The excess cost associated with healthcare-associated bloodstream infections at Auckland City Hospital

Andrew Burns, Lesley Bowers, Nick Pak, Jean Wignall, Sally Roberts

Abstract

Aim This study was undertaken to determine the cost of healthcare-associated bloodstream infections (HA-BSI) in adult patients admitted to an Auckland City Hospital.

Method A matched cohort study was performed with a 1:2 or 1:1 match in which all patients admitted between January and June 2005 who had HA-BSI were included. Controls were selected from patients admitted between July 2004 and December 2006. Patients with haemodialysis central line-related HA-BSI were not matched with controls as the admission was related purely to that episode of infection.

Results There were 106 episodes of HA-BSI in 99 patients. Fifty-five patients were able to be matched 1:1 or 1:2 with controls, group 1. Nineteen BSI episodes were in patients undergoing renal replacement therapy by haemodialysis and the patients were admitted as a consequence of this episode of infection, group 2. An episode of HA-BSI increased the length of the hospital admission by 9.7 days and 7.9 days in group 1 and group 2, respectively. The excess cost associated with an episode of HA-BSI was $20,394 in group 1 and $11,139 in group 2.

Conclusion There are substantial costs associated with HA-BSI. A proportion of these infections can be reduced by effective infection control measures.

Healthcare-associated infections are not uncommon; it is estimated that up to 5–10% of hospitalised patients acquire an infection after admission to hospital. The rate for hospital-acquired infections among patients admitted to Auckland District Health Board (ADHB) hospitals in the 1990s was estimated to be 9.5% with a cumulative incidence of 6.33%.

The cost of healthcare-associated infections is difficult to measure but is not insignificant. It has been estimated that the annual cost to New Zealand hospitals is in excess of NZ$50 million and $85 million for medical and surgical admissions, respectively. The excess cost results as a consequence of the additional length of stay required for the diagnosis and treatment of these infections. A proportion of these infections can be prevented by infection control interventions. Accurate costing of healthcare-associated infections within the New Zealand healthcare setting is needed to help identify the most cost effective strategy for reducing these infections.

This study was undertaken to determine the cost of healthcare-associated bloodstream infections (HA-BSI) in adult patients admitted to an Auckland City Hospital. This will allow all healthcare workers to be better informed about the economic impact of these events.
**Method**

Auckland City Hospital is a 710 bed tertiary referral, university-affiliated hospital serving a population of 367,740 people; 10% of the New Zealand population in 2001. It provides general and subspecialty medical and surgical care including orthopaedic, urological, vascular, otorhinolaryngology, neurosurgical, cardiothoracic surgery and transplantation surgery, haematology/oncology, older person’s health, women’s health and has three adult intensive care units.

**Definitions**—A bloodstream infection (BSI) must meet the conditions in one of the following criteria:

- Isolation of one or more recognised bacterial or fungal pathogens from one or more blood cultures;
- If the isolate is a potential contaminant then the presence of at least one of the following signs and symptoms within 24 hours of a positive blood culture being collected, fever (>38°C), chills or rigors or hypotension and the potential contaminant was isolated from two or more sets of blood cultures drawn on separate occasions within a 48 hour period or
- The potential contaminant is from a single blood culture drawn from a patient with an intravascular line and appropriate antimicrobial therapy against that isolate is commenced.

A healthcare-associated event was defined as follows:

- Acquired during hospitalisation and not present or incubating on admission;
- Is a complication of the presence of an indwelling medical device;
- Occurs within 30 days of a surgical procedure, where the bloodstream infection is related to the surgical site infection;
- An invasive instrumentation or incision related to the bloodstream infection was performed within 48 hours before onset of the infection; or
- Is associated with neutropenia contributed to by cytotoxic therapy.

The healthcare-associated events are subcategorised as being non-inpatient associated or inpatient-associated. Inpatient associated events are those that occur more than 48 hours after admission or within 48 hours of discharge.

**Bloodstream infection events**—Every episode of bloodstream infection occurring in an inpatient is reviewed by the Infectious Diseases and Clinical Microbiology services. Data from the clinical and microbiology records are recorded on a standard form and then entered into an electronic database by the Infection Control Service.

