PUBLIC HEALTH LABORATORY SERVICE

1899 1999

contributing to health worldwide

The Socio-economic Burden of Hospital Acquired Infection

EXECUTIVE SUMMARY

Rosalind Plowman

Nicholas Graves

Mark Griffin

Jennifer A Roberts

Anthony V Swan

Barry Cookson

Lynda Taylor

Acknowledgements

The project steering committee wish to thank the Board and staff of the study hospital for their willingness to take part in this study, and for their help and support throughout. We would especially like to thank the Director of Nursing Practice for her invaluable contribution to the study design, and for dealing with practical issues at the study site. We would also like to thank the Information Officer, who extracted information from the hospital dataset, often at very short notice; the Laboratory Manager, who gave up considerable time to assist with the costing of laboratory tests; the Medical Coding Manager and Medical Records Supervisor; the Systems and Information Manager and the Assistant Manager for the Primary Health Care Directorate who had the daunting task of extracting the relevant data from the primary health care database; general practitioners and practice managers for their help and support with accessing medical records post-discharge; the nursing staff and consultants on the study wards and, most important of all, the patients concerned who gave up their time to take part in the study. We would also like to thank Tracy Cowan who edited the document, Stewart McGregor from the Communications Unit, Public Health Laboratory Service for designing the cover and assisting in laying out the document, and Tola Awogbamiye from the Communications Unit for her help and support in preparing this document for publication.

The project was funded by the Department of Health, and we thank Dr Elizabeth Meerabeau, Dr Elizabeth Tebbs and Dr William Maton-Howarth for their support.

Project Team

Rosalind Plowman BA, MSc, RGN	Project Co-ordinator
Nicholas Graves BA, MA	Research Economist
Mark Griffin BA, MSc	Statistician
Rachael Dunk RN	Research Assistant
Alison Franklin BSc, RN	Research Assistant
Janette Trevarthen RN, OHND	Research Assistant
Maggie Waters RN	Research Assistant
Jennifer White RN	Research Assistant
Linda Wright BSc, RN	Research Assistant
Barbara Ayres	Project Secretary
Christine Berry	Administrative support

Project Steering Committee

Jane Bandcroft RGN, DN, HV, FPCert	Director of Nursing Practice, Study Hospital
Barry Cookson MBBS, BDS, MSc, Hon Dip.HIC, MRCP, FRCPath	Director of Laboratory of Hospital Infection, Public Health Laboratory Service
Helen Glenister BSc, MBA, PhD, RGN	Nursing Director, Medical Devices Agency, Department of Health
Bernadette Nazareth MBBS, MSc, MRCPath	Consultant in Communicable Disease Control, Redbridge and Waltham Health Authority
Jennifer ARoberts MSc Econ, PhD, HMPHM	Reader in Economics of Public Health, London School of Hygiene and Tropical Medicine, London
Mike Rowland MBBS, FRCP, FFPHM	Consultant Epidemiologist, Communicable Disease Surveillance Centre, Anglia and Oxford RHA
Anthony Swan PhD, HMFPHM, C Stat	Director, Statistics Unit, Public Health Laboratory Service
Lynda Taylor MBA, RGN, RM	Head of Infection Control Unit, Laboratory of Hospital Infection, Public Health Laboratory Service
Jennie Wilson BSc, RGN	Programme Leader Infection Control and Surveillance, Infection Control Unit, Laboratory of Hospital Infection, Public Health Laboratory Service

Advisory Committee Members

Sue Dewar RN, DNCert,	MA District nurse, Chichester Priority Care Services Trust
Georgia Duckworth MSc, FRCP, FRC Path, FRIPHH	Regional Epidemiologist, CDSC, North Thames
Johanna Finn BSc, MHSM, Dip HSM	Chief Executive, West Suffolk Hospitals Trust
Paul Gillett MRCP, FRC Path	Consultant Medical Microbiologist, Stoke Mandeville Hospital
Jayne Holmes RGN Senior Nurse,	Queen Elizabeth II Hospital, Welwyn Garden City (to 23 November 1996)
Rosemary Jenkins MSc, DMS, MTD, RGN, RM	Nursing Officer, Department of Health (from September 1994 to to 30 September 1995)
William Maton-Howarth PhD	Senior Principal Scientific Officer Department of Health (from 1 April 1997)
Jennifer McIntyre MSc, RGN	Nursing Officer, Department of Health (from 30 September 1995)
Elizabeth Meerabeau BSc, PhD, MBA, RGN, RHV, RNT, RHVT	Research Liaison Officer Department of Health (to 27th March 1997)
Richard Murray MA	Economic Advisor, Department of Health (from September 1995)
Elizabeth Tebbs MBBS, ChB	Senior Medical Officer, Department of Health
Ann Whittle	Department of Health (to 31st October 1995)
Kay Butcher	Department of Health (to 31st October 1995)
Millie Carter	Nursing Officer, Department of Health (to September 1994)
Simon Harding PhD	Economic Advisor, Department of Health (to September 1995)

Introduction

At any one time approximately one in 10 patients in acute hospitals have a hospital-acquired infection (HAI) (DoH / PHLS, 1995). At the same time, an unquantified number of patients, discharged from hospital into the community, have an infection related to their recent hospital admission. These infections impose a burden on the secondary, tertiary and primary health-care sectors, community care services, the patients themselves and those who care for them. These burdens may be both financial and non-financial.

