Total and Attributable Costs of Surgical-Wound Infections at a Canadian Tertiary-Care Center

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REFERENCES

TOTAL AND ATTRIBUTABLE COSTS OF SURGICAL-WOUND INFECTIONS AT A CANADIAN TERTIARY-CARE CENTER

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ABSTRACT

OBJECTIVE: To determine the total and attributable costs of surgical-wound infections in a Canadian teaching hospital.

DESIGN: Retrospective incidence series study with chart review and examination of resource utilization attributable to wound infection. The charts of inpatients with wound infections were examined using the Appropriateness Evaluation Protocol (AEP), a validated chart review instrument designed to determine appropriateness of care, modified for wound infections.

SETTING: A university referral center in Canada.

PATIENTS: Medical records were abstracted from patients with wound infections who underwent an inpatient clean or clean-contaminated procedure during 1991.

MEASUREMENTS: During the wound-infection treatment period, the hospital costs associated with providing care were tabulated for all inpatient days and for outpatient and emergency visits. Costs taken into account included nursing salary and benefits, nonphysician professional services, operating room time, laboratory, pharmacy, supplies, ancillary tests, and hotel costs.

RESULTS: We identified 108 wound infections. Twenty-two patients required 28 surgical procedures related to a wound infection. Inpatient days totalled 1,116, costing $394,337. Fifty-five emergency and 42 clinic visits occurred, costing $27,193. By applying the AEP to the inpatient days, 833 days, or 10.2 days per case, were directly attributable to the wound infection. The hospital costs for inpatient care attributable to wound infections were $321,533 in total, or $3,937 per infection. Costs were distributed as follows: nursing, 51%; hotel, 14%; pharmacy, 10%; laboratory, 9%; emergency and outpatient clinic, 6%; professional services, 5%; operating room, 3%; and ancillary tests, 2%.

CONCLUSIONS: Wound infections contribute markedly to extra days of hospitalization and related costs. The AEP method is applied easily to determine attributable days of care and costs of wound infections, which are necessary to calculate the cost-benefit of infection control programs (*Infect Control Hosp Epidemiol* 1998;19:254-259).

Surgical-wound infections are costly to the hospital where the procedure was performed, to the patient who is unable to return home or to work until the infection subsides, and to society as a whole, which funds the healthcare system in Canada. Effective infection control programs can reduce the incidence of wound infections, but these programs require an investment in expert personnel and resources to perform the surveillance and report infection rates back to surgeons. As hospital budgets are decreasing across Canada, infection control practitioners and physicians must evaluate the cost benefits of surgical-wound infection surveillance programs. One of the barriers to establishing the costs of a surgical-wound infection has been attributing the proportion of the hospital care that was dedicated specifically to the surgical wound. Differing methodologies can be used to cost nosocomial infections, and each has its own advantages and limitations.[1]

The Appropriateness Evaluation Protocol (AEP)

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is a standardized chart-review instrument that previously has been shown to be reproducible and has been validated extensively in several clinical settings. It has been adapted successfully for use in determining attributable costs of nosocomial staphylococcal infections.[2] The AEP-based method offers the advantage of being performed easily and giving predictable results. We used the AEP and adapted it to measure gross and attributable costs of surgical-wound infections in our tertiary medical center.

METHODS

Kingston General Hospital is a publically funded, tertiary, teaching, referral hospital with 425 inpatient beds, where a total of 5,513 clean or clean-contaminated surgeries were performed in all surgical disciplines during the study period of 1991. Nurses and ancillary healthcare providers were salaried under union contracts. Physicians and surgeons were reimbursed through direct billing to the provincial health insurance plan, except for laboratory physicians who were salaried by the hospital. Only salaries paid directly by the hospital were included as part of the costing in this study. The hospital operates an on-site outpatient clinic and emergency room funded from the hospital's global budget.

Surveillance for surgical-wound infections was carried out by infection control practitioners through combined review of the hospital record, Kardex, and culture reports for all patients undergoing an inpatient clean or clean-contaminated surgical procedure in the general, vascular, neurological, orthopedic, gynecologic, obstetric, urologic, cardiac, and thoracic surgical services. No surveillance was carried out for non–surgical-wound nosocomial infections.

