

Cost–Benefit Analysis of Preventing Nosocomial Bloodstream Infections among Hemodialysis Patients in Canada in 2004

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ABSTRACT

Objectives: Hemodialysis-associated bloodstream infection (BSI) is a significant public health problem because the number of hemodialysis patients in Canada had doubled from 1996 to 2005. Our study aimed to determine the costs of nosocomial BSIs in Canada and estimate the investment expenses for establishing infection control programs in general hospitals and conduct cost–benefit analysis.

Materials and Methods: The data from the Canadian Nosocomial Infection Surveillance Program was used to estimate the incidence rate of nosocomial BSI. We used Canadian Institute of Health Information data to estimate the extra costs of BSIs per stay across Canada in 2004. The cost of establishing and maintaining an infection control program in 1985 was estimated by the US Centers for Disease Control and Prevention and converted into 2004 Canadian costs. The possible 20% to 30% reduction of total nosocomial BSIs was hypothesized.

Results: A total of 2524 hemodialysis-associated BSIs were projected among 15,278 hemodialysis patients in Canada in 2004. The total annual costs to treat BSIs were estimated to be CDN\$49.01 million. Total investment costs in prevention and human resources were CDN\$8.15 million. The savings of avoidable medical costs after establishing infection control programs were CDN\$14.52 million. The benefit/cost ratio was 1.0 to 1.8:1.

Conclusion: Our study provides evidence that the economic benefit from implementing infection control programs could be expected to be well in excess of additional cost postinfection if the reduction of BSI can be reduced by 20% to 30%. Infection control offered double benefits: saving money while simultaneously improving the quality of care.

Keywords: bloodstream infection, costs and benefits, health economics, infection control program.

Introduction

Infections acquired during the use of health-care services are significant public health problems both for the health-care delivery system and the patient. It has been reported that an estimated 220,000 nosocomial infections are acquired in health-care facilities and 8000 deaths attributable to these infections occur annually in Canada [1]. The most common nosocomial infections are surgical wounds, blood stream, and urinary tract infections [2,3]. Taylor et al. reported that the relative risk for bloodstream infection (BSI) was 2.5 with arteriovenous graft access, 15.5 with cuffed and tunneled central venous catheter (CVC) access, and 22.5 with uncuffed CVC access [4].

Nosocomial BSIs result in dramatic increases in economic cost. In the United States in 2000, approximately 240,000 dialysis patients were treated at 3700 outpatient facilities [5]. The length of hospital stay was extended by 1 to 4 weeks at a cost of up to \$40,000 (US dollars) per survivor [6–9]. The US Centers for Disease Control and Prevention (US CDC) estimated that the excess costs associated with nosocomial infections in US hospitals were \$4.5 billion in 1992 [10]. In Canada, there are no detailed reports on excess costs associated with nosocomial infections, including BSIs.

The purpose of this study was to determine the cost of nosocomial BSIs among hemodialysis patients in Canada in 2004. We

also estimated the cost of an infection control program a middle-sized hospital in Canada in 2004 with the assumption that the outpatient hemodialysis centre is run out of the hospital. Finally, we conducted cost–benefit analyses of establishing and running hospital-based infection control programs in Canada.

Methods

Incidence Rate of BSI in Canada

We have used the data from a prospective surveillance study by Taylor et al. [11]. During the 6-month follow-up period between 1 December 1998 and 31 May 1999, there were 184 BSIs which occurred in 133,158 dialysis procedures with an incidence rate of 1.4 cases per 1000 procedures in 11 hemodialysis centres across Canada.

Estimation of Average Treatment Cost per Stay (Unit Cost)

According to the surveys of BSIs, out of the 6697 patients in 59 hospitals in the United States, the inpatients and the outpatients accounted for 60% and 40% of total BSI cases respectively [12]. We used the cost of acute care hospital stays by medical condition in Canada 2004 to 2005 to estimate the cost of BSI per stay [13]. The cost attributable to the treatment of one case of BSI among all genders in 2004 was CAD\$19,418 per stay. The treatment costs for the outpatients with BSIs are significantly lower. There was no valid estimate from previous studies. We assumed that the treatment costs of the outpatients with BSIs were CAD\$8,000 to CAD\$12,000. We conducted a sensitivity analysis for the cost–benefit of different scenarios.

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Total Hemodialysis Patients in Canada in 2004

According to the Canadian Institute for Health Information's statistics [14], there were a total of 15,278 hemodialysis patients and 1,802,922 hemodialysis procedures in Canada in 2004.