Studies that have estimated the cost of HAI generally focus on the burden to the hospital sector. Little is known about the costs incurred by the primary health-care sector, community care services, individual patients and their family and friends. These costs become increasingly relevant as the length of hospital stay becomes shorter and patients are discharged home at an earlier point in their recovery. This change in discharge pattern is likely to result in some treatment costs being shifted from the secondary health-care sector to the primary health-care sector and community care services, and may result in an increase in the costs borne by patients, their family and friends.

The aim of this research was to provide a more comprehensive assessment of the nature, distribution and magnitude of the costs resulting from HAIs. To achieve this, a detailed analysis of the resources used in hospital and post-discharge was undertaken.

The results of this research should be of use to both purchasers and providers of health care, in particular those involved in the planning and management of infection prevention and control programmes.

The research was commissioned by the Department of Health to the Central Public Health Laboratory and the London School of Hygiene and Tropical Medicine, and forms part of the Department of Health's Research and Development Programme.

Aims and objectives

The aim of the study was to assess the burden of HAI in terms of the costs to the public sector, patients, informal carers and society as a whole. Specific objectives were to:

1. Determine the overall burden of HAI in terms of the:
   - Costs to the secondary and primary health-care sectors and community care services.
   - Impact on the health status of patients.
   - Costs to patients, informal carers and the economy.
2. Establish the relative costs of different types of HAI.
3. Determine the type of patients who incur the highest costs for specific infections.
4. Use the data obtained to construct models to predict the effects of HAI on the cost categories described above.

Research methods

Adult patients with a minimum in-patient stay of 30 hours were recruited from the general wards of a district general hospital over a 13-month period between April 1994 and May 1995. Information on daily resource use was recorded for each patient for the duration of their hospital stay. Patients who presented with signs and symptoms of infection which met the definitions of infection used in this study, and a sample of patients who did not, were followed up post-discharge using a structured questionnaire. This questionnaire provided information on possible surgical wound, chest and urinary tract infections experienced after discharge from hospital; care received from health and community care services, family and friends; personal expenditure on items such as drugs and dressings; time of return to normal activities and, if applicable, employment; and information on the patients' health status following discharge from hospital. Information about care received post-discharge was also obtained from the patients' health-care records. Estimates of the cost of the resources used were made and analysed to determine the extent to which observed variations in costs incurred by infected and uninfected patients could be explained by the presence of an HAI.

The in-patient analysis considered how resource use and associated costs varied between patients with and without an HAI, and how these outcome measures varied with site of infection. The post-discharge analysis considered how costs varied between four patient groups:

- Patients who did not have an HAI identified during the in-patient phase or an infection identified post-discharge (Group 1).

- Patients who did not have an HAI identified during the in-patient phase, but reported symptoms and treatment that met the study criteria for one or more infections present post-discharge (Group 2).
- Patients who had one or more HAIs identified during the in-patient phase, but did not report symptoms and treatment that met the study criteria for one or more infections present post-discharge (Group 3).
- Patients who had one or more HAIs identified during the in-patient phase, and reported symptoms and treatment that met the study criteria for one or more infections present post-discharge (Group 4).

Patients were classified as having a possible infection post-discharge if they reported symptoms and treatment which met the criteria for surgical wound, chest or urinary tract infections used in this study. It was not possible to determine whether in all cases an infection was present, or whether it was acquired in hospital. Furthermore, where patients presented with an HAI in hospital, it was not clear whether the symptoms reported post-discharge represented a new infection or a continuation of a previously diagnosed infection.

Since factors other than the presence of an HAI may have accounted for some of the additional resource use and costs incurred by infected patients, resource and cost outcome measures were analysed using regression modelling which controlled for a range of potential confounders (age, sex, diagnosis, number of co-morbidities, admission specialty, admission type and, where appropriate, time of return of questionnaire). Estimates allowing for the effects of these confounders were subsequently derived from this modelling process.

Results

Recruitment and post-discharge response rates

- Four thousand adult patients were recruited into the study from the medical, surgical, orthopaedic, urology, gynaecology, ear, nose and throat (ENT), elderly care and, if they had a caesarean section, obstetric specialties.
- Complete in-patient data sets were obtained for 3980 patients.
- A total of 1449 patients were selected for follow-up into the community: 215 had an infection identified during the in-patient phase.
- Of those patients selected for follow-up, 41 died either before the first questionnaire was sent at four weeks post-discharge, or between the distribution of the first and second questionnaires at eight weeks post-discharge. Four of these patients had an HAI identified during the in-patient phase. All 41 patients were excluded from the response rate.
- Seventy-one per cent of patients returned the questionnaire after a maximum of two reminders.
- The response rate was similar for patients with and without an HAI identified during the in-patient phase.

