infection after cholecystectomy, hysterectomy or appendectomy between 1997/98 and 1999/00. Logistic regression was used to explore associations between infection and patient characteristics, readmission, and peri-operative mortality, while controlling for surgical characteristics.

Main results

Hospitalization with post-operative infection was relatively rare, occurring in 1.4% of cholecystectomy, 2.0% of hysterectomy, and 3.8% of appendectomy patients. The associated costs of readmission for post-operative infection for the three surgeries were estimated at $5.4 to $6.3 million annually. Old age, being male, surgical complexity and approach, and diabetes were associated with hospitalization involving a post-operative infection.

Key words

length of stay, post-operative, patient admission, patient readmission, surgical site

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Despite efforts to control infection, advances in surgical techniques, and use of antibiotic prophylactics, no surgery is free of the risk of infection.[1,2] Surgical site, bloodstream, and catheter-associated urinary tract infections, as well as hospital-borne pneumonia, remain important concerns.

Health Canada has estimated that each year between 5% and 10% of all people admitted to hospital contract an infection.[3] With over 2 million Canadians hospitalized annually, potentially 105,000 to 210,000 people may be affected.[4] According to the Community and Hospital Infection Control Association, 8,500 Canadians die each year owing to complications arising from infections acquired in hospital, and the annual related costs to individuals and the health care system exceed $750 million.[5] Patients who acquire infections spend considerably more time in hospital, undergo more testing, and require more medications and medical care than patients who do not develop infections.[6-8]

Methods

Data source

This analysis is based on data from the Health Person-Oriented Information Database, maintained by Statistics Canada. This database contains information on inpatient hospital separations (discharges or deaths) from most acute care and some psychiatric, chronic and rehabilitation hospitals across Canada.[9] Each record contains demographic (for example, postal code, date of birth), non-medical administrative (such as scrambled and unscrambled health insurance number, dates of admission and separation) and clinical information (diagnoses and procedures, for example).[10] This analysis used only data that could be linked; that is, the records with valid identifiers. Annually, approximately 13% of the hospital morbidity records are excluded from the additional processing that enables the files to be analyzed at the person level: 10% because they are records for newborns, and the remaining 3% because the record contains either an invalid identifier or is for a person residing outside the province. A more complete description of the Health Person-Oriented Information Database is available in another publication.[9]

To prepare the data for analysis, hospital separation records for each patient were merged, based on a unique patient identifier, and sorted chronologically. Records of hospital stays for each patient were thus linked, beginning with the admission during which the surgery took place, followed by readmissions within 30 days of surgery. For each patient, data from only the first 20 admissions, beginning in April 1997 and ending in March 2000, were used in the analysis. A total of 382,277 linked records were included, representing 141,766 cholecystectomy, 159,644 hysterectomy, and 80,867 appendectomy patients. Virtually all of these inpatients (99.9%) had had their surgery in an acute care hospital (data not shown).

Cost information is not available for all provinces. The Alberta cost information used in this analysis reflects the average cost of procedures derived from data submitted by nine Alberta hospitals.[11] Cost information for Ontario reflects the average cost of procedures and treatment of diagnoses from data submitted by a subset of 22 specialty, community or teaching hospitals (Ontario Case Costing Initiative).[12-13] The cost data do not necessarily correspond with total provincial averages of hospital-based services.

Analytical techniques

Patients who had had one of the three surgeries—cholecystectomy, hysterectomy or appendectomy—during fiscal years 1997/98 to 1999/00 were grouped by surgery.

Date of surgery was not available; therefore, it was imputed as the day after the date of admission for the surgical stay.

Descriptive analyses were based on tabulations of numbers and percentages. Statistical significance of differences between proportions was tested ($p < 0.05$). The proportions of patients hospitalized with post-operative infection either during the surgical stay or readmission were calculated. The overall rate for hospitalization with post-operative infection was calculated by dividing the number of patients with infection noted on any hospital record within 30 days of surgery by the total number of patients who had the surgery, then multiplying by 100. Readmissions for infection were considered to include only those patients who were re-hospitalized within 30 days with a post-operative infection identified as the “most responsible” diagnosis. Peri-operative death rates (in-hospital death within 30 days of the procedure) were similarly calculated.

Separate logistic regression models were fitted for each surgery in order to calculate the odds of hospitalization with a post-operative infection, readmission for post-operative infection, and dying within 30 days of surgery. Selection of control variables was guided by the literature and the availability of data in the Health Person-Oriented Information Database (see *Limitations*).