The definition used to determine the onset of a surgical-wound infection was according to the National Nosocomial Infection Surveillance System in effect during 1991.[3] The treatment of the surgical-wound infection was deemed to be complete if the patient had been afebrile for 48 hours *and* the previously documented pus at the incision site had been absent for at least 48 hours *and* at least *two* of the following: (1) discontinuation of dressing changes; or (2) discontinuation of antibiotics originally prescribed for the treatment of the wound infection; or (3) surgeon's diagnosis that the wound infection had resolved. The gross inpatient surgical-wound infection period was the number of inpatient days from onset to end of the infection according to the above definition. The attributable inpatient surgical-wound infection period was derived by applying the AEP-based chart review to the gross inpatient surgical-wound infection period, which discounted those inpatient days that were not attributable to caring for the surgical-wound infection.

All patients operated on during the study period who developed a surgical-wound infection were counted. Patients seen in the outpatient clinic or emergency room with surgical-wound infections due to inpatient surgical procedures performed during the study period also were included. The period of postoperative surveillance was 30 days, except for those procedures that included the insertion of a prosthetic device or material (eg, hip replacement or sternal wires) where surveillance was continued for 1 year. However, no formal postdischarge surveillance was in effect at the time of this study. The complete medical record of all identified cases of wound infection was independently reviewed retrospectively by both an infection control practitioner and an internist. The date of the onset and the end of the wound infection was determined according to the study definitions and the "gross inpatient surgical-wound infection period" was calculated in days.

During the gross inpatient surgical-wound infection period, the following hospital cost areas were enumerated by an infection control practitioner: number of days on each inpatient nursing unit, including ventilator days in the intensive-care unit; all medications administered, their dose, route, and number of doses given, and the number of days of intravenous access or parenteral nutrition; nonphysician professional services (eg, physiotherapy for amputation, dietitian visits in the intensive-care unit); all laboratory, imaging, and other diagnostic procedures performed; and all surgical procedures performed because of the wound infection (eg, amputation of an infected leg).

For patients treated for their wound infection in the outpatient clinic, the number of visits was calculated. For patients seen in the emergency room for their wound infection, the length of the time spent in the emergency room was calculated. The difference between the time of first nursing assessment and the time of discharge from the emergency room was used to determine the total time spent in the emergency room, so as to exclude waiting room time. Medications, nonphysician professional services, laboratory, imaging, and other diagnostic procedures in the outpatient clinic or emergency room were calculated in the same fashion as for inpatients.

For each cost area, salaries and supply costs were determined by the hospital's finance department using their accounting records. These costs were averaged "per unit of utilization" to derive an average unit cost for each area, as shown in Table 1. The unit cost was multiplied by the number of units consumed during the gross surgical-wound infection period.

TABLE 1
COSTING AREAS AND UNITS OF UTILIZATION USED IN CALCULATING HOSPITAL COSTS OF SURGICAL-WOUND INFECTIONS

Hospital Area	Unit of Utilization
Nursing inpatient units	Inpatient days
Ambulatory clinic	Clinic visits
Emergency room	Hours in emergency room
Operating rooms	Hours of operating room time
Physiotherapy	Number of visits/attendances
Occupational therapy	Number of visits/attendances
Clinical nutrition	Number of inpatient and outpatient visits
Social work	Number of visits
Pastoral care	Number of visits
Respiratory therapy	Number of ventilator days
Radiology	Cost per test item
Laboratory	Cost per test item
Medications	Acquisition cost per dose
Pharmacy	Daily dispensing cost per drug
Other diagnostic tests (ECG, etc)	Cost per test
Hotel costs	Inpatient days

Abbreviation: ECG, electrocardiogram.

TABLE 2
COSTING OF HOSPITAL HOTEL ITEMS

Hotel Item	Proration Based Upon
Communications	Proportion of patient telephones to total in hospital
Plant operations, housekeeping, security, and maintenance	Patient-care–area floor space as a proportion of total hospital floor space
Laundry and linen services	Total costs less those for nonpatient areas

Salary costs included unit or area directors, supervisors, assistant supervisors, receptionists, secretaries, staffing clerks, storekeepers, nurses, nursing assistants, technicians, technologists, laboratory assistants, clinical instructors, infection control practitioners, and purchased services. Benefits at 15% were included in all salary calculations. Fees billed or billable by physicians to the provincial health insurance plan were not included. Salaries of laboratory physicians and scientists were included in determining laboratory costs.