Incidence of HAIs

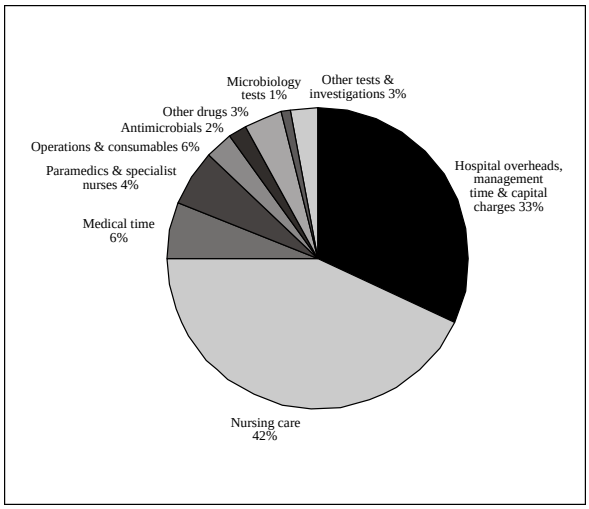
- In-patient phase: 7.8% (95% CI: 7.0; 8.6) of patients were identified during the in-patient phase as having acquired one or more HAIs.
- Post-discharge phase: 19.1% (95% CI: 16.5; 21.9) of those patients who returned the questionnaire and who did not have an HAI identified during the in-patient phase and 30% (95% CI: 22.8; 38.0) of patients who had an HAI identified during the in-patient phase reported symptoms and treatment that met the criteria for a urinary tract, chest and / or surgical wound infection used in this study.

Impact of HAI on hospital costs incurred during the in-patient phase

Patients who presented with one or more HAIs during their in-patient stay were found to incur costs that were, on average, 2.9 times greater than those for uninfected patients. In these study patients, this represented an absolute increase of £3154 per case. After adjusting for the effects of potential confounders the ratio was almost identical (2.8; 95% CI: 2.6; 3.0), suggesting that confounding had relatively little effect.

Hospital overheads, capital charges and the cost of management time accounted for 33% of the additional costs incurred, while nursing care accounted for 42%, medical care 6%, operations and consumables 6%, paramedics and specialist nurses 4%, antimicrobials 2%, other drugs 3%, microbiology tests 1%, and other tests and investigations 3% (see Figure 1).

Figure 1.The distribution of the additional costs incurred by patients with one or more HAIs compared with uninfected patients during the in-patient hospital stay



The mean costs of treating infected and uninfected patients varied with specialty. Table 1 (page 4) shows the mean costs incurred, the ratio of the costs incurred by infected patients compared with uninfected patients, and the additional costs incurred by infected patients in this study. The figures in parentheses are the estimates obtained from the regression analysis.

Impact of specific types of HAI on hospital costs incurred during the in-patient phase

The impact that HAIs had on hospital costs varied with the site of infection. Table 2 (page 4) shows the mean costs incurred, the ratio of the costs incurred by infected patients compared with uninfected patients, and the additional costs incurred by infected patients. The figures in parentheses are the estimates obtained from the regression analysis.

Infections of the urinary tract were found to be the least expensive, with costs, on average, 1.8 times higher than those for uninfected patients. In these patients, this is, on average, equivalent to an additional £1327 per patient.

Patients who acquired infections of the lower respiratory tract, skin, surgical wound or 'other' sites experienced similar patterns of increase in costs. Costs were, on average, two to 2.5 times greater than those incurred by uninfected patients, equivalent to an average increase of between £1618 and £2398 per patient.

The four patients who acquired bloodstream infections incurred costs that were, on average, over four times those for uninfected patients. In these patients, this is equivalent to an additional £5397 per patient. However, since there were only four patients in this infection group, two of whom died, general conclusions based on these results must be treated with caution.

Patients who acquired more than one HAI incurred the highest expenses, with costs, on average, 6.6 times greater than those incurred by uninfected patients. In these patients, this is equivalent to an additional £9152 per patient.

For all sites of infection, adjustment for potential confounders made little difference and the relative magnitudes of effects were almost entirely unchanged.

Impact of HAI on length of hospital stay

Patients who acquired an infection in hospital remained in hospital, on average, 2.9 times longer than uninfected patients, equivalent to an extra 14 days. After adjusting for other factors that might influence length of stay, the ratio of increase was modified to 2.5 (95% CI: 2.3; 2.7), which is, on average, equivalent to an extra 11 days.

Impact of specific types of HAI on length of hospital stay

The extended hospital stay experienced by patients with an HAI varied with site of infection (Table 3, see page 5). Patients who acquired more than one infection were observed to have the greatest increase in mean length of stay. Patients with bloodstream infections had the lowest increase. However, as mentioned above, there were only four patients in this group, two of whom died while still in hospital.

Impact of HAI on the health-care sector post-discharge

With the exception of patients who presented with an HAI as an in-patient and did not have an infection identified post-discharge, who on average incurred lower GP costs than patients in the other infection groups, patients who had an HAI identified during the in-patient phase, and/or an infection identified post-discharge, on average, had greater contact with their GP, visited the hospital more frequently for outpatient appointments and received more visits from district nurses compared with uninfected patients. Patients who acquired an infection therefore imposed an additional economic burden on

Table 1.Mean costs incurred during the in-patient phase by patients with and without an HAI and by admission specialty