Average length of readmission was calculated separately for each surgical group by summing the number of days of hospitalizations for which the “most responsible” diagnosis was a post-operative infection, and dividing by the number of patients who were readmitted. When the date indicated that a subsequent stay began before or on the same day as the preceding stay ended, the overlapping day was double-counted. Such overlaps are rare and do not substantially change the length-of-stay calculations. They also likely reflect instances where patients were discharged, then readmitted on the same day. On average, 4% of each of the three surgical cohorts had overlapping and/or concurrent admissions associated with the surgical stay (data not shown).

Peri-operative mortality was defined as a discharge condition of “dead” within 30 days of the imputed surgery date. If a patient died out of hospital, the death could not be included.

The burden of post-operative infection on the health care system was measured by calculating the mean number of days of hospitalization for patients who were readmitted for treatment of a post-operative infection (defined as an admission for which post-operative infection accounted for the major portion of the stay) within 30 days of the surgery. The average length of readmission was obtained by summing the days of subsequent hospitalizations within 30 days of surgery.

This article examines hospitalization for post-operative infection in patients who underwent one of three common surgical procedures during the 1997/98, 1998/99 or 1999/00 fiscal year: cholecystectomy (gall bladder removal), hysterectomy (removal of the uterus) and appendectomy (removal of the appendix). Associations between patient characteristics and post-operative infection are investigated, as are surgical approach and complexity (see *Definitions*).

The Health Person-Oriented Information Database structures hospital morbidity data so that each patient's hospital admissions could be linked using a unique identifier (see *Methods* and *Limitations*). In addition to the number of hospitalizations, the average total length and the estimated costs of re-hospitalization for post-operative infection were calculated. Using linked data provides a more accurate assessment of the burden post-operative infections place on the health care system. Without such records, a substantial proportion of the post-operative infections observed in this study would have been missed.

Patient-linked hospitalization data do not capture all post-operative infections. Many such infections are treated in outpatient clinics or physicians' offices and thus do not appear in hospital records. It is likely that only the most serious ones result in a patient being readmitted to hospital.

Hospitalization uncommon

Hospitalization with post-operative infection was relatively rare among cholecystectomy, hysterectomy and appendectomy patients (see *Definitions*). Of the 382,277 in-patients who had one of these surgeries in 1997/98, 1998/99 or 1999/00, just 2.2% (8,323) developed an infection that was noted during the initial surgical stay and/or subsequent admission(s) to hospital within 30 days of the surgery (Table 1).

The percentage of patients hospitalized with a post-operative infection varied by surgery. Infection was significantly less likely after cholecystectomy (1.4%) or hysterectomy (2.0%) than after appendectomy (3.8%). These figures are comparable with findings from other studies.[2,14-16]

Risk of post-operative infection

The risk of post-operative infection is influenced by patient characteristics such as sex, age, pre-existing infection (peritonitis, for example), presence of other conditions, and by surgical approach and complexity. Information about other factors that may affect a patient's risk of developing an infection—weight, nutritional and smoking habits, use of prophylactic antibiotics, and so on—was not available in the data used for this analysis (see *Limitations*).

Female cholecystectomy patients outnumbered their male counterparts by more than 2 to 1, but men were twice as likely to be hospitalized with a post-operative infection, a finding previously noted in research on gall bladder and other surgery patients.[17-21] Post-operative infection was also more common among male than female appendectomy patients (Table 2). Research has indicated that testosterone has a depressive effect on the body's

Table 1
Hospitalization with post-operative infection within 30 days of cholecystectomy, hysterectomy or appendectomy, Canada excluding territories, 1997/98 to 1999/00

	Total		Cholecystectomy		Hysterectomy		Appendectomy	
	Number	%	Number	%	Number	%	Number	%
Total	382,277	100.0	141,766	100.0	159,644	100.0	80,867	100.0
Post-operative infection within 30 days of surgery (noted during surgical admission and/or upon readmission)	8,323	2.2	1,961	1.4*	3,254	2.0	3,108	3.8
Post-operative infection noted upon readmission and coded as condition most responsible for hospital stay†	3,554	0.9	593	0.4	1,540	1.0	1,421	1.8

Data source: Health Person-Oriented Information Database, 1997/98 to 1999/00
† 219 of these patients also had an infection diagnosed during their surgical admission.
** Significantly different from rates of infection following hysterectomy and appendectomy (p < 0.05)*

Limitations

This analysis is based on inpatient hospitalization information only. Data on outpatient/day surgery procedures, which comprise an unknown proportion of the total, are not included in this analysis. Tabulations of hospitalization with post-operative infection based on information from the Health Person-Oriented Information Database do not reflect the extent of post-operative infection. Only patients whose discharge summaries contained an ICD-9 code of 998.5 within 30 days of the surgery were included in the analysis. Post-operative infections that later developed in patients who were not readmitted were not documented in hospital records, so they could not be counted in this analysis.