All inpatients with a documented healthcare-associated BSI (HA-BSI) between January and June 2005 were included in the study. Those excluded were: patients admitted under the care of the Haematology Service; patients ≤15 years of age; patients having a second HA-BSI during the same admission and patients who remained in hospital for 30 days or more following their episode of HA-BSI. The latter two exclusions were made because it was felt that these patients would be outliers and would be difficult to match.

**Matching**—A matched cohort study was performed with a 1:2 or 1:1 match in which all patients admitted between January and June 2005 who had HA-BSI were defined as the cases, group 1. Controls were selected from patients admitted between July 2004 and December 2006. Controls were selected in a sequential stepwise manner according to a 16-point scoring system that had been adapted from a previous study. The controls were matched for primary and secondary diagnosis (based on International Classification of Diseases [ICD]) and primary procedure ICD (5 points), length of stay in hospital equal to the interval from admission to infection in cases ± 20% (5 points), age ± 5 years (4 points) and gender (2 points).

Patients with haemodialysis central line-related HA-BSI were not matched with controls as the admission was related purely to that episode of infection and the entire admission was regarded as excess cost secondary to the HA-BSI, group 2.

**Costing**—Data to assess the cost was extracted from the Auckland District Health Board (ADHB) clinical costing system; Power Cost Manager (PCM). PCM is a ‘bottom-up’ costing tool which means that the cost of individual patient care is identified by capturing every item of utilisation on each patient during his or her stay. Expenditure is allocated according to the utilisation. The increased length of stay and excess costs were calculated by averaging the difference between the cases and matched controls.
for group 1, or by averaging the length of stay and costs for all the cases alone for group 2. The hospital costs included the costs associated with diagnostic tests, allied health input, pharmacology, radiology, and bed costs.

**Results**

During 2005 the rate of HA-BSI for Auckland City Hospital was 1.4/1000 in-patient days. For the six month time period, January to June 2005, excluding patients under the care of the Haematology Service and those ≤15 years of age, there were 106 episodes of HA-BSI in 99 patients. Six episodes in 5 patients were excluded because the patient had two or more episodes of BSI during the same admission and could not be matched (3 patients), the patient was not admitted (1) and the patient died 2 days after the episode of BSI (1).

A further 37 episodes were excluded because the patient was discharged more than 30 days after the episode of BSI (18) or the patient was undergoing renal replacement therapy by haemodialysis (19). Of the remaining 63 patients, 55 were matched with controls (either 1 or 2), and 8 could not be matched. Of the 55 matched patients, 29 patients were matched 1:1 and 26 matched 1:2, group 1.

Nineteen BSI episodes occurred in 16 patients undergoing renal replacement therapy by haemodialysis and the patients were admitted as a consequence of this episode of infection. The entire length of the subsequent admission was attributed to the BSI and was considered an excess cost, group 2.

**Match score** — The use of the modified scoring system allowed for evaluation of the appropriateness of the match. The maximum score was 16. With the matching of group 1, the average score for the controls was 13.3 (83% matching appropriateness). Forty-three of the 81 controls were matched for all four variables (53%) and 69 (84%) of the controls were matched with three or more of the variables.

**Demographics and microbiology** — The demographics of the cases and controls are shown on table 1. Patients admitted to all adult services within Auckland City Hospital were included as cases; surgical services 40, medical services 13, maternity services 2, and intensive care 3. The source was identified for 83% of the episodes; the most common source was vascular access devices (38%) followed by procedure-related events (22%).

The most common cause of HA-BSI was *Staphylococcus aureus* (16.3%), coagulase negative staphylococci (14.9%), *Escherichia coli* (12.7%), *Streptococci* spp. (12.6%), and other *Enterobacteriaceae* (22%).
Table 1. Patient demographics, total and excess length of stay, and average and excess cost for cases and controls