Specialty	Mean costs (£)				Ratio of costs (model estimate;95% CI)	Additional costs (£) (model estimate)
	No HAI (a)	n	HAI (b)	n	(b/a)	(b-a)
Medicine	1559	800	7271	38	4.7 (4.6;3.8,5.6)	5712 (5621)
Surgery	1290	844	6189	54	4.8 (3.9;3.3,4.7)	4898 (3795)
Orthopaedics	2089	473	5385	40	2.6 (2.6;2.1,3.1)	3296 (3285)
Urology	1276	439	2758	27	2.2 (2.2;1.7,2.8)	1482 (1544)
Gynaecology	1661	339	2196	51	1.3 (1.3;1.1,1.5)	535 (470)
Elderly care	1748	508	5277	74	3.0 (3.1;2.6,3.5)	3529 (3578)
ENT	2127	64	5644	2	2.7 (1.9;0.8,4.6)	3516 (2007)
Obstetrics*	2481	204	2761	23	1.1 (1.1;0.8,1.4)	280 (118)
Overall	1628	3671	4782	309	2.9 (2.8;2.6,3.0)	3154 (2917)

*Caesarean sections only

Table 2.Mean costs incurred during the in-patient phase by site of HAI

Site of infection	Mean costs (£)	n	Ratio of costs (model estimate;95% CI)	Additional costs (£) (model estimate)
No HAI	1628	3671		
UTI	2955	107	1.8 (1.7;1.5,1.9)	1327 (1122)
LRTI	4027	48	2.5 (2.3;1.9,2.7)	2398 (2080)
SWI	3246	38	2.0 (2.0;1.6,2.4)	1618 (1594)
BSI	7026	4	4.3 (4.8;2.6,8.8)	5397 (6209)
Skin	3418	25	2.1 (2.0;1.6,2.5)	1790 (1615)
Other	3892	30	2.4 (2.5;2.0,3.1)	2263 (2465)
Multiple	10780	57	6.6 (6.3;5.4,7.4)	9152 (8631)
Any infection	4782	309	2.9 (2.8;2.6,3.0)	3154 (2917)

UTI=urinary tract infection;LRTI=lower respiratory tract infection;SWI=surgical wound infection;BSI=bloodstream infection

these services. Acquiring an infection was not found to have a positive impact on the number or cost of health visitor and community midwife visits. Table 4 (page 5) summarises the impact of HAI on health sector costs post-discharge. The mean costs incurred by patients in the four HAI groups are presented, together with the ratio of the costs incurred by infected patients compared with uninfected patients and the additional costs incurred by infected patients. The figures in parentheses are the estimates obtained from the regression analysis.

General practitioners

Patients who did not present with an HAI while in hospital but reported symptoms and treatment that met the study criteria for an infection post-discharge, and patients who developed an HAI while in hospital and had an

Table 3.Mean length of hospital stay by site of HAI

Site of infection	Mean LoS (days)	n	Ratio (model estimate;95% CI)	Additional days (model estimate)
No HAI	8	3671		
UTI	14	107	1.8 (1.7;1.5,1.9)	6 (5)
LRTI	20	48	2.6 (2.1;1.7,2.6)	12 (8)
SWI	14	38	1.9 (1.9;1.6,2.4)	7 (7)
BSI	10	4	1.2 (1.5;0.8,3.0)	2 (4)
Skin	20	25	2.6 (2.4;1.8,3.1)	12 (11)
Other	21	30	2.8 (2.6;2.1,3.4)	13 (12)
Multiple	45	57	6.0 (4.8;4.0,5.8)	38 (29)
Any infection	22	309	2.9 (2.5;2.3,2.7)	14 (11)

LoS=length of stay;UTI=urinary tract infection;LRTI=lower respiratory tract infection;SWI=surgical wound infection;BSI=bloodstream infection

Table 4.Impact of HAI on health sector costs incurred post-discharge

One or more HAIs identified during the in-patient phase	One or more infections identified post-discharge	n	Health-care professional visited*	Mean observed costs (£)	Ratio of costs (model estimate;95% CI)	Additional costs (£) (model estimate)
No	No	664	GP	18	—	—
		658	HD/HN	32	—	—
		558	DN	34	—	—
No	Yes	159	GP	28	1.6 (1.7;1.3,2.3)	10 (12)
		160	HD/HN	39	1.2 (1.9;1.3,2.6)	7 (28)
		130	DN	39	1.2 (1.5;1.0,2.1)	6 (16)
Yes	No	99	GP	14	0.8 (0.8;0.5,1.1)	-4 (-4)
		102	HD/HN	36	1.1 (1.3;0.9,2.0)	4 (11)
		89	DN	59	1.8 (1.6;1.0,2.3)	25 (19)
Yes	Yes	43	GP	24	1.4 (1.5;0.9,2.6)	6 (10)
		43	HD/HN	40	1.3 (2.7;1.5,4.7)	8 (53)
		39	DN	78	2.3 (2.6;1.4,4.7)	44 (53)

*Sources:GP and HD/HN (the post-discharge questionnaire);DN (the DN database)

GP=general practitioner; HD/HN=hospital doctor/hospital nurse;DN=district nurse

infection identified post-discharge, on average, incurred proportionally greater costs than patients in the other two groups. However, the average increases in the absolute costs observed were minimal.

Hospital doctor/nurse

Patients who did not present with an HAI while in hospital but had an infection identified post-discharge, and patients who presented with an HAI while in hospital and had an infection identified post-discharge incurred slightly higher costs than patients in the other two categories.