The accuracy of the diagnosis of post-operative infection has not been validated, and the specificity and sensitivity of the coding is unknown. Hospitals in jurisdictions where funding is based on discharge abstract data may have a greater incentive to report more diagnoses and/or more post-operative infections. The completeness of reporting may also be influenced by the availability of health records resources, and provincial and/or individual hospital data-capture guidelines. For example, some hospitals may identify a diagnosis based on a laboratory test alone. Coding of post-operative infection may also be influenced by a hospital's participation in nosocomial infection surveillance programs and/or other types of coding practices specific to individual hospitals.[22]

A recent reabstraction study showed that approximately 7% of the principal procedures and 13% of the most responsible diagnoses are not coded accurately. However, common and relatively uncomplicated procedures, such as the three surgical procedures examined in this analysis, are easier to identify and are likely more accurately coded.[23]

The principal procedure from each record was used to select patients for this study. Records with multiple procedures were not excluded from the analysis because the majority of other procedures on each record relate to the principal procedure. In over 99% of all patients, the principal procedure was equivalent to the first procedure field (as expected); 47% of these records noted additional procedures. The Health Person-Oriented Information Database is made up of administrative data primarily designed for billing purposes. It is likely that some of the variation in the number of procedures on each record reflects differing levels of coding specificity or procedure itemization within and among hospitals.

Information on several patient and hospital characteristics that may influence post-operative infection risk was not available in the Health Person-Oriented Information Database; for example, patients' weight, nutritional and smoking habits, immunity status, current immuno-suppression therapy, length of pre-operative stay, severity of pre-operative conditions, presence of distant infection, use of prophylactic antibiotics, emergency versus elective appendectomy, type of wound closure, and effectiveness of infection control practices and programs at each hospital.[24-26] Incomplete reporting of a patient's co-morbid conditions may also limit interpretation of the risk factors for post-operative infections.

The accuracy of the cost estimates for readmissions owing to infection is unknown. The estimates pertain only to patients who were readmitted for infection. But many other patients received treatment for post-operative infection during surgical admission and readmissions, although it may not have been the chief factor that extended the hospital stay and/or necessitated the readmission. Estimated differences between the average accumulated lengths of stay of patients who were and were not treated for infection suggest that costs to treat patients with post-operative infection associated with the three surgeries could range from $18 million to $21.2 million annually (data not shown).

An important body of research focuses on the relationship between the number of surgeries performed at a particular institution and patient outcomes. In general, patients who undergo a specific procedure in hospitals where a high volume of that procedure is performed have better outcomes than those treated in lower-volume hospitals.[27-30] It is not possible to ascertain surgical volume by hospital with available documentation because the definition of "hospital" is inconsistent within and across provinces and between data years. For instance, "hospital" is variously defined as an individual hospital or a corporation comprising more than one hospital, due to the amalgamation of several individual hospitals, or a ward within a hospital. Therefore, the effect of surgical volume on the risk of post-operative infection or mortality could not be assessed in this analysis.

Because the date of surgery is not provided on the Health Person-Oriented Information Database, it was imputed as the day after the admission date. The validity of the imputed surgery date is unknown.

The data used in this study capture only deaths that occurred in hospital. Other patients may have died because of complications associated with post-operative infections, but because these deaths did not occur in hospital, they could not be included.

ability to fight infection.[18,19] It has also been suggested that estrogen may account for women's higher level of immunity.[18,19]

Of course, additional factors may contribute to men's elevated risk of developing an infection after surgery. For example, compared with women, higher proportions of men in all but the youngest age groups smoke daily,[31] and smoking has been shown to impede healing and immune responses.[32]

Table 2
Distribution of surgery and percentage with post-operative infection within 30 days of cholecystectomy, hysterectomy or appendectomy, by selected characteristics, Canada excluding territories, 1997/98 to 1999/00

