Costs of Healthcare Associated Infection

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Econometrics: an increasing priority in Healthcare

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- **The patient is (at last) the focus of Healthcare delivery**
- **Emphasis on Continuous Quality Improvement**
  - **Safety**
  - **Patient Care**
- **Need to look at cost effectiveness**

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Increasing Complexity and Cost of Treatment

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Judge opens floodgates for patients to charge NHS for surgery abroad

By Oliver Wright
Health Correspondent

Motherhood lost
Two women lost their legal

scheme — which is similar to the EHI system used by holiday makers to obtain emergen-

than the year she origin faced, but "significar though probably not subst

Increasing demands from patients for better value for money and choice of treatment

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"Oh!!! That hospital looks nice!"

The High Profile of Hospital Acquired Infection (HAI)

- Increasing pressure to address the cost-effectiveness of healthcare delivery
- Realisation that monitoring Infection Control can gauge the quality of the whole organisation

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- HAI is a significant burden and the cost effectiveness of control and prevention is important

BUT we must get the balance right

Costs of Healthcare Associated Infection

- Terminology and examples
- Socio Economic Burden of HAI
  Plowman et al, 2001
- MRSA Screening methods
  Kunori et al, 2002
- HTA MRSA Systematic Review : Costs of MRSA
  Cooper et al, 2004

Terminology

Direct Costs:

Identified to provision of patient care and equals

– fixed costs unrelated to volume (e.g. staff)

and

– variable costs related to volume (e.g. drugs)

Terminology

"Indirect costs"(opinions differ!)

- **Opportunity Costs**:
  Various definitions! Value of the next best alternative use of the resources e.g. lost bed day
- **Intangible e.g.**
  – **cost of pain on quality of life**
  – **benefits of "joint production"**
  What is the value of teaching spin-offs from healthcare delivery (or even infections!)?

Terminology

- **Cost Analysis**
  How much spending on a programme
- **Economic evaluation**
  Assesses cost analysis <u>and</u> outcomes

Economic Evaluations

Cost effectiveness

– Compares costs of interventions per case prevented, life saved

– Must assess the full costs e.g. antimicrobials
  - Antimicrobials used eg A versus B
  - Route oral/parenteral
  - Administration e.g. time/trained staff, syringes, swabs, alcohol, monitoring disposal of vials, avoidance of needle-stick injuries

Economic Evaluations

Cost Utility Analysis
Compares outcomes in terms of subjective values of individuals or society

– Quality Adjusted Life Years (QALYs): simplest

– Healthy Year Equivalents (HYEs)

– Disability Adjusted Life Years (DALY's): World Bank used

e.g. 15 years functioning at a 1/3rd of full health is 5y full health functioning

Economic Evaluations

Cost Benefit

- Very complex and least used: equivalent of the RCT!
- Net Present Value
  Value of benefits minus costs
- Cost-Benefit Ratio
  - All costs and benefits are assessed
  - Indirect costs e.g. disability
  - Intangible costs e.g. pain

Assessing Value: some issues!

Assessing Value: some approaches

- Scenario setting of all the "players" (e.g. patients & advocates, Health Care Workers, politicians...)
- What would you pay not to have a complication e.g. rheumatoid arthritis patients would pay 20% of their income not to have it
- Patients should pay $5/d to support infection control (USA ICD)

Willingness to pay?

- Valuation techniques to determine the willingness to pay:
  - Are individuals used to directly paying for health services?
  - Studies show that individuals usually significantly inflate their willingness to pay.
  - Usually related to income (i.e. ability to pay) and so resources are directed towards programmes with a greater impact on the more affluent.

Other Terminology

- **Marginal analysis**
  Decisions made on the margins between increased expenditure, production and outcomes e.g. benefit of additional intervention such as theatre ventilation
- **Incremental analysis**
  Analyses the cost per case prevented between two interventions
- **Production expenses**:
  Intermediate expenditure for a desired effect
  e.g. needlestick avoidance measures, antimicrobial impregnated devices

Cost Identifications

- What does it cost to produce an intervention or an alternative?
- Identifies cost of items and activities and puts a cost on them
  - Retrospective: cheap and limited to what can identify
  - Prospective: actual, dependent on collection intensity, expensive
  - Analytical approach : identify process steps and resources used
  - Adjust for factors affecting estimates e.g. Sensitivity analyses
  - Simulations: Stochastic/Deterministic modelling

Assessment of Additional Costs of HAIs

- **Concurrent**
  - Trained staff estimate the additional resources used (e.g. Haley, 1985)
  - Some have also estimated whether the costs were attributable to underlying condition, the HAI or to both (Wakefield, 1987)

Assessment of Additional Costs of HAIs

- **Comparative**
  - Compares the level of resource use for infected and matched non infected patients (e.g. Coello et al, 1993, Rubinstein et al, 1982)
  - Large samples are needed and inability to match well may skew the results
  - Statistical regression techniques with confidence intervals quoted (e.g. Plowman et al, 1999)
  - "Gamma factor" correction (Plowman et al, 1999) and "Instrumental Variables" (Graves et al, 2005) analyses to correct for "endogenicity" of infection

Endogenicity: Colinearity between Infection & Length of Stay (LoS)

- HAI prolongs LoS
- Prolonged LoS increases the risk of an HAIs
- Costs of LoS may be over attributed to HAI
- Graves et al (in press) took into account known factors that increased the risk of HAIs but not the LoS (the use of naso gastric tube and oxygen therapy) and used a multi-stage strategy to review costs of HAIs

The Economic Burden of Hospital Acquired Infection (HAI)

Ros Plowman, Nick Graves et al, *J Hosp Infect* 2001; **47**:198-209.

Studies Estimating the Economic Impact of HAIs

- Studies consistently demonstrate that:
  - HAIs are a substantial economic burden to the health sector
  - the magnitude varies with site of infection
- BUT provide limited data on the distribution of in-patient costs
- AND in general limit costs incurred by the hospital alone

Estimates of the cost of UTIs

First author	Country	Type of patient	No infections	Extra days	Extra cost*
Coello (1993)	UK	General surgery, orthopaedics & gynaecology	36	3.6	£498
Rubenstein (1992)	US	General surgery & orthopaedics	30	5.1	£653

*all costs have been converted into sterling using the OECD Health Data database (1996)

Estimates of the cost of SSIs

First author	County	Type of patient	No. infections	Extra days	Extra cost*
Rubertelli (1992)	US	General surgery & orthopaedics	19	12.3	$1,852
Mugford (1989)	UK	Caesarean sections	41	2.1	£1,011
Coello (1993)	UK	General surgery, orthopaedics & gynaecology	12	10.2	£1,333
Poulsen (1992)	Denmark	Surgical	291	5.7	no data

*all costs have been converted into sterling using the OECD 'Health Data' database (1998)

Estimates of the cost of chest infections

First author	County	Type of patient	No. infections	Extra days	Extra cost*
Kaegelen (1992)	Germany	Intensive care	34	10.1	£5,3333
Haley (1981)	US	All admissions	75	6	$7,4361

*all costs have been converted into sterling using the OECD 'Health Data' database (1998)

Some of the studies that estimated the burden beyond the hospital sector

- Davies & Cottingham (1979) impact of orthopaedic infections on primary health care services
- Hyryla *et al* (1994) in-patient and post-discharge hospital costs of surgical site infections (SSIs) warranted compensation in Finland
- Fabry *et al* (1982) - examined whether SSIs delayed the time of return to work

Aims and objectives of Our Study

1. Determine the overall burden of HAI in terms of:
   - Costs to 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