District nurses

Patients who had an HAI identified during the in-patient phase, and/or an infection identified post-discharge, on average, had a greater impact on district nursing costs compared with uninfected patients. Patients who presented with an HAI as an in-patient and had an infection identified post-discharge had the greatest impact on district nursing costs.

The results from the regression analysis suggest there was some confounding and that the effects of HAI on GP, district nursing and hospital costs in a number of cases were probably larger than those observed.

Impact of HAI on costs incurred by patients

Personal expenditure on items such as drugs and dressings was found to vary with HAI group. The mean costs incurred by patients in the four HAI groups are presented in Table 5, together with the ratio of the costs incurred by infected patients compared with uninfected patients and the additional costs incurred by infected patients. The figures in parentheses are the estimates obtained from the regression analysis.

Increases in personal expenditure were greatest for patients who presented with an HAI as an in-patient and had an infection identified post-discharge. These patients experienced costs that were 3.2 times greater than those incurred by uninfected patients. Adjustment for potential confounders made little difference and the relative magnitudes of effect remained similar to the observed effects.

Impact of HAI on the number of days from admission to return to normal daily activities

The number of days from admission to resuming normal daily activities varied with HAI group. The mean number of days from admission to resuming normal daily activities for patients in the four infection groups are presented in Table 6, together with the ratio of the number of days infected patients were away from normal daily activities, compared with uninfected patients. The additional number of days that infected patients took to resume normal daily activities, compared with uninfected patients, are also presented.

Patients who had an HAI identified during the in-patient phase and/or an infection identified post-discharge, on average, took longer to resume normal daily activities than patients in the uninfected group. Patients who had an HAI identified during the in-patient period and reported symptoms and treatment that met the criteria for an

Table 5.Impact of HAI on personal costs incurred by patients

One or more HAIs identified during the in-patient phase	One or more infections identified post-discharge	n	Mean observed costs (£)	Ratio of costs (model estimate;95% CI)	Additional costs (£) (model estimate)
No	No	691	9	—	—
No	Yes	163	15	1.7 (1.5;1.1,1.9)	6 (4)
Yes	No	105	5	0.5 (0.9;0.6,1.3)	-4 (1)
Yes	Yes	45	30	3.2 (3.2;2.0,5.0)	20 (20)

Table 6.Mean number of days from admission to return to normal daily activities by HAI status

One or more HAIs identified during the in-patient phase	One or more infections identified post-discharge	n	Mean no. of days	Ratio of days (model estimate;95% CI)	Additional days (model estimate)
No	No	642	29		
No	Yes	155	35	1.2 (1.2;1.1,1.4)	6 (6)
Yes	No	94	41	1.4 (1.4;1.3,1.6)	12 (13)
Yes	Yes	43	43	1.5 (1.6;1.3,1.9)	13 (17)

infection post-discharge took longer to resume normal daily activities than patients in the other infection groups.

Impact of HAI on the number and value of days emplo yed patients were away from paid employment

The number and value of days from admission to return to paid employment varied with HAI group. The mean number and value of days from admission to return to paid employment for patients in the four infection groups are presented in Tables 7–8, together with the ratio of the number and value of days infected patients were away from employment, compared with uninfected patients. The additional number of days infected patients were away from paid employment, compared with uninfected patients, are also presented.

Patients who had an HAI identified during the in-patient phase and/or an infection identified post-discharge had a greater number of days away from employment than uninfected patients.

Impact of HAI on the number of days informal carers spent caring for patients and their dependants

The number and value of days informal carers spent caring for the patient's dependants during the in-patient period and the patient post-discharge varied with HAI group. The mean number of days of care provided by informal carers for patients in the four infection groups are presented in Table 9 (page 8) and the estimated value of this time is presented in Table 10 (page 8). The ratio of the number of days of care received by infected compared with uninfected patients and the associated value, together with the number of additional days of care received by infected compared with uninfected patients, are also presented in these tables.

Patients who reported symptoms and treatment that met the study criteria for one or more infections present post-discharge, regardless of whether they presented with an infection in hospital, on average, received more care from informal carers than patients who had not acquired an infection, or who presented with an infection in hospital but did not have an infection identified post-discharge.

Table 7.Mean number of days from admission to return to employment by HAI status

One or more HAIs identified during the in-patient phase	One or more infections identified post-discharge	n	Mean no. of days	Ratio of days (model estimate;95% CI)	Additional days (model estimate)
No	No	267	23		
No	Yes	66	29	1.2 (1.1;1.0,1.3)	6 (2)
Yes	No	30	29	1.3 (1.2;1.0,1.5)	6 (6)
Yes	Yes	11	28	1.2 (1.3;0.9,1.7)	5 (6)

Table 8.Mean value of days from admission to return to employment by HAI status

One or more HAIs identified during the in-patient phase	One or more infections identified post-discharge	n	Mean value of days	Ratio of costs (model estimate;95% CI)	Additional costs (£) (model estimate)
No	No	267	1429		
No	Yes	66	1724	1.2 (1.1;1.0,1.3)	295 (200)
Yes	No	30	1649	1.2 (1.2;1.0,1.5)	220 (300)
Yes	Yes	11	1889	1.3 (1.6;1.1,2.2)	460 (801)

Table 9.Mean number days informal carers spent caring for dependants and patients by HAI status