	Cholecystectomy		Hysterectomy		Appendectomy	
	Total	Hospi-talized with infection	Total	Hospi-talized with infection	Total	Hospi-talized with infection
	%		%		%	
Total	100.0	...	100.0	...	100.0	...
Sex						
Men	30.0	2.2*	...	...	55.2	4.4*
Women†	70.0	1.0	100.0	2.0	44.8	3.1
Age group						
≤ 29†	12.8	0.5	3.3	3.0	56.9	3.0
30-39	15.4	0.6*	24.4	2.2*	17.6	3.6*
40-49	17.6	0.8*	40.3	2.0*	12.0	4.9*
50-59	19.0	1.3*	16.0	1.8*	6.8	5.8*
60-69	16.9	1.9*	8.6	1.7*	3.7	7.6*
70+	18.4	2.9*	7.5	2.1*	3.0	7.2*
Surgical approach						
Open	16.6	4.3*	...	...	...	...
Laparoscopic†	83.4	0.8	...	...	...	...
Abdominal	...	...	68.7	2.3*	...	...
Vaginal†	...	...	31.4	1.6	...	...
Surgical complexity						
High	...	...	0.9	3.4*	...	...
Low†	...	...	99.1	2.0	...	...
Appendix						
Ruptured/Peritonitis/ Peritoneal abscess	...	...	...	...	28.2	8.0*
No record of rupture/peritonitis/ peritoneal abscess†	...	...	...	...	71.9	2.2
Diabetes						
Yes	5.3	2.9*	4.7	4.0*	1.5	10.1*
No†	94.7	1.3	95.3	2.0	98.5	3.7

Data source: Health Person-Oriented Information Database, 1997/98 to 1999/00
† Reference group
··· Not applicable
** Significantly different from reference group (p < 0.05)*

For people who had a cholecystectomy or appendectomy, post-operative infection was more frequent among the older patients. Previous research indicates that advanced age is a major risk factor for post-operative infection, partly because seniors are far more likely to have other conditions that may delay healing.[33-35]

The relationship between age and risk of infection was generally reversed for hysterectomy patients, meaning that women younger than 30 were more likely than older women to be hospitalized for an infection. Whenever possible, young women, and those with one or no children, are treated to preserve their childbearing capacity.[36] It is therefore reasonable to assume that the conditions necessitating hysterectomy in young women are relatively serious, and these women are consequently at higher risk of post-operative infection. Information about other factors that might predispose a patient to infection, such as complications encountered during the operation, tumour size, underlying diagnoses or length of surgery, is not available in the Health Person-Oriented Information Database (see *Limitations*).

Differences by surgical approach

The percentage of hospitalizations with post-operative infection varied by surgical procedure and complexity, and by underlying disease. Cholecystectomy patients who had open versus laparoscopic surgery, hysterectomy patients who had an abdominal procedure, appendectomy patients who already had an infection when they had surgery, and patients with diabetes were all over-represented among those hospitalized with post-operative infections (Table 2).

For cholecystectomy patients, surgical approach was strongly associated with post-operative infection (Table 3). Those who underwent an open cholecystectomy had over 4 times the odds of being hospitalized with an infection post-operatively, compared with patients whose surgery was performed laparoscopically, even when risk factors such as age, sex and diabetes were taken into account.

Definitions

In accordance with the *Canadian Classification of Diagnostic, Therapeutic, and Surgical Procedures* (CCP),[37] cholecystectomy, hysterectomy and appendectomy were defined based on the surgical codes in the principal procedure field of the hospital morbidity record. This field represents the “most significant” procedure performed during a patient’s hospital stay; that is, the one having the greatest impact on the length of stay and/or use of hospital resources.[38] The CCP codes for open cholecystectomy were 63.11, 63.12 and 63.13; for the laparoscopic procedure, the code was 63.14. Codes 80.2, 80.3 and 80.5 indicate abdominal hysterectomy; 80.4 and 80.6, vaginal. The CCP code for appendectomy was 59.0.

Post-operative infection refers to abscess or septicemia that occurred after surgery and that was diagnosed and documented in hospital records either during the patient’s original hospitalization or during readmission with 30 days of surgery. The *International Classification of Diseases, Ninth Revision* (ICD-9)[39] code 998.5 in any of the diagnostic fields (records contained a maximum of 16) was used to identify patients hospitalized with such an infection within 30 days of the surgery (including the surgical hospitalization or readmissions).

Because the *date of surgery* was not available, it was defined as the day following the date of admission to hospital for surgery.

