Chapter 30

The Costs of Healthcare-Associated Infections

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Key Points

- Healthcare-associated infections delay patient discharge and increase costs.
- Healthcare-associated infections are accompanied by increasing numbers of laboratory and diagnostic investigations.
- Healthcare-associated infections increase infection prevention and control costs, including epidemiological investigations, and medical, nursing and management time.
- Economic evaluations can aid decision making for infection prevention and control programmes.

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Introduction

Healthcare-associated infections (HAI) are an important cause of morbidity and mortality and therefore should be rigorously controlled as part of the general duty of safe patient care. HAIs also have considerable economic impact on health care services and the cost of national health care. The members of the infection control team need to understand the financial burden of HAIs and how to evaluate the cost savings of any infection prevention intervention and provide information to support the infection prevention and control (IPC) programme.

Economic Consequences

Measuring the cost of HAIs is difficult and the financial impact varies between different health care systems. Nevertheless, HAIs can have the following economic results (Also see Table 1):

1. HAIs delay patient discharge, resulting in increased ‘hotel’ costs. In addition, the patient suffers additional costs due to absence from work, and relatives/friends suffer costs of time and travel to visit the patient;
2. Infections require increased treatment costs (for example, drug therapy and procedures, including repeat surgery). The patient may be discharged from hospital while infected and these costs then fall on General Practice or Community Services;
3. HAIs involve increasing numbers of laboratory and diagnostic investigations;
4. HAIs increase IPC costs, including epidemiological investigations and medical, nursing, and management time;
5. A HAI is often the subject of litigation.

There may also be costs associated with blocked beds and closed wards or operating theatres, resulting in increased unit costs for admissions and procedures and lengthening waiting lists. Patient morbidity resulting from a HAI generates community and society costs that are difficult to quantify but may have considerable impact. Also difficult to measure in economic terms is loss of reputation – either for the facility or for individual units – which can have a significant impact on contracts and patient referral.

Overall Cost Estimates

Many studies have focused on the severity of HAIs and their risk for patient safety and have tried to analyse the economic impact of HAIs by various methods. These methods are often flawed by the failure to distinguish accurately between the type and amount of resources specifically associated with treating HAIs and those incurred by the original disease for which the patient was admitted. It is important to focus not only on the HAI’s incidence as the measure of effectiveness, but also on events that stem from the changes in its occurrence, such as use of antibiotics, length of stay, mortality, and costs. Costs might be expected to be higher in tertiary referral hospitals. Costs will be different for various countries and will change with time; however the relative magnitudes will be similar.

Table 1. Economic consequences of healthcare-associated infections

<table>
<thead>
<tr>
<th>Hospitalisation Costs</th>
<th>Use of antibiotics</th>
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<tr>
<td></td>
<td>Increased length of hospitalisation</td>
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<tr>
<td></td>
<td>Intensive care unit stay</td>
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<tr>
<td>Intervention Costs</td>
<td>Tests performed</td>
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<tr>
<td></td>
<td>Barriers used (e.g., gown, gloves)</td>
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<td></td>
<td>Nurse/physician time</td>
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<td></td>
<td>Isolation room</td>
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<tr>
<td>Outpatient/Community Care Costs</td>
<td>Physician visits</td>
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<tr>
<td></td>
<td>Use of antibiotics</td>
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<tr>
<td></td>
<td>Home health visits</td>
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<tr>
<td></td>
<td>Rehabilitation centre stay</td>
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<tr>
<td>Patient Costs/Outcomes</td>
<td>Mortality</td>
</tr>
<tr>
<td></td>
<td>Morbidity</td>
</tr>
<tr>
<td></td>
<td>Infections</td>
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<tr>
<td></td>
<td>Lost wages</td>
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<td>Travel expenses</td>
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Although measuring the cost of HAIs is difficult, some studies have demonstrated the probable magnitude of the problem. HAIs were estimated to cost the United Kingdom’s National Health Service approximately £1 billion a year; £56 million is estimated to be incurred after patients are discharged from hospital. In addition to increased costs, each one of these infections means additional use of resources, greater patient discomfort and a decrease in patient safety.⁴

One study in the United States noted that the direct hospital-related financial burden of HAIs was estimated to be between 25.0 and 31.5 billion dollars per year.⁵ Another US study found that each HAI adds $12,197 in incremental costs to hospitals.⁶

In Mexico, Navarrete-Navarro and Armengol-Sanchez⁷ estimated costs associated with HAIs in paediatric intensive care. Infected children had an extra hospital stay of 9.6 days. This was the major factor contributing to an average cost per infection of nearly US $12,000. Another study in Mexico⁸ estimated that for case patients with catheter-associated bloodstream infections (CLABSI), the mean extra length of stay was 6.1 days, the mean extra cost of antibiotics was US $598 and the mean extra hospital cost was $11,591. Similarly, in Argentina⁹, it was determined that the mean extra length of stay for patients with bloodstream infection compared with control patients was 11.9 days, the mean extra antibiotic cost was US $1,913, and the mean extra cost was $4,888.