All supplies used in the delivery of patient care were included. Housekeeping and cleaning supplies, travel expenses, repairs and maintenance, and equipment rental also were included. Capital equipment was not included, because this is an indirect cost not avoidable by preventing a wound infection.

Hospital operating hotel costs were based on 1991 actual costs. All patient food costs were included. Costs for communications, housekeeping, plant operations, security and maintenance, and linen services were prorated as a portion of the hospital total costs for these support services, as shown in Table 2.

Drug acquisition costs were determined on the basis of a single dose, which was multiplied by the number of doses given to produce a total cost for each drug at each dose administered. All intravenous drugs were given by minibags prepared in the pharmacy. The costs of these bags are reflected in the ancillary supply costs. Pharmacy salary costs were calculated on the basis of time spent by pharmacists and pharmacy technicians to process medication orders and to dispense the first and subsequent days' doses of medications by different routes. The time spent in minutes was multiplied by the salary per minute of the pharmacist and the pharmacy technician. Doses of medications were prepared for each 24-hour period in the pharmacy, and the time spent in preparing the first day's dose was higher than for subsequent days' doses. Therefore, the number of initial doses and the number of subsequent doses were tallied for all medications, and direct salary costs were calculated by multiplying the number of days of therapy by the appropriate unit salary cost for both the initial day and subsequent days of treatment. Indirect pharmacy salary costs were calculated on the basis of the average cost per day of treatment prepared by the pharmacy. Laboratory test items were costed according to the actual costs of materials, labor, and supplies required to perform each test.

Determining which postoperative inhospital days were directly attributable to a wound infection was accomplished by applying AEP modified for nosocomial surgical-wound infections.[2,4] Outpatient and emergency room care was not examined by the AEP-based instrument, because it was not designed for this purpose. The entire medical record for the gross inpatient surgical-wound infection days of patients were reviewed by one of the physician authors (D.V.) in a two-stage manner. The first review was called a "full AEP review," in which the wound-infection days in the patient record were examined completely for both infection- and noninfection-related data. This part of the review indicated if the days of care within the gross surgical-wound infection period were appropriate for

TABLE 3
APPROPRIATENESS EVALUATION PROTOCOL WOUND-INFECTION CRITERIA

Category	Wound-Infection Care Criteria
Diagnostic	Cultures of the wound or other relevant sites
	Needle aspiration for diagnosis
	Biopsy for diagnosis
	Imaging studies
Therapeutic	Incision and drainage or debridement of wound
	Insertion of drain(s)
	Placement of long-term intravenous access for antibiotics (eg, Hickman catheter)
	Other surgical procedure for the infection
	Life support due to systemic spread of infection
Monitoring	Antibiotic levels
	Follow-up cultures of the wound
	Hemodynamic or respiratory monitoring due to severe infection
Nursing	Isolation for the wound infection
	Dressing changes
	Maintenance and care of wound drains
	Administration of antibiotics

either infection-related care (IC) or other care (OC; IC+OC=full AEP). The charts for the gross surgical-wound infection days were reviewed again, and, this time, the infection-related care elements were excluded specifically, and only the OC data elements were used to decide the appropriateness of the days of care (partial AEP). The full AEP used an explicit set of 16 criteria that apply to adult medical and surgical inpatient care.[5] In addition to the above AEP criteria, a subset of surgical-wound-infection–specific criteria modified from the methods described by Wakefield and others were added to the full AEP to determine which days of care related to the wound infection (IC; Table 3).[2,4,6] Days of care for which the "full AEP review" (OC+IC) indicated the need for inhospital care was appropriate, but for which the "partial AEP review" (OC) did not demonstrate the need for inpatient care on the basis of noninfection criteria, were considered attributable to the surgical-wound infection. The costs associated with the attributable infection days were used in determining attributable inpatient costs.[4,6]

All costs were calculated in 1991 Canadian dollars.