Each patient was followed for 30 days from the imputed date of surgery. A *30-day follow-up* period is considered sufficient time for a post-operative infection to develop and is consistent with the Centers for Disease Control and Prevention’s (CDC) National Nosocomial Infection Surveillance (NNIS) system surveillance criteria.[24,40]

A variable reflecting *surgical complexity* was based on information from Appendix H.4 of the Canadian Institute for Health Information’s *Case Mix Group (CMG) Directory*.[41] According to this document, procedures requiring at least seven days of in-hospital care were considered to have a high level of complexity. This includes radical hysterectomy, which is the removal of the uterus, fallopian tubes, parametrium (the tissue at the side of the uterus), the upper third of the vagina, and the pelvic lymph nodes via an abdominal incision or the vagina.[42]

Patients were classified as having *diabetes* if, during the surgical hospitalization, a diagnosis of diabetes mellitus (ICD-9 code 250) was noted in any of the 16 diagnostic or “most responsible” diagnosis fields.

Six *age groups* (29 or younger, 30 to 39, 40 to 49, 50 to 59, 60 to 69, and 70 or older) were used for most of the analysis. These groups were combined as 60 or younger and over age 60 to examine in-hospital deaths within 30 days of surgery.

Two categories were used to consider the pathological state of the *appendix*. Patients were considered to have a ruptured appendix and/or peritonitis and/or peritoneal abscess if a diagnosis of 540.0 or 540.1 appeared in any of the 16 diagnostic fields of the surgical hospitalization record.

Readmission refers to patients who had another admission to hospital within 30 days of the imputed surgery date, with a record showing post-operative infection as the diagnosis “most responsible” for the repeat stay.

Estimated costs of readmission were included in the cost-per-day values. Costs may be direct, such as those incurred by the hospital department providing service to the patient (salaries, supplies and equipment, for example) or indirect, meaning those incurred by departments not providing services to patients, such as administrative services (admitting and registration, health records, finance, etc.).

The *average total cost of readmission* was calculated by multiplying the estimated daily costs of hospital care by the *average length of hospital stay* for readmissions where the most responsible diagnosis was post-operative infection.

Cost per day of hospitalization was calculated for the Ontario data by dividing the average total cost per case by the average length of stay. Alberta provides information on cost per day of hospitalization directly (see *Limitations*).

Annual additional hospital costs of post-operative infection for each surgery were calculated by multiplying the average total length of readmission for post-operative infection by the cost per day by the number of readmitted infected patients. Because three years of data were used, the total costs were divided by three to obtain the *average annual cost of readmissions for infection*.

Case mix groups are defined using a system that classifies hospital patients and makes it possible to group them into a manageable number of categories, depending on clinical similarity.[43,44] Often more than one case mix group (CMG) corresponded to the *Canadian Classification of Diagnostic, Therapeutic, and Surgical Procedures* codes denoting each surgery.[37] The CMG or *International Classification of Diseases, Ninth revision, clinical modification* (ICD-9-CM) code associated with the lowest cost per day was used to estimate the cost of readmission for each surgery. For the Ontario portion of the hysterectomy costing, the costs corresponding to the ICD-9-CM codes were used. Costs associated with hysterectomy performed in Alberta were available only by CMG. For the Alberta hysterectomy cost estimate, the costs associated with CMG 577 (major gynecological procedures for ovarian or adnexal malignancy) for 2000/01 were used. Data from 1999/00 and associated with ICD-9-CM for abdominal hysterectomy were used to estimate Ontario costs for hysterectomy.

Laparoscopic cholecystectomy limits exposure to bacteria, because only small incisions are made in the abdominal wall.[45-48] The time required to perform laparoscopic surgery also tends to be shorter.[49] Of course, patients are selected for laparoscopic surgery based on a pre-operative assessment of various factors, some of which relate to their risk of surgical and post-operative complications. Patients at lower risk of complications, including infection, likely comprised a larger proportion of those who underwent laparoscopic cholecystectomy, so it is not surprising that this technique was associated with lower odds of infection. With only a limited number of variables available (see *Limitations*), it is likely that some of the observed difference associated with surgical approach is due to other pre-surgical differences in patient risk.[50]

For hysterectomy patients, a protective association emerged between vaginal approach, compared with abdominal, and post-operative infection. Vaginal hysterectomy tends to be associated with fewer complications than the abdominal surgery.[51] The condition necessitating an abdominal rather than a vaginal approach may also pre-dispose the patient to infection.[52,53] Infection may also be less likely in women who undergo vaginal hysterectomy, as there is no external incision.