One or more HAIs identified during the in-patient phase	One or more infections identified post-discharge	n	Mean no. of days	Ratio of days (model estimate;95% CI)	Additional days (model estimate)
No	No	691	10.3		
No	Yes	163	14.4	1.4 (1.2;1.0,1.6)	4.1 (2.1)
Yes	No	105	10.5	1.0 (0.9;0.6,1.2)	0.2 (-1.3)
Yes	Yes	45	20.9	2.0 (1.6;1.0,2.5)	10.6 (6.1)

Table 10.Mean value of days informal carers spent caring for dependants and patients by HAI status

One or more HAIs identified during the in-patient phase	One or more infections identified post-discharge	n	Mean value of days (£)	Ratio of costs (model estimate;95% CI)	Additional costs (£) (model estimate)
No	No	691	348		
No	Yes	163	488	1.4 (1.3;0.8,2.1)	140 (96)
Yes	No	105	355	1.0 (0.7;0.4,1.3)	7 (-100)
Yes	Yes	45	707	2.0 (2.3;0.9,5.6)	359 (454)

Impact of HAI on health status

The responses given to the general health status questionnaire, the SF-36, administered four weeks post-discharge, provided information on eight dimensions of health. Two summary measures relating to physical and mental well-being were derived from these data. Patients with an HAI, on average, obtained lower scores for these two measures than patients who did not acquire an infection, indicating a poorer outcome as determined by these health measures. Patients who presented with an HAI as an in-patient and reported symptoms and treatment which met the study criteria for an infection present post-discharge, on average, reported the lowest health status.

Impact of HAI on in-patient mortality

The in-patient death rate was found to be considerably higher in patients with an HAI which presented during the hospital stay: 13% of patients with an HAI died compared with 2% of patients who did not present with an HAI in hospital. After adjustment for the effects of age, sex, diagnosis, number of co-morbidities, admission specialty and admission type, patients with an HAI were found to be 7.1 (95% CI: 4.3; 11.7) times more likely to die in hospital than uninfected patients.

Estimates were made of the number of years of life lost by infected patients who died. Patients aged 25–44 years who acquired an infection in hospital and subsequently died, on average, lost 44 years; patients aged 45–64 lost 19 years, patients aged over 65–84 years lost 11 years, and patients aged 85 years and over lost 4 years. Since it was not possible to determine for each individual case whether the HAI was the primary cause of death, a contributing factor, or whether it made no contribution to the death, neither the number nor value of the years of life lost as a result of an HAI could be determined. However, it is important to acknowledge that years of life lost do have a value and represent an important cost associated with HAI.

National estimates

The study results were used to estimate the economic burden of HAIs occurring in adult (≥18 years) patients, excluding day cases, admitted to the specialties covered in this study throughout England. Patients admitted to these specialties accounted for approximately 70% of adult, non-day case NHS admissions in England in 1994–1995.

The results presented are based on the assumption that the incidence of HAI, the ratio of increase in costs incurred by infected compared with uninfected patients and the mean cost of treating uninfected patients observed in this study are representative of the incidence and costs incurred by patients admitted to the specialties covered in this study throughout England.

Estimates of the economic burden of HAI to the NHS in England

HAIs were estimated to cost the NHS in England £986.36 million annually. Of this aggregate cost, £930.62 million (95% CI: £780.26; £1080.97 million) was estimated to have been incurred during the patients' hospital stay and £55.74 million post-discharge. These post-discharge costs were distributed between GPs (£8.4 million), hospitals (outpatient consultations) (£26.83 million) and district nursing services (£20.51 million). The estimates of the effect of HAI on health sector costs incurred post-discharge varied considerably, depending on whether the HAI presented during the in-patient and/or post-discharge phase. The 95% confidence intervals obtained for the different infection groups were wide and this should be taken into account when using these estimates.

The in-patient hospital estimates represent 9.1% of the acute, geriatric and obstetric programme budget for 1994-95, and estimates of the cost to the hospital sector post-discharge 0.9% of the outpatient acute, geriatric and obstetric programme budget for the same year (data from Department of Health). The estimated burden to GPs represents 0.3% of the general medical services budget for 1994-95 (data from the Department of Health) and the estimated burden to district nursing services represents 2.4% of their budget for the same year (data from the Department of Health).

Table 11 presents estimates of the impact of specific types of infection on in-patient costs. The cost estimates are limited to those incurred by the hospital sector during the in-patient stay. Nationally, infections of the urinary tract were estimated to be the most expensive single-site infection, costing an estimated £123.89 million per annum (95% CI: £80.96; £166.83). These infections were relatively inexpensive to treat (the additional cost per case observed in this study was £1327, model estimate £1122), but their relatively high incidence means that, nationally, they impose a substantial burden on the NHS. No attempt was made to derive site-specific estimates of the impact of HAI on health sector costs incurred post-discharge.