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cases Group 2 (19)</th>
<th>Cases Group 1 (55)</th>
<th>Controls* (81)</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>58.1 ± 14.0</td>
<td>58.1 ± 21.0</td>
<td>57.7 ± 20.3</td>
<td>p=0.5</td>
</tr>
<tr>
<td>Gender (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Male</td>
<td>10 (53)</td>
<td>35 (64)</td>
<td>39 (48)</td>
<td>p=0.08</td>
</tr>
<tr>
<td>– Female</td>
<td>9 (47)</td>
<td>20 (36)</td>
<td>43 (52)</td>
<td></td>
</tr>
<tr>
<td>Match</td>
<td></td>
<td>1:1 29</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1:2 26</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>Total LOS (days)</td>
<td>7.9 ± 4.0</td>
<td>24.1 ± 13.2</td>
<td>14.4 ± 12.4</td>
<td></td>
</tr>
<tr>
<td>Excess LOS (days)</td>
<td>7.9</td>
<td>9.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average costs</td>
<td>$11,139</td>
<td>$53,486</td>
<td>$33,092</td>
<td></td>
</tr>
<tr>
<td>Mean ± SD (median, range)</td>
<td>± $13,561 ($7381, 1038-63,160)</td>
<td>± $45,426 ($41,067, 3713-192,342)</td>
<td>± $37,388 ($19,020, 1705-192,342)</td>
<td></td>
</tr>
<tr>
<td>Excess costs per episode of</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HA-BSI</td>
<td>$11,139</td>
<td>$20,394</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Excess length of stay and cost—The average length of stay for group 1, group 2 and the control group is shown in Table 1. An episode of HA-BSI increased the length of the hospital admission by 9.7 days and 7.9 days in group 1 and group 2, respectively. The excess cost associated with an episode of HA-BSI was $20,394 for cases in group 1 and $11,139 for cases in group 2.

Discussion

This is the first study to look at the cost of healthcare-associated bloodstream infections (HA-BSI) occurring in patients admitted to a New Zealand hospital. Patients admitted to Auckland City Hospital were divided into two groups; those admitted to general medical or surgical services and who subsequently developed a HA-BSI, group 1, and those patients undergoing renal replacement therapy with haemodialysis who developed a HA-BSI requiring admission for treatment of the infection, group 2.

The average excess costs associated with HA-BSI in these patient groups were $20,394 and $11,139, respectively. A significant proportion of this cost is due to the additional length of stay resulting from these infections, an average of 9.7 and 7.9 days respectively.

The excess cost associated with healthcare–associated infections is widely appreciated. The estimated cost of predicted healthcare-associated infections (HAI) in medical and surgical admissions to ADHB in 2003 was estimated to be $10.2 million and $8.64 million, respectively. At ADHB post-sternotomy mediastinitis has been shown to be associated with an excess cost of $45,677. These estimated costs only cover the cost to the District Health Board and do not include the cost to the patient and their family from loss of income and the impact of the patient’s quality of life.

It is difficult to compare the results of this study with other studies that have looked at the cost of HA-BSI due to the different methodology used to obtain the costing data.
One study looking at the weight-adjusted mean cost estimates for HAI reported the cost for nosocomial bloodstream infections to be US$23,242 per episode. This study extrapolated the cost from published studies and adjusted the cost to 2005 US dollars calculating a mean cost for each specific HAI. The authors included studies that estimated costs by measuring incremental costs associated with diagnosing and treating HAI but acknowledged that the matching method applied in some of these studies may be suboptimal and incomplete. We attempted to minimise overestimation of costs by matching cases and controls using an adaptation of a previously published matching schema. The controls were matched for four of the six variables used in that study: primary and secondary diagnosis (based on International Classification of Diseases (ICD)) and primary procedure ICD, length of stay in hospital equal to the interval from admission to infection in cases ± 20%, age ± 5 years and gender. Neither the ward of admission nor the presence of a central venous catheter was matched for.

The additional cost associated with HA-BSI in this historical cohort (1994–1995) was €15,413, equivalent to NZ$30,434 in 1995. The costing was determined by estimating the ‘hotel’ average daily cost which included the medical and nursing time and by adding the cost of antibiotic treatment. The increased length of stay attributable to the HA-BSI was multiplied by the single-day hospital cost to produce an overall cost associated with that episode. This approach is likely to overestimate the cost of the HA-BSI episode as it assumes that the daily costs remain the same whereas while the daily fixed costs such as capital expenditure, employee salaries, building maintenance and utilities will remain the same, but the variable costs, diagnostic tests, interventions and treatment, will vary. Patients with HA-BSI associated with a haemodialysis vascular access device were not matched with controls as the entire admission was due to the episode of bacteraemia. These patients, on average, were hospitalised for 7.9 days, at an average cost of $11,139. This cost did not include the ongoing care provided at the outpatient haemodialysis unit (cost of antimicrobial agent and nursing/medical time) following discharge from hospital nor any other costs associated with subsequent complications arising from the HA-BSI that may have resulted in readmission. This may explain why the cost for an episode of HA-BSI in group 2 is almost half that of group 1.