RESULTS

During the study period, 5,513 clean or clean-contaminated procedures were performed by the surgical services surveyed. One hundred eight surgical wounds were identified, yielding a wound-infection rate of 1.96%. Twenty-two patients required 28 repeat surgical procedures related to the wound infection. Nine patients with surgical-wound infection died.

TABLE 4
LABORATORY COSTS*

Laboratory	Cost
Hematology	$ 11,221†
Chemistry	$21,060
Blood bank	$1,081
Cytology	$6
Microbiology	$6,435
Total	$39,803

* Based on data from the total wound-infection period.
† All costs are in Canadian dollars, 1991.

Twenty-six of the 108 patients with a wound infection never were admitted into hospital. There were 55 visits to the emergency room, totaling 105 hours. Many patients were seen only once, some had wounds opened and dressed, and most received antibiotic prescriptions to be purchased outside of the hospital. The emergency room costs were $231.63 per visit hour, for a total of $24,321.15. The 42 outpatient department visits accounted for $962.22. An additional $1,909.38 in diagnostic procedures and laboratory tests occurred in the emergency and outpatient departments to provide care attributable to these 26 surgical-wound infections, for a total cost of $27,192.75. None of these patients required treatment in the operating room.

Eighty-two patients were treated for their wound infection in hospital, accounting for 1,116 gross inpatient surgical-wound infection days. The mean gross inpatient surgical-wound infection period (not adjusted by application of the AEP-based review) was 13.6±15.3 days (range, 2-77 days). Costs for nursing and supplies on the inpatient wards were $217,335, of which 90% were nursing salaries and benefits. Fifty-one intensive-care unit days accounted for 24.6% of the nursing costs. Nonphysician professional services accounted for $19,609, and 49 hours of operating room time cost $12,250. There were $7,209 in diagnostic imaging and other ancillary diagnostic testing costs and $38,230 in laboratory costs. The distribution of laboratory costs is shown in Table 4.

Pharmacy costs totaled $41,617, 90% of which were drug acquisition and administration supply costs, and only 10% were labor costs. Importantly,

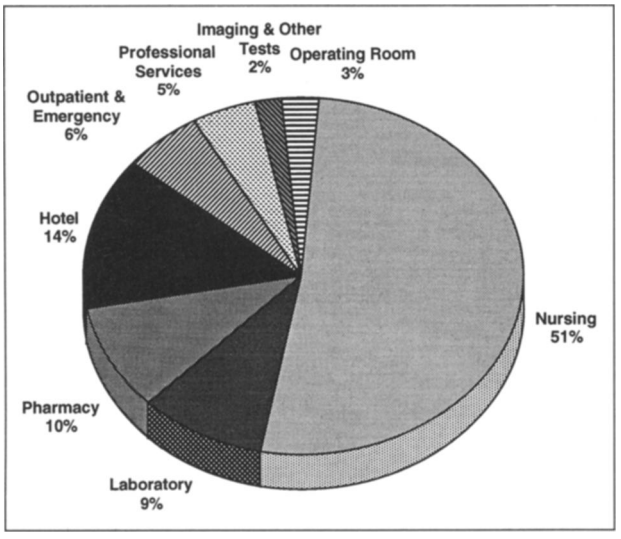

FIGURE Distribution of gross inpatient and outpatient surgical-wound–infection costs.

84% of drug acquisition costs were for antibiotics used to treat the surgical-wound infections.

Hospital hotel costs totalled $58,088 or a mean of $52 per patient hospital day.

The gross inpatient surgical-wound infection costs totaled $394,337, and the outpatient and emergency room care totaled $27,193, giving a grand total of $421,530 for non–AEP-adjusted inpatient and outpatient costs of surgical-wound infections. The distribution by costing area is shown in Figure 1.

By applying the modified AEP to the 1,116 gross inpatient surgical-wound infection days, 283 days could be discounted as having other care elements and therefore not attributable to the care of the wound infection. This left 833 inpatient days directly attributable to caring for the wound infection, for a mean of 10.2 days, median of 4.5 days, and standard deviation of 14.1 days per infection. The attributable costs associated with the wound infections totaled $321,532, based upon the modified AEP review. A summary of gross and attributable costs is shown in Table 5.