Table 11.National estimates of the burden of HAI to the hospital sector in England by site of infection (in-patient costs only*)

Site of infection	Estimates of the national burden of HAI Figures expressed in £ (millions)		
	Estimate	95% CI	
		Low	High
UTI	123.89	80.96	166.83
LRTI	103.77	59.41	148.12
SWI	62.37	30.93	93.82
BSI	25.53	-6.86	57.91
Skin	41.79	15.40	68.17
Other	75.87	36.52	115.23
Multiple	507.77	348.89	666.65

UTI=urinary tract infection;LRTI=lower respiratory tract infection; SWI=surgical wound infection;BSI=bloodstream infection

*Estimates are limited to the additional costs incurred as a result of HAIs occurring in adult patients,excluding day cases,admitted to the specialties covered in this study:approximately 70% of all adult,non-day case NHS admissions

Estimates of the economic burden of HAI to patients

Personal expenditure on items such as drugs and dressings incurred by patients who acquire an infection in hospital are estimated to amount to £4.74 million annually. The estimates derived varied considerably depending on whether the patient presented with an HAI in hospital and/or had an infection identified post-discharge. The confidence intervals derived for each HAI group were wide and this should be taken into account when using these estimates.

Estimates of the number of extra days patients took to resume normal daily activities

Nationally, patients who acquire an infection in hospital, when compared with uninfected patients, were estimated to take an additional 8.7 million days to resume normal daily activities. The estimates varied considerably with HAI group and the 95% confidence intervals were wide. These factors should be taken into account when considering these estimates.

The benefits of prevention

This study was not directly concerned with estimating the benefits of prevention. However, the estimates presented provide important information on the value of resources that might be released for alternative use if a proportion of infections are prevented. These may be viewed as the gross benefits of prevention. Net benefits will depend on the cost and effectiveness of prevention activities.

Estimates of the gross benefits which may result from a 10% reduction in the observed incidence rate, both in terms of the benefits to the study hospital and to provider units throughout England, are presented in the report. In addition to estimates of the value of resources released for alternative use, the value of consumables released and the number of bed days released are presented.

At the level of the study hospital, a 10% reduction in the observed incidence rate was estimated to result in the release of resources valued at £361 297 (95% CI: 302 924; 419 670). Asimilar reduction at the national level was estimated to result in the release of resources valued at £93.06 million (95% CI: 78.03; 108.10 million).

In the short term, only a relatively small proportion of these benefits are likely to be in the form of cash savings. However, over a longer period of time it is possible that some of the fixed costs might be avoided and, as such, the proportion of benefits that may accrue as cash benefits may increase.

In terms of the number of bed days released for alternative use, at the level of the study hospital a similar level of reduction may result in an estimated 1413 (95% CI: 1168; 1659) bed days released for alternative use; equivalent to an estimated 191 finished consultant episodes (95% CI: 158; 224). At the national level, 364 056 (95% CI: 300 880; 427 223) bed days may be released; equivalent to an estimated 47902 finished consultant episodes (95% CI: 39589; 56214).

These estimates, although considerable, may be conservative estimates of the value of resources that might be released. They are limited to the benefits that may result from a reduction in the incidence of HAI occurring in adult patients admitted to the specialties covered in this study, and are based on a 10% reduction in the incidence rate. The literature suggests that up to 30% of HAIs may be prevented through effective infection control programmes (Haley, 1986).

Discussion

The results of this study clearly indicate that HAIs impose a substantial burden on the secondary and primary health-care sectors, on infected patients and their informal carers. A detailed analysis of the effect of HAI on resource use and costs was undertaken, the results of which provide important information on the nature, magnitude and distribution of the economic burden. The approach taken is considerably more detailed than earlier studies which have generally limited the analysis of costs to those incurred by the hospital sector and have not attempted to determine the distribution of these costs in any great detail.

Three main points should be borne in mind when interpreting these findings.

First, attributing costs to the presence of an HAI is extremely complex. The characteristics of patients with an HAI may differ systematically from those of uninfected patients. If these differences result in additional resource use, this would bias the estimates of the effects of HAIs. The in-patient regression analysis showed this was not the case for age, sex, admission type, specialty, diagnosis and co-morbidities. Nonetheless, the possibility that there may be some other confounding factors cannot be completely ruled out. For example, due to factors not included in the regression analysis, patients with an HAI may have remained in hospital longer than similar patients who did not acquire an infection, regardless of whether they acquired an infection or not. An analysis investigating this possibility revealed some evidence that the difference in length of stay between patients with and without an HAI was not due entirely to the infection. Consequently, the estimates of the effect of HAI on length of stay and the associated costs may be biased. However, estimates of the magnitude of this bias were very sensitive to the strong simplifying assumptions on which they were based and, as such, it would be unwise to conclude more than that the estimated effects of HAI on length of hospital stay presented may include an upward bias. The post-discharge regression analysis indicated that there was some confounding and that the effects in a number of cases were probably larger than those observed in the unadjusted figures.

Second, the study was restricted to patients admitted to one NHS trust over a 13-month period. Future patients admitted to this and other NHS trusts might differ in various ways. In addition, estimates of the costs of resources used were, in most cases, specific to this NHS trust, and

clinical practice affecting resource use might differ with time and with provider unit. However, it seems reasonable to assume that any differences that occur will be the same for patients with and without an HAI. On this assumption, the proportion by which an HAI increases resource use will not be affected and, consequently, the proportional effects estimated from this study will be generalisable. Absolute increases in costs incurred by infected patients may differ with time and with provider unit. However, since the study hospital was found to be broadly similar to other provider units in terms of factors such as average length of stay and average cost per bed day, it is reasonable to assume that the estimated effects of HAI on absolute costs are also fairly generalisable.