A study in Turkey suggested that a patient with a HAI spent an additional 23 days in the hospital compared with a patient not affected with a HAI. The extra cost for an infected patient was calculated as US $2,026.¹⁰

Al-Rawajfah, et al., studied bloodstream infections in a hospital in Jordan.¹¹ They found a mean length of stay of 12.1 days vs. 9.3 for controls. Inflation-adjusted charges for cases were US $7,426 vs. $3,274.

A study from Thailand¹² looked at the extra costs associated with surgical site infections. The excess cost was US $1,091 and the mean excess postoperative stay was 21.3 days.

Mathai, et al.¹³ in India, found that the attributable cost of ventilator-associated pneumonia (VAP) in an intensive care unit (ICU) was calculated to be US $5,200. The patients with VAP experienced significantly longer hospital stay [21 versus 11 days] and incurred greater hospital costs [US $6,250 versus $2,598].

Since the introduction of bundles of care to prevent infections, researchers started evaluating the cost-effectiveness of these measures. An Australian study¹⁴ examined the cost-effectiveness of a central venous catheter care bundle. They found the bundle cost-effective without an antimicrobial catheter if nationwide implementation costs over an 18 month period are below AUS $4.3 million ($94,559 per ICU).

Types of Economic Evaluations

Several types of economic analyses can be employed, including: cost effectiveness, cost benefit, and cost utility. The most preferred analyses are cost-effectiveness and cost utility. See Table 2.

A cost-effectiveness analysis compares interventions or products with different costs and different levels of effectiveness. A cost utility analysis is similar, except the benefits of a specific intervention are adjusted by health preference scores. Cost utility analyses are useful when there are no expected mortality differences between interventions, only differences in physical well-being which can be expressed as QALY.¹ One example is a study on the use of vancomycin as prophylaxis for coronary artery bypass surgery.¹⁶ There are various cost-effectiveness studies in the literature – see Table 3 for examples.

| Cost-effectiveness analysis | A single clinical outcome expressed in natural units (e.g., postoperative infections prevented or life years gained) is used. If multiple clinical outcomes are used, cost-consequences analysis may be reported which includes all clinical outcomes and costs for each alternative. |
| Cost-utility analysis | Clinical outcomes (health states) are converted into utility scores using a utility measurement instrument to estimate quality-adjusted-life-years (QALYs). Alternatively other utility measures such as healthy-years-equivalent may be used. |
| Cost-benefit analysis | Clinical outcomes are converted into monetary units so that a net benefit (or cost) can be estimated. Methods used to convert health benefits to monetary values include willingness to pay and the human capital approach. |

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When data on costs used in analyses are from different years, they should be brought into current year values. A typical method is to inflate the amounts using a standard price index for the country. The World Health Organization recommends that a threshold for calling an intervention cost-effective be three times the country’s gross domestic product per capita. Another method is to determine that the intervention dominated other relevant strategies (that is, it was both less costly in terms of resource use and more clinically effective compared with all the other relevant alternative strategies). Costs that can be measured include the health care facility costs, health care facility charges, resources used, and actual reimbursed charges. Hospital costs are a useful measure; they best reflect the actual economic burden to the institution. If the only information available is charges, the data can be adjusted using cost-to-charge ratios.

The number of bed-days lost to a case of HAI may be an appropriate outcome to describe a large proportion of the cost to the facility. This opportunity cost is typically much lower than the cost calculated with an accounting approach using the hospital budget for a given period divided by the total patient bed-days over the same period.

Costs of Outbreaks

Several investigators have attempted to measure the costs associated with outbreaks of infection. Again, the costs are tentative and must be considered in relation to the health care system studied and the year of study. Nevertheless, costs are considerable.

For example, a 4-month outbreak of *Klebsiella pneumoniae* infection in a neonatal intensive care unit was estimated to cost a hospital more than US $300,000. Kim et al measured the costs of MRSA in their hospital and calculated that it cost all Canadian hospitals $42m - $59m annually. An epidemic of infections resulting from extended-spectrum β-lactamase-producing *Klebsiella pneumoniae* resulted in various changes in practice. A study to evaluate the economic benefits of the changes was performed; the cost savings potentially associated with the interventions ranged from US $183,781 - $330,318. The authors estimated the costs potentially avoided as a result of changes in practices using the number of HAIs potentially prevented. They included expenditures that were incurred as a result of the improvement efforts.