Complexity associated with infection

Surgical complexity was strongly associated with post-operative infection among hysterectomy patients. (Information on complexity was relevant only for hysterectomy because it was the only surgery for which complexity varied) (see *Definitions*). Women who had a more invasive or "radical"

Table 3

Adjusted odds ratios for hospitalization with post-operative infection within 30 days of cholecystectomy, hysterectomy or appendectomy in relation to selected characteristics, Canada excluding territories, 1997/98 to 1999/00

	Cholecystectomy		Hysterectomy		Appendectomy	
	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval
Sex						
Men	1.4*	1.3, 1.6	...	...	1.4*	1.3, 1.5
Women†	1.0	...	...	...	1.0	...
Age group						
≤ 29†	1.0	...	1.0	...	1.0	...
30-39	1.2	0.9, 1.6	0.7*	0.6, 0.8	1.2*	1.1, 1.3
40-49	1.2	1.0, 1.6	0.6*	0.5, 0.8	1.4*	1.3, 1.6
50-59	1.9*	1.5, 2.4	0.5*	0.5, 0.7	1.5*	1.3, 1.7
60-69	2.5*	2.0, 3.2	0.5*	0.4, 0.7	1.8*	1.5, 2.0
70+	3.3*	2.6, 4.1	0.7*	0.5, 0.8	1.5*	1.3, 1.8
Surgical approach						
Open	4.2*	3.8, 4.6	...	...	...	...
Laparoscopic†	1.0	...	...	...	...	...
Abdominal	...	...	1.5*	1.3, 1.6	...	...
Vaginal†	...	...	1.0	...	...	...
Surgical complexity						
High	...	...	1.6*	1.2, 2.1	...	...
Low†	...	...	1.0	...	...	...
Appendix						
Ruptured/Peritonitis/Peritoneal abscess	...	...	...	...	3.5*	3.2, 3.7
No record of rupture/peritonitis/ peritoneal abscess†	...	...	...	...	1.0	...
Diabetes						
Yes	1.4*	1.2, 1.6	2.1*	1.8, 2.5	1.9*	1.6, 2.3
No†	1.0	...	1.0	...	1.0	...

Data source: Health Person-Oriented Information Database, 1997/98 to 1999/00
† Reference group
··· Not applicable
** Significantly different from reference group (p < 0.05)*

procedure were more likely to be diagnosed with an infection after surgery, compared with those who had a less complex operation (Table 3). Surgeries involving extensive tissue removal usually indicate more pervasive illness and generally poor overall health.[54,55] More complex hysterectomies may also be more difficult and time-consuming to perform.[56] The link between surgical duration and risk of post-operative infection is not fully understood; nevertheless, longer operations may increase the risk of a surgical site becoming infected.[45,49,56]

As expected, diabetes was associated with hospitalized post-operative infection in cholecystectomy, hysterectomy and appendectomy patients. Other studies have also found an increased risk of acquiring a post-operative infection among people with diabetes.[57-59] In addition to vascular disorders, diabetes is related to obesity, another risk factor for post-operative infection.[33,60-62]

Repeat admissions

Not surprisingly, diagnosis of post-operative infection during the original surgical admission substantially increased the odds of a patient being readmitted for infection within 30 days—a finding that emerged for each of the three surgeries (Appendix Table A).

More hospital days

Together, cholecystectomy, hysterectomy, and appendectomy patients spent an average of about 4 days in hospital (Table 4). But the average number of hospital days for patients with post-operative infection greatly exceeded that for those with no documented infection. For patients diagnosed with infection, total time in hospital, including readmission within the 30-day follow-up period, ranged from about 10½ days for those who had had a hysterectomy or an appendectomy to about 18½ days for those who underwent a cholecystectomy.

Factors other than infection influence time in hospital. For patients diagnosed with a post-operative infection during the initial surgical stay, it is not known how much of that time was because of the infection. When the patient is readmitted and the hospital record identifies a post-operative infection as the diagnosis most responsible for the hospitalization, there is greater certainty about attributing the time to infection. Hysterectomy and appendectomy patients were in hospital, on average, about 5½ additional days for their infections. Cholecystectomy patients required 8 additional days of hospital treatment.