Investment Cost of Establishing and Maintaining an Infection Control Program in a Hospital

In 1975, the US CDC estimated the cost of an infection control program that was implemented in a 250-bed hospital. These estimates were subsequently revised in 1979, and further adjusted to 1985 prices [15]. Personnel resources for a hospital infection control program included a hospital epidemiologist, an infection control practitioner (nurse), and one secretary and computer support personnel. There was also nonpersonnel support such as office support, computing support, audiovisual support, microbiology laboratory support, pathology services, and reference laboratory testing. We assumed that the infection control team took 10% of their time investigating BSI [16]. The cost of establishing and maintaining an infection control program in 1985 US\$ was estimated to be US\$60,000 [15]. This estimate (US\$60,000) included the costs of employing an infection control nurse, a part-time physician consult, part-time clerical support, and the cost of consumables and overheads. So far, there is no accurate estimate of annual cost for establishing and maintaining an infection control program in a hospital in Canada. We applied the unit cost in US\$ as a surrogate indicator for our cost analysis. According to the Bank of Canada's inflation rate statistics, there was an average annual inflation rate of 2.74% during 1985 to 2004, with a total of 67.4% increment in principals. The cost of establishing and maintaining an infection control program in 2004 in a hospital in Canada was estimated to be US\$100,225/program/year or CAD\$133,633 (currency exchange rate on 30 June 2004).

Estimate of the Gross Benefits of Prevention

In the early 1980s, an effective infection control program—defined by an appropriately trained clinical leader, one infection control practitioner for 250 beds and a nosocomial surveillance program—decreased the prevalence of endemic nosocomial infection in acute care facilities by 30% to 50% [17]. Since most of hemodialysis patients were outpatients, we assumed that the BSI prevalence could be prevented by the range of 10% to 30%. We applied the 10% to 30% reduction in BSIs to calculate the gross benefits of infection control programs for the health sectors in Canada.

Results

Average Yearly Cost Attributable to Nosocomial BSIs in Canada in 2004

There were a total of 1,802,922 hemodialysis procedures in Canada in 2004. Since the incidence rate was 1.4 cases per 1000

hemodialysis procedures, a total of 2524 BSIs cases were estimated by multiplying 1,802,922 hemodialysis procedures with 1.4 cases/1000 procedures.

Total annual cost to treat 2524 BSIs cases was estimated to be 49.01 million by multiplying 2524 BSIs cases by CAD\$19,418 per stay for one BSI case.

Table 1 illustrates the potential benefits of implementing infection control programs in all hemodialysis units in Canada in 2004 by different scenarios of avoidable BSI prevalence rate. For example, if the available BSI rate was decreased by 15%, the potential benefits (cost-savings) for implementing infection control programs was estimated to be CAD\$7.35 million per year by multiplying CAD\$49.01 million by 15%.

Cost for Investment in Prevention Measures and Human Resources

Suppose that one infection control team is responsible for 250 hemodialysis patients; a total of 15,278 patients would need about 61 infection control programs across Canada in 2004.

Total running costs for implementing infection control programs in 2004 was estimated to be CAD\$8.15 million by multiplying 61 infection control programs by CAD\$133,633/program.

Cost-benefit Analysis

There are close correlations between the ratios of benefit/cost and avoidable BSI rates.

Figure 1 depicts the sensitivity analysis of the ratios of benefit/cost in different scenarios of avoidable BSI rates. If the avoidable BSI rate maintained around 17%, the ratio of benefit-cost would reach to 1:1. If the avoidable BSI rate increased to 30%, the ratio of benefit-cost would reach to 1.80:1.

Sensitivity Analysis for Outpatients

In the previous calculations, we assumed that the treatment costs of the outpatients were the same as the hospitalized patients. In reality, hemodialysis outpatients have lower treatment costs for BSIs. Table 2 illustrates the sensitivity analysis of cost-benefit ratios by infection control programs among inpatients and outpatients in Canada. When the outpatients treatment costs are maintained at CAD\$12,000 per BSIs and the inpatients costs are maintained at CAD\$19,418, and the infection control program can prevent the 20% of the total of BSIs, the benefit/cost ratio would be 1.01:1.

Discussion

In Canada, the number of hemodialysis patients doubled from 7098 in 1996 to 15,938 in 2005 because of the ageing community, diabetes, other underlying causes, and the increased

Table 1 The estimated benefits and investment costs of an infection control program for preventing BSIs infections in a 250-patients hemodialysis unit*

Avoidable BSI cases (%)	Total therapy cost for BSI cases (million/year)	Possible cost savings-benefit (million/year)	Infection control program investment costs (million/year)
10	49.01	4.90	8.15
15	49.01	7.35	8.15
16.6	49.01	8.17	8.15
20	49.01	9.80	8.15
25	49.01	12.25	8.15
30	49.01	14.70	8.15

*According to The Community and Hospital Infection Control Association-Canada from website: http://www.kgh.on.ca/Infection_Control/Infection_control_RICH.asp. BSI, bloodstream infection.

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