DISCUSSION

The principal objective of this study was to determine the costs associated with surgical-wound infections in a tertiary-level Canadian medical center. The methods we used are readily available to most Canadian hospitals and afford the opportunity to determine local institutional costs of surgical-wound infections. These costing data are important to making informed decisions about the cost benefit of surgical-wound surveillance and control activities in a given hospital setting.

TABLE 5
SUMMARY OF GROSS AND ATTRIBUTABLE INPATIENT COSTS OF SURGICAL-WOUND INFECTIONS*

Cost	Total Cost	Mean Cost	Median Cost	SD
Gross	$394,337	$4,809	$2,473	$5,403
Attributable	$321,532	$3,937	$1,737	$5,442

Abbreviation: SD, standard deviation.
* Canadian dollars, 1991. Consumer price increase between 1991 and 1996 was 7.4%.

A number of studies have measured costs associated with surgical-wound infections. However, there can be difficulties in interpreting these results and in generalizing them to one's own institution. Several studies have used charges to patients, which may bear scant relation to the actual costs to the hospital. This is especially relevant to those institutions that are publically funded and do not charge patients for their services, as is the case in Canadian hospitals. Cost accounting systems that are increasingly in place in hospitals facilitate itemizing the many costs associated with caring for a patient.

We chose to measure attribution of costs to the wound infection in a direct manner using a modification of the AEP as originally developed by Restuccia[7] and others. The AEP uses diagnosis-independent, patient-, physician-, and nursing-care–specific objective criteria of the inpatient care rendered to determine if that day of care in an acute-care institution was or was not required for any reason. This protocol is objective, uses information readily obtained from the hospital record, is generic to inpatient service areas (medicine, surgery, etc), is not dependent upon the diagnosis, is very well studied, and is extensively validated.[5,7] The AEP can be adapted to selected nosocomial infections by adding specific criteria associated with the nosocomial infection under study.[2] This technique is simple and not subject to the severity of illness bias that makes matched cohort studies difficult to perform. As well, finding adequately matched controls in a matched cohort study can require a very large database upon which to draw.[1]

An attributable inpatient cost of $3,937 per wound infection and a mean inpatient length of stay of 10 extra days is similar to results of other published studies.[8-12] Assuming a consumer price increase of 7.4% between 1991 and 1996 for southern Ontario (Statistics Canada, oral communication, May 1996), the current attributable cost of a surgical-wound infection is $4,228. The actual costs of a wound infection to the healthcare system as a whole

are greater, because we did not take into account the physicians' and surgeons' charges to the provincial health insurance plan. Given that many hospitals in the United States are prospectively funded, surveying and preventing surgical-wound infections carries a potent financial incentive.[13] In Canada, provincial government grants to hospitals are based increasingly upon productivity, and the increased length of stay attributable to surgical-wound infections serves to decrease the hospital's efficiency in providing surgical services to its community.

The Study of the Efficacy of Nosocomial Infection Control demonstrated that 35% of surgical-wound infections could be prevented by an effective wound-infection surveillance and control program, and this has been corroborated by others.[9,11,14] Detailed costing of each of the hospital resources utilized in caring for a patient with a surgical-wound infection is time-consuming and tedious. However, the AEP, modified for surgical-wound infections, provides a valid and readily applied tool for determining the attributable length of stay for surgical-wound infections. This information allows hospitals to assess the contribution wound infections make to excess length of stay and the impact nosocomial infection control programs have on preventing this common complication.

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Gerberding New Director of CDC's Hospital Infections Program

Gina Pugliese, RN, MS
Martin S. Favero, PhD

The CDC has announced the appointment of Dr. Julie Gerberding as the new director of the Hospital Infections Program. Dr. Gerberding has been an Associate Professor of Medicine and of Epidemiology and Biostatistics at the University of California, San Francisco, and Director of the Center for Epidemiology and Infection Prevention at San Francisco General Hospital. She is well known for her research in the risks of nosocomial and occupational transmission of bloodborne pathogens. Gerberding is the first person outside the CDC ranks and the first woman to direct the Hospital Infections Program. Past directors have included Richard Dixon, Robert Haley, James Hughes, William Martone, Martin Favero, and William Jarvis. Gerberding is scheduled to begin her new position in August 1998.