Post-operative infections costly

The average number of days patients with post-operative infection spent in hospital exceeded those for uninfected patients by 2.5 to 5 times (Table 4). It is not possible to determine how much additional time in hospital was due to post-operative infection, and how much was caused by other factors. Nonetheless, when readmissions were restricted to those for which post-operative infection accounted for the major portion (the "most responsible" diagnosis) of the stay, the extra days required by cholecystectomy, hysterectomy and appendectomy patients were estimated to have cost the health care system an additional $5.4 to $6.3 million annually (Table 5). This is likely a conservative estimate, as it

Table 4
Average number of hospital days for cholecystectomy, hysterectomy and appendectomy patients, by post-operative infection status, Canada excluding territories, 1997/98 to 1999/00

	Number of patients	Average number of hospital days†	Average length of readmission‡ (days)
Cholecystectomy	141,766	4.0	...
Uninfected	139,805	3.8	...
Infected	1,961	18.3	...
Readmitted†	593	13.4	8.3
Hysterectomy	159,644	4.3	...
Uninfected	156,390	4.2	...
Infected	3,254	10.6	...
Readmitted†	1,540	9.8	5.5
Appendectomy	80,867	3.8	...
Uninfected	77,759	3.5	...
Infected	3,108	10.5	...
Readmitted†	1,421	10.3	5.6

Data source: Health Person-Oriented Information Database, 1997/98 to 1999/00
... Not applicable
† Includes surgical stay and readmissions within 30 days of surgery.
‡ "Most responsible diagnosis" = post-operative infection

Table 5
Estimated costs of readmission with post-operative infection† after cholecystectomy, hysterectomy or appendectomy, based on cost data from Alberta and Ontario

	Cholecystectomy	Hysterectomy	Appendectomy
Number of patients readmitted	593	1,540	1,421
Average length of readmission (days)	8.4	5.5	5.6
Cost per day	$768 - $920	$801 - $925	$700 - $826
Average total cost of readmission‡	$6,451 - $7,728	$4,406 - $5,088	$3,920 - $4,626
Additional annual cost of readmissions	$1.28 - $1.53 million	$2.26 - $2.61 million	$1.86 - $2.19 million

Data sources: Health Person-Oriented Information Database, 1997/98, 1998/99, 1999/00; Health Costing in Alberta—2002 Annual Report; Ontario Case Costing Initiative—OCCI Database FY 2000/2001—Typical Cases; Ontario Case Costing Initiative—OCCI Database Top 50 Prinicipal Procedures by Volume of Cases FY 1999/2000—Typical Cases (References 11-13)
† "Most responsible diagnosis" = post-operative infection
‡ Average length of stay multiplied by cost per day

Table 6
Adjusted odds ratios for dying in hospital within 30 days of cholecystectomy, hysterectomy or appendectomy in relation to hospitalization with post-operative infection and other selected characteristics, Canada excluding territories, 1997/98 to 1999/00

	Cholecystectomy		Hysterectomy		Appendectomy	
	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval
Hospitalization with post-operative infection						
Yes	3.3*	2.5, 4.4	2.5*	1.3, 5.0	1.6	0.8, 3.3
No†	1.0	...	1.0	...	1.0	...
Sex						
Men	1.3*	1.1, 1.6	...	...	1.7*	1.0, 2.7
Women†	1.0	...	...	...	1.0	...
Age group						
≤ 60	0.1*	0.1, 0.1	0.0‡	0.0, 0.1	0.0‡	0.0, 0.0
> 60†	1.0	...	1.0	...	1.0	...
Surgical approach						
Laparoscopic†	1.0	...	...	...	...	...
Open	5.8*	4.7, 7.0	...	...	...	...
Abdominal	...	...	5.6*	3.4, 9.2	...	...
Vaginal†	...	...	1.0	...	...	...
Surgical complexity						
High	...	...	0.6	0.1, 4.4	...	...
Low†	...	...	1.0	...	...	...
Appendix						
Ruptured/Peritonitis/Peritoneal abscess	...	...	...	...	1.4	0.8, 2.2
No record of rupture/peritonitis/ peritoneal abscess†	...	...	...	...	1.0	...
Diabetes						
Yes	1.8*	1.4, 2.3	1.9*	1.1, 3.1	5.0*	2.9, 8.4
No†	1.0	...	1.0	...	1.0	...

Data source: Health Person-Oriented Information Database, 1997/98 to 1999/00
† Reference group
‡ The odds of appendectomy and hysterectomy patients dying in hospital within 30 days of their surgery are significantly reduced for those 60 or younger ($p < 0.02$ and $p < 0.05$, respectively).
··· Not applicable
** Significantly different from reference group ($p < 0.05$)*

does not include the cost of post-operative infection during readmissions when the infection was not the "most responsible" diagnosis (see *Limitations*). Also not included are costs to the health care system that did not involve hospitalization.