One other study has looked at the costs associated with Staphylococcus aureus bacteraemia among patients receiving long-term haemodialysis and showed a mean cost of US$24,034 per episode. However, 31% of patients in that study had complications arising from the episode of bacteraemia and not surprisingly the cost was significantly greater in those with patients with complications (US$ 32,462 vs $17,011).

Other studies reporting the cost per episode of HA-BSI have focused on central-line associated bacteraemia or Staphylococcus aureus (methicillin susceptible or resistant) bacteraemia. Central line-associated bloodstream infections accounted for just under half of all the HA-BSI in our study where a source for the episode of bacteraemia was identified.

A simple evidence-based intervention designed to improve patient safety has shown that central line-associated bloodstream infections can be reduced by up to 66%. This intervention, termed the central line insertion ‘care bundle’, involves the use of a
checklist to ensure that five simple interventions occur at the time of insertion of every central line. These interventions are hand hygiene, maximal barrier precautions, chlorhexidine skin preparation, avoidance of femoral site if possible and removing all unnecessary lines. Reducing the rate of central line-associated bloodstream infections by the implementation of such interventions will result in cost savings and is a cost-effective intervention.

Healthcare-associated infections are time-dependent exposures; the longer the patient stays in hospital the greater the risk of acquiring an infection. HA-BSI can occur at any time during a hospital stay and other factors, such as comorbidity and primary diagnosis, can also impact on length of stay. We attempted to address this potential bias by matching cases and controls for the length of time in hospital before the HA-BSI episode.

We also excluded patients who were in hospital for greater than 30 days as their stay was already prolonged and it seemed unlikely that the HA-BSI would have had an impact of the total length of stay and hence the cost of hospitalisation. We also excluded patients admitted to the Adult Haematology Service who have central lines in place for prolonged periods of time, are at greater risk of a HA-BSI and may have lengthy stays in hospital notwithstanding the advent of any infection.

This study has confirmed that there are substantial costs, and bed-days lost, associated with HA-BSI. A proportion of these infections can be reduced by effective infection control measures. Whilst acknowledging that only a limited proportion of the excess cost can be saved because a significant proportion of this excess cost is fixed, it is important to accurately estimate the costs of such infections and to estimate the number of bed-days that can be freed up for two reasons. Firstly, the bed-days can be used for other purposes and secondly, this information can be used for assessing the cost-effectiveness of infection control programmes.

As a consequence limited resources can be directed towards programmes that have been shown to contribute to better outcomes for patients. National initiatives such as the Ministry of Health, Quality Improvement Committee’s Infection Prevention and Control Project are an important start. The implementation of initiatives aimed at improving healthcare worker hand hygiene compliance (Hand Hygiene New Zealand) and reducing central line-related BSI (Catheter-related Bloodstream Infection Prevention Guidance) will result in an overall reduction in the rate of healthcare-associated infections. These two initiative are only a start in the process of improving patient safety in our hospitals by strengthening the delivery of effective infection control programmes.

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**Author information:** Andrew Burns, Infectious Diseases Registrar, Department of Microbiology, Auckland District Health Board, Auckland; Lesley Bowers, Infection Control Nurse Specialist, Infection Control Service, Auckland District Health Board, Auckland, Nick Pak, Analyst, Decision Support Unit, Auckland District Health Board, Auckland; Jean Wignall, Lead Analyst and Manager, Decision Support Unit, Auckland District Health Board, Auckland; Sally Roberts, Infectious Diseases Physician and Clinical Microbiologist, Department of Microbiology, Auckland District Health Board, Auckland
Correspondence: Sally Roberts, Department of Microbiology, LabPlus, Auckland City Hospital, Grafton, Auckland, New Zealand. Fax: +64 (0)9 3074939; email: sallyrob@adhb.govt.nz

References:


