Health-care-associated infection: morbidity, mortality and costs

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Health-care-associated infection is rightly an area of increasing attention, not least because of considerable resource issues. Not all infection is preventable. However, much is possible and is indeed obligatory to avoid unnecessary infection, and attendant morbidity, mortality and, increasingly, litigation.

Hospital-acquired infection (HAI) is increasingly seen as a high priority issue in the NHS. The Commission for Health Improvement (2003) now uses two infection control performance indicators (including one on methicillin-resistant *Staphylococcus aureus* (MRSA) bacteraemia rates) to assess NHS trusts in the star ratings exercise. The Controls Assurance Standards scheme has included infection control as a non-clinical (rather than clinical) risk since 1999 (NHS Executive, 1999). Proficiency in infection control is also an integral part of the Clinical Negligence Scheme for Trusts, by which hospitals' insurance risk, and therefore the size of the annual premiums paid by trusts, is assessed (NHS Litigation Authority, 2002).

Data from several different health-care systems indicate that 5–10% of inpatients acquire an infection during their hospital stay (Plowman et al, 1997). There were about 9.6 million UK NHS hospital admissions in 2002–3, and so approximately 0.5–1 million hospital infections occur each year in the UK alone. Surveillance of HAI was pioneered in the USA, particularly by the work of Haley in the 1970s (Haley, 1985). These studies demonstrated that hospital infection rates could be reduced by about a third using intensive surveillance, feedback to clinicians and a control programme. Using these assumptions (which have never been validated in the NHS setting), about 170 000–330 000 hospital infections may be preventable each year in the UK.

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MEASURING HAI

Studies on the costs of HAIs have used different methods, definitions and degrees of stringency when calculating indirect costs, and therefore there is still uncertainty over their true economic impact on the community and on the economy. Accepting these limitations, an Office of Health Economics' publication highlighted the burden attributable to HAIs (Plowman et al, 1997). Interestingly, both this publication and the more recent UK National Audit Office (NAO, 2000) report have prompted media headlines focused on the fact that more UK annual deaths result from HAIs (approximately 5000) than from road traffic accidents. This figure was an estimate based on US data for the 1970–1980s which ranked HAI in the top 10 causes of death (Haley, 1985). Hence, HAI in the UK in 1995 was estimated as a primary cause of or major contributor to death in 1% or 3% respectively of all fatalities (approximately 5000 and 15 000 deaths respectively) (Hospital Infection Working Group of the Department of Health and Public Health Laboratory Service, 1995).

At the outset of a discussion of the impact of HAI it is important to stress that a lack of consistency over definitions means that studies apparently examining the same area may not be truly comparable. Surgical site infections (SSIs) are particularly prone to misdiagnosis and a frequent erroneous assumption is that a culture positive wound swab result is synonymous with wound sepsis. Furthermore, it is well known that a large proportion of SSIs present in the community even though they were acquired in hospital, and this percentage is likely to increase as hospital stays decrease (Weigelt et al, 1992; Mangram et al, 1999). Thus, unless an effective form of post-discharge surveillance is carried out then there will be marked under-ascertainment of SSIs.

Infections caused by MRSA strains have traditionally been associated with hospital care, but a failure to distinguish between colonization and infection can lead to over-diagnosis. It is now also clear that true community-acquired MRSA infections can occur, and indeed these may be associated with virulent MRSA strains that are distinct from those causing HAIs (Daum et al, 2002).

METHICILLIN-RESISTANT *S. AUREUS*

The discrepancies between studies that show an increased mortality associated with MRSA as opposed to methicillin-susceptible *S. aureus* (MSSA) bacteraemia and those that do not are most likely explained by confounding factors. When these are adequately controlled for, a significant increase in mortality associated with MRSA bacteraemia appears to be consistent; a recent meta-analysis found an odds ratio for death associated with MRSA bacteraemia of 1.93 (95% confidence interval = 1.54–2.42; $P<0.001$) (Cosgrove et al, 2003). There is, however, no convincing evidence that MRSA strains per se are more virulent than MSSA strains. Indeed it is clear that some MSSA are more virulent than others, and the same is true for MRSA. Also, there is evidence that vancomycin, the first-line therapy for serious MRSA infection, is an inferior antistaphylococcal agent compared with semi-synthetic penicillins such as flucloxacillin (Gonzalez et al, 1999). Therefore, it is not surprising that patients with MRSA sepsis tend to have worse outcome than those with infections caused by MSSA.

MORBIDITY AND MORTALITY OF HAI

In a case-control study of patients treated at a US teaching hospital in the 1990s, patients who developed a SSI had longer and more costly hospitalizations than patients who did not develop such infections (Kirkland et al, 1999). Importantly, they were twice as likely to die, 60% more likely to spend time in an intensive therapy unit (ITU), and had a more than five times increased risk of readmission to hospital. Outcome of HAI tends to be most severe in immunocompromised patients or those with multiple medical complications. Hence, mortality attributable to HAI in ITU patients is consistently higher (relative risk of death equal to 4.0) than in less invasive settings (see SSI study above) (Girou et al, 1998).

A prominent exception to this generalization is severe acute respiratory syndrome (SARS). Up until July 2003, a cumulative total of 8098 probable cases of SARS (including 774 deaths attributable to SARS) had been reported by 32 countries to the World Health Organization (2003). Ninety-seven per cent of the cases were reported from five areas: Hong Kong (21%), Taiwan (8%), the rest of mainland China (63%), Singapore (2%) and Canada (2%). Over 1700 health-care workers were infected. For the seven countries with at least 20 SARS cases (the former plus USA and Vietnam) the case fatality ratio ranged from 0–17% (9.6% overall).

There are multiple reports of HAI in patients with human immunodeficiency virus (HIV) disease (Laing, 1999). In particular, nosocomial spread of multidrug-resistant tuberculosis to both patients and health-care workers has emphasized the need for effective infection control measures during the management of immunodeficient patients. The delay between exposure and diagnosis, atypical presentation of infections such as tuberculosis and repeated hospital admissions of HIV-positive patients mean that a nosocomial infection may be misclassified as community-acquired.

Patients undergoing cytotoxic and/or immunosuppressive chemotherapy and particularly bone marrow transplantation are prone to invasive aspergillosis (Manuel and Kibbler, 1998). While such cases are acquired in hospital, susceptibility clearly relates to the profound T cell immunosuppression that is required to effect a therapeutic cure. It is probably impossible to remove the risk of such infections completely, and there remains a lack of evidence for the effectiveness of 'preventative' measures such as dust containment, provision of positive pressure/high efficiency particle arrester (HEPA) air filtration and antifungal prophylaxis.

COSTS OF HAI

There is little or no consensus on the cost of a hernia operation, so how can we possibly expect there to be accepted true costs for a wound infection? Scant data are available on the costs of the control measures for HAI (e.g. isolation facilities, cleaning, committees, policies), the negative impact on hospital activity (e.g. ward closure, surgical waiting list targets), staff confidence, litigation, socioeconomic loss and mortality. However, the main cost driver in HAI is the resultant increased duration of stay. For example, in the case of patients with *Clostridium difficile* diarrhoea acquired in hospital and secondary to antimicrobial therapy, 94% of the estimated cost of such episodes is the result of the increased duration of stay, with the remainder made up of additional laboratory tests (5%) and treatment (1%) (Wilcox et al, 1996).

In reality, there is actually a remarkable level of agreement about the magnitude of prolonged stay consequent on HAI (*Table 1*). Since the major calculated cost of HAI is usually the result of increased length of hospital stay, it is crucial that measurement of this is accurate. Four main options exist. Crude weighting estimates the additional inpatient days for those with HAI. The concurrent method relies on expert interpretation of whether or not the additional hospital days are actually the result of the HAI. The comparative method matches HAI cases with comparable non-infected controls, and is generally the favoured approach.

A socioeconomic study of HAI in the NHS in England in 1994/5 used modelling based on logistic regression to calculate confidence limits for the estimated increased lengths of stay (Plowman et al, 2001). Extrapolating from measurements in a single district general hospital, the calculated cost to the NHS was £1000 million per annum (Plowman et al, 2001). This figure was about 10-fold higher than the previous estimate in the 1980s (Department of Health and Social Security, 1988).

The most recent study examined approximately 4000 inpatients and identified 7.8% as having acquired at least one HAI while in hospital. Additionally, 30% of this HAI cohort and 19% of the remainder reported post-discharge symptoms consistent with the diagnosis of urinary tract, chest or surgical infections. On average, a patient with HAI spent 2.5 times longer in hospital and cost £3000 more to treat than a similar non-HAI patient. This sum is of a similar order to most of those calculated by the studies listed in *Table 1*. These studies highlight the socioeconomic burden of HAIs and the potential for savings and/or health gains if even only a small proportion of HAIs are prevented.

INVESTIGATION OF HAI

The investigation of outbreaks of infection is often relatively inexpensive. However, without a designated budget there may be a lack of incentive to investigate these fully. A recent cluster in Leeds of five peri-delivery cases of maternal group A streptococcal infections prompted the formation of a multidisciplinary outbreak control group. Two hundred medical, nursing and ancillary staff and students were screened for throat and/or skin carriage of group A streptococci. Sampling was also performed to identify a possible environmental point source for the outbreak. Staff found to be colonized with group A streptococci were treated and excluded from work, and all isolates were DNA fingerprinted. The cluster of cases did not recur but no cause of outbreak was found. The investigations cost £2–3000, which is a negligible amount in comparison with the costs of ward closures, cancelled operating lists, and the direct consequences to patients of HAI.

Capacity to meet the modest requirements and expense of investigating and controlling HAI may mean that larger orders of magnitude costs may be avoided. Put simply, expensive decisions should not be taken without access to crucial data. For example, pathogens apparently similar by routine laboratory testing may be shown to be unrelated by DNA fingerprinting. Such capacity should be available in a timely fashion, as infection control decisions about the need to close or reopen a unit, or to carry out other interventions such as surveillance screening equipment, are often required at short notice. Such decision making may not be compatible with the time delay sometimes associated with obtaining results from reference laboratories. Hence, core laboratory investigations to investigate potential HAI and particularly clusters of cases should be available locally.

TABLE 1.
Studies of cost and increased length of stay associated with HAI

Reference	Country	Type of HAI (number in study)	Increased length of stay (days)	*Cost per case
Haley et al (1981)	USA	All (177)	1	£891
Girard et al (1983)	France	Neonatal (61)	6.7	£1118
Mugford et al (1989)	UK	Caesarean (41)	2.1	£1011
Kappstein et al (1992)	Germany	ICU pneumonia (34)	10.1	£5533
Coello et al (1993)	UK	UTI (36)	3.6	£498
Coello et al (1993)	UK	Wound (12)	10.2	£1553
Wilcox et al (1996)	UK	*Clostridium difficile* diarrhoea	21	£4107
Zoutman et al (1998)	Canada	Wound (108)	10.2	£1780
Plowman et al (2001)	UK	All (309)	11	£3000
Kirkland et al (1999)	USA	Wound (255)	12	£3360

*All prices adjusted where necessary to £ sterling and approximate 1995/96 values.
HAI = hospital-acquired infection; ICU = intensive care unit; UTI = urinary tract infection

THE BIG PICTURE

Expenditure on infection control can improve patient care, reduce costs and prevent litigation for the hospital trust. About one third of HAIs may be preventable, but a more conservative target of a 15% cut has been proposed in the NAO (2000) infection control survey report. This reduction could save the NHS £150 million annually. Infection control can affect the quality of service and budget provision should reflect this.

Trusts will increasingly be forced to recognize that control of HAI is part of risk management. However, the unpredictable nature of infection control, and particularly the funding of measures required to curtail outbreaks, makes it difficult to calculate accurate budgets. Unfortunately, budgets provided for infection control rarely recognize this. Therefore mechanisms should exist to use contingency funds or to cross-charge units or subsidiaries for justifiable and yet unforeseen infection control costs.

Infection control costs can be 'ring-fenced' from the corporate budget. This means that the practice of infection control is not under the influence of management or other disciplines. The budget should include salaries of the infection control team, resources for audit, teaching, surveillance and management of outbreaks, and may be linked to patient throughput. Clearly many different external factors affect infection control practice and costs. For example, nursing and medical staff levels must be sufficient for safe infection control practice, or costs may rise (Haley et al, 1981). Other impediments to optimal infection control practice which in turn influence infection control costs include poor ward design and sub-standard environmental cleaning. However, the modern day scourge of infection control in the NHS is overactivity and the excessive movement of patients and their microbes around the hospital. In order to ensure that infection control is a basic component of medical practice we must allow those charged with its practice the resources and time to succeed. **HM**

Conflict of interest: none.

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KEY POINTS

- Between 5 and 10% of inpatients acquire an infection during their hospital stay.
- A large proportion of surgical site infections present in the community and this percentage is set to increase as hospital stays shorten.
- Patients with methicillin-resistant *Staphylococcus aureus* bacteraemia are almost twice as likely to die as those with bacteraemia caused by methicillin-susceptible *Staph. aureus*.
- The great majority of excess cost associated with hospital-acquired infection (HAI) is the result of prolongation of hospital stay.
- On average an NHS patient with HAI spent 2.5 times longer in hospital and costs £3000 more to treat than a similar patient who does not have an HAI.
- American studies have shown that HAI rates could be reduced by about a third using intensive surveillance, feedback to clinicians and a control programme.
- Overactivity and excessive patient movement are impediments to good infection control practice.