Contribution to death unknown

Less than 1% of the patients who underwent a cholecystectomy, hysterectomy or appendectomy died in hospital within 30 days of the procedure (data not shown). Among those who died, the proportion who had developed a post-operative infection requiring in-hospital treatment ranged from 6% to 13%. However, without cause-of-death data, the infection's contribution to death is unknown. It is likely that a combination of factors played a role in these patients' deaths.

Nonetheless, it is evident that for patients with post-operative infection, the odds of dying in hospital within 30 days of surgery—even when other, possibly confounding, factors are taken into account—are elevated. Cholecystectomy patients with post-operative infection faced more than 3 times the odds, and hysterectomy patients 2.5 times the odds, of dying in hospital soon after the surgery, compared with patients not diagnosed with a post-operative infection (Table 6). Post-operative infection did not increase the odds of in-hospital death following appendectomy, reflecting the much younger age of these patients. Death following an appendectomy was significantly associated with diabetes, being male, and advanced age.

Concluding remarks

This analysis of data from the Health Person-Oriented Information Database indicates that hospitalization with post-operative infection following cholecystectomy, hysterectomy or appendectomy is relatively rare—a finding consistent with the literature. Of the 382,277 patients who underwent one of these surgeries in the 1997/98-to-1999/00 period, post-operative infection was documented in hospital records for only 2.2%.

Several factors were associated with post-operative infection: being male, age, surgery performed in the presence of an established infection, surgical complexity, and diabetes. Laparoscopic procedures were related to a greatly reduced risk of post-operative infection among cholecystectomy patients, although other factors likely contributed to this relationship. Infection during the original surgical admission increased the risk of readmission for an infection. Again, however, other factors that could not be taken into account also most certainly contributed to these relationships.

Post-operative infection necessitating hospitalization following these three common surgeries may not occur often, but when it does, it is costly in terms of hospital resources. On average, readmissions for post-operative infection increased time in hospital by 5.5 to 8.4 days, depending on the surgery. It was estimated that these extra days cost the health care system $5.4 to $6.3 million a year. Although the number of infections that could be prevented is not known, even a modest decrease could result in considerable savings.

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Appendix

Table A
Adjusted odds ratios for readmission for post-operative infection within 30 days of cholecystectomy, hysterectomy or appendectomy in relation to selected characteristics, Canada excluding territories, 1997/98 to 1999/00

	Cholecystectomy		Hysterectomy		Appendectomy	
	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval	Odds ratio	95% confidence interval
Sex						
Men	1.1	0.9, 1.3	...	...	1.2*	1.1, 1.3
Women†	1.0	...	...	...	1.0	...
Age group						
≤ 29†	1.0	...	1.0	...	1.0	...
30-39	1.0	0.7, 1.4	0.7*	0.5, 0.8	0.9	0.8, 1.1
40-49	0.8	0.6, 1.2	0.5*	0.4, 0.7	0.9	0.8, 1.1
50-59	1.3	0.9, 1.8	0.4*	0.3, 0.5	0.7*	0.6, 0.9
60-69	1.4*	1.0, 2.0	0.3*	0.2, 0.4	0.6*	0.5, 0.8
70+	1.6*	1.2, 2.2	0.3*	0.2, 0.4	0.5*	0.4, 0.8
Previous post-operative infection diagnosed during surgical stay						
Yes	3.3*	2.2, 4.9	5.5*	4.3, 7.1	3.5*	2.9, 4.3
No†	1.0	...	1.0	...	1.0	...
Surgical approach						
Open	2.3*	1.9, 2.7	...	...	...	...
Laparoscopic†	1.0	...	...	...	...	...
Abdominal	...	...	0.9*	0.8, 1.0	...	...
Vaginal†	...	...	1.0	...	...	...
Surgical complexity						
High	...	...	1.1	0.6,1.8	...	...
Low†	...	...	1.0	...	...	...
Appendix						
Ruptured/Peritonitis/Peritoneal abscess	...	...	...	...	2.3*	2.1, 2.6
No record of rupture/peritonitis/ peritoneal abscess†	...	...	...	...	1.0	...
Diabetes						
Yes	1.4*	1.0, 1.8	2.2*	1.7, 2.8	1.3	0.9, 1.9
No†	1.0	...	1.0	...	1.0	...

Data source: Health Person-Oriented Information Database, 1997/98 to 1999/00
Note: Includes only patients who were readmitted with an infection that was classified as the diagnosis most responsible for the length of stay.
† Reference group
··· Not applicable
** Significantly different from reference group (p < 0.05)*