Cost-benefit of Infection Prevention and Control

Determining whether there is an economic benefit to IPC activities is important to demonstrate the need for financial and administrative support. This type of evaluation also assists in setting priorities for IPC programs.

In the iconic Study on the Efficacy of Nosocomial Infection Control (SENIC) of 1974-1983, US hospitals with one full-time infection control nurse (ICN) per 250 beds, an infection control doctor (ICD), moderately intense surveillance, and systems for reporting wound infection rates to surgeons reduced their HAI rates by 32%. In other hospitals the HAI rate increased by 18%. The SENIC study estimated the annual cost of HAIs in US hospitals was $1b (in 1975 dollars). The cost of IPC teams (0.2 ICD and 1 ICN per 250 beds) was $72m per year; only 7% of the infection costs. Therefore, if IPC programmes were effective in preventing only 7% of HAIs (normally distributed), the costs of the programmes would be covered. A 20% effectiveness would save $200m and 50% would save $0.5b (1975 US dollars).

Raschka, et al., evaluated the effect of regional consolidation of an IPC program on reduction of selected HAIs. Regionalisation led to a 19% reduction in these HAIs over 4 years and a cost avoidance of at least CAD $9 million. Another Canadian study provided evidence that IPC programmes focused on haemodialysis-associated bloodstream infections yielded a benefit/cost ratio of 1-1.8:1.

In a review on cost-effective measures that could be employed against HAIs in developing countries, Nyamogoba and Obala concluded that IPC programmes are cost-effective. In particular, computer-assisted epidemiological surveillance appeared to be the most important aspect of IPC programmes; they identified changes in risk factors that may increase infection rates.

Herzer et al used a decision tree model to compare an IPC programme for bloodstream infection prevention with no programme. The study found that such programmes prevent 42 CLABSIs per 1,000 patients and averts 6 deaths per 1,000 patients at no additional cost. The authors concluded that these programmes reduce unnecessary morbidity, mortality, and economic costs associated with CLABSIs.

A cost-effectiveness analysis of investments in HAI prevention in intensive care units in the US was performed by Dick et al. They found that on-going investment in an IPC programme focused on CLABSI and VAP prevention is cost-effective.
A business case analysis is a type of cost utility analysis because it typically does not include patient outcomes. The Association for Professionals in Infection Control & Epidemiology documented the business case for reducing HAIs from the perspective of the health care executive. Case studies of significant cost savings were presented along with a methodology for determining the cost of various categories of HAIs. Similarly, guidelines on how to develop a business case for IPC were developed by the Society for Healthcare Epidemiology of America. This publication outlines steps for developing a business case analysis and explains economic concepts.

Decreasing organisational revenues and efforts to reduce overall operating costs have had a direct impact on IPC programmes. Senior managers in health care organisations are focusing on achieving and maintaining revenues while controlling costs. IPC professionals must align themselves and their programs with these organisational goals by: (1) identifying areas in which the IPC programme can support and enhances revenues, (2) avoiding excess costs for care, especially those related to HAIs, (3) identifying opportunities for cost reduction through value analysis, and (4) participating in efforts to measure and prevent other adverse outcomes of care.

Low Resource Issues

Improved data collection efforts would help estimate the burden of HAIs in low resource countries; drug resistance is a significant area where data are needed. Computer-assisted epidemiological surveillance may be an important aspect of these IPC programmes. Costs of HAIs in one’s own facility may be modelled on studies in the literature noted earlier.

Summary

The costs of HAIs are huge and include patient morbidity and mortality, hospital and community medical costs, the impact of blocked beds, and wider socio-economic costs. The costs of IPC programmes and staffing are relatively minor and with only a small degree of effectiveness they can pay for themselves. Investment in IPC is therefore highly cost-effective.

The constantly changing external environment, advancing technology, legislation, the introduction of government mandates, and a drive to maximise health care resources have made costing of IPC a management priority. Economic evaluations play an increasingly important role in IPC. It is important for IPC advocates to partner with individuals from many different fields to give decision-makers the information they need to make choices.