Third, when considering both the gross and net benefits of prevention, it is important to realise that any savings represent a reduction in individual treatment costs and not necessarily an overall saving to the health sector. This will depend on how released resources are utilised and this will, to some extent, depend on the structure of the contracts and agreements in place. If, for example, the prevention of infection results in a reduction in length of hospital stay, bed days will be released for alternative use. If these released bed days are utilised by more expensive patients then, rather than resulting in a cost saving for the NHS, overall expenditure will increase. However, this will be offset by benefits gained by the extra patients treated.

Conclusion

The results of this study provide a detailed account of the socio-economic burden imposed by HAIs occurring in adult patients admitted to selected specialties common to most NHS provider units. It represents the first comprehensive attempt to estimate these costs. The results provide valuable information that might be used at national and local level to inform the management of HAI and, when used alongside effectiveness studies of infection prevention and control measures, will facilitate the development of effective policies to control HAI.

Recommendations

Specific recommendations arising from this research

Commissioners of health care (purchasing agencies) should:

- Be aware of the magnitude of the overall burden imposed by HAI and how it is distributed.
- Ensure adequate details on infection control arrangements and ongoing strategies for the prevention of infection are in place in all provider units with which they contract.
- Recognise that, in a number of cases, HAIs present after discharge from hospital, and that these infections should be monitored and the needs of affected patients met.

Providers of health care should:

- Use the findings of this study, together with information on the effectiveness of different infection control activities, to inform infection prevention and control strategies within their provider unit.
- Ensure appropriate arrangements are in place to monitor infections presenting post-discharge and the needs of affected patients are met.

Educational institutions involved in the education of health care personnel should:

- Include the socio-economic burden imposed by HAI in their educational programmes on HAI and in so doing raise awareness of the issues relating to HAI and the importance of infection prevention and control strategies.

Further research and development

During the course of this study a number of areas which would benefit from further research and development were identified. These are briefly presented below.

The first area that requires some further work relates to how generalisable the results of this study are to future patients in other health-care settings. For reasons discussed above, it seems reasonable to assume that the results are generalisable, but further work will be carried out to assess in greater detail whether the pattern of resource use observed in this study is broadly similar to that found in other provider units. It is also recommended that further methodological work be undertaken to increase knowledge of how best to estimate the cost of hospital services.

Attributing costs to the presence of an HAI presented a number of methodological difficulties. In this study, regression analysis was used to control for a range of factors. However, as discussed above, factors not included may have had an impact on resource use and costs. For

example, patients with an HAI may have remained in hospital longer than uninfected patients due to factors other than those included in the regression analysis. An analysis has been undertaken to investigate this, but the results were sensitive to the strong simplifying assumptions on which the analysis was based. It is therefore recommended that further work on the complex relationship between length of stay and HAIs be undertaken to assess more precisely what part of the length of stay can be ascribed to the effect of HAI and the associated costs.

Following discharge from hospital, patients with an HAI were found to make more visits to their GPand / or doctor or nurse at the hospital than uninfected patients. Consequently, infected patients had a greater economic impact on these health-care services than uninfected patients. The analysis to date has not taken into account the resource intensity of these visits. It is possible that visits made by patients with an HAI were more resource-intensive, and thus the economic impact was greater, than that estimated in this study. It is therefore recommended that the data obtained in this study be further analysed to determine the resource intensity of visits made to GPs and hospital doctors / nurses, and how this varies between patients with and without an HAI. It is also recommended that further work be conducted to determine whether the health needs of patients experiencing HAIs in the community are being met.

Acquiring an HAI in hospital was associated with a reduction in mental and physical well-being, as measured by the SF-36. It is recommended that further work be carried out to explore the nature and reasons for the apparent reduction in mental and physical well-being observed in patients with an HAI compared with uninfected patients, and that the results of this work are used, where possible, to inform clinical practice.

As part of this study, a decision support system to model and predict the effects of HAI on components of resource use and their costs within different provider units was developed. It is recommended that this system be further developed to create a user-friendly decision support mechanism which meets the information needs of both purchasers and providers of health care.

The results of this study provide information on the nature, distribution and magnitude of the burdens imposed by HAI. These burdens represent the potential gross benefits of prevention. Further work is required to determine the cost-effectiveness of selected infection control practices. The information derived may then be used to inform infection control practice and the overall allocation of resources to infection control.

Finally, the results of this study relate to adult patients, excluding day cases, admitted to the general specialties of a district general hospital. Patients admitted to these specialties accounted for approximately 70% of adult, non-day case NHS admissions in 1994–95. It is recommended that future work examine the socio-economic burden of HAIs occurring in the other patient groups, in particular in patients at high risk of acquiring an infection in hospital (e.g. babies cared for in special care baby units) and patients undergoing major and specialised surgery (e.g. cardiothoracic surgery and organ transplantation).

References

DoH/PHLS (1995) *Hospital Infection Control. Guidance on the control of infection in hospitals.* The Hospital Infection Working Group of the Department of Health and Public Health Laboratory Service, London.

Haley, R.W. (1986) *Managing Hospital Infection Control for Cost-Effectiveness:A Strategy for Reducing Infectious Complications.* Chicago: American Hospital Publishing.