References

9. Rosenthal VD, Guzman S, Migone O, Crnich CJ. The attributable cost, length of hospital stay, and mortality of central line-


Further Reading


### Table 3. Cost Effectiveness Studies

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<th>Evaluation</th>
<th>Conclusion</th>
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<tr>
<td>17</td>
<td>Compare reusable and single-use surgical gowns and drapes</td>
<td>Single-use gown and drape sets provide the highest benefit rates</td>
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<td>18</td>
<td>Economic outcomes of VAP prevention associated with silver-coated endotracheal tubes versus uncoated endotracheal tubes</td>
<td>Silver-coated endotracheal tubes yielded savings (US $9,630–$16,356) per case of VAP prevented</td>
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<tr>
<td>19</td>
<td>Determine the costs and benefits of the MRSA Search and Destroy policy in a Dutch hospital during 2001 through 2006</td>
<td>Application of the policy resulted in a transmission rate of 0.30 and was estimated to prevent 36 cases of MRSA bacteraemia per year, resulting in annual savings of €427,356 for the hospital and ten lives per year</td>
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<tr>
<td>20</td>
<td>Measure the cost-effectiveness of the reduction in catheter-related bacteraemia after the introduction of a total parenteral nutrition (TPN) surveillance clinical nurse manager (CNM)</td>
<td>Introduction of TPN surveillance CNM saved the hospital at least 78,300€ per annum and led to a significant decrease in bacteraemia in TPN patients</td>
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<td>21</td>
<td>Determine whether point of use water filtration decreases the risk of colonisation and infection with waterborne pathogens in a sub-acute care unit, and whether existing filtration technology can be easily and cost-effectively implemented in such a setting</td>
<td>Total patient care costs were reduced by US $248,136 during the study period. Subtracting the $17,100 cost of filtration, the net cost savings was $231,036</td>
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<td>22</td>
<td>Assessed the cost-effectiveness of universal MRSA polymerase chain reaction (PCR) screening on admission to surgery</td>
<td>Compared to no screening, the PCR strategy resulted in higher costs (CHF 10,503 vs. 10,358) but a lower infection probability (0.0041 vs. 0.0088), producing a base-case incremental cost-effectiveness ratio of CHF 30,784 per MRSA infection avoided</td>
</tr>
<tr>
<td>23</td>
<td>Determine the hospital policy for routine MRSA screening strategies</td>
<td>Used US $30 MRSA PCR screening costs per test and $1,808.87 +/- $16.93 excess cost for each patient with hospital-acquired infection, screening of potential MRSA carriers at admission can reduce the nosocomial MRSA infection rate to approximately 50% of its baseline level. Screening requires a great MRSA prevalence to be cost beneficial, and, in the hospitals with a low MRSA prevalence, screening does not prevent an adequate number of cases to cover the costs of the program</td>
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<tr>
<td>Reference</td>
<td>Evaluation</td>
<td>Conclusion</td>
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<tr>
<td>24</td>
<td>Economic impact of adding chlorhexidine gluconate (CHG)-impregnated sponge dressing to standard care (i.e., CHG-impregnated sponge dressing skin preparation and transparent film dressing vs skin preparation and transparent film dressing) for the prevention of central-line infections was evaluated</td>
<td>Based on model calculations, a hypothetical 400-bed hospital inserting 3,078 central venous catheters (CVCs) per year is expected to avoid an average of 35 CR-BSIs, 145 local infections, and 281 intensive care unit days annually with the systematic use of CHG-impregnated sponge dressing. Potential hospital net cost savings (mainly because of reduced CR-BSIs with use of the dressing) would be $895,000 annually.</td>
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<td>25</td>
<td>Evaluate preoperative use of mupirocin in patients undergoing total joint arthroplasty</td>
<td>The treat-all and screen-and-treat strategies both had lower costs and greater benefits, compared with the no-treatment strategy.</td>
</tr>
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<td>26</td>
<td>Investigate the effects of prolonging hang time of total parenteral nutrition (TPN) fluid on CLABSI, TPN-related cost and nursing workload</td>
<td>Extending TPN hang time from 24 to 48 hours did not alter CLABSI rate - Annual cost saving using 48-hour TPN was AUD 97,603.00. By using 48-hour TPN, 68.3% of nurses indicated that their workload decreased and 80.5% indicated that time spent changing TPN reduced.</td>
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<td>27</td>
<td>Examine the cost and cost–benefit of IPC interventions against MRSA and to examine factors affecting economic estimates</td>
<td>Higher save/cost ratios observed in the intermediate to high endemicity setting compared with the low endemicity setting, in hospitals with &lt;500-beds and with interventions of &gt;6 months. IPC intervention showed a favourable cost/benefit ratio.</td>
</tr>
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<td>28</td>
<td>Determine the immediate central venous catheter (CVC)-related costs (including only the cost of the CVC itself, the diagnosis of CLABSI, and the antimicrobial agents used to treat the CLABSI) when second generation chlorhexidine-silver sulfadiazine (CHSS)-impregnated or standard catheters were used for femoral venous access</td>
<td>CHSS-impregnated catheters were associated with a lower risk of CLABSI when catheter duration was controlled for. CHSS-impregnated catheters were associated with lower CVC-related costs per catheter day than standard catheters.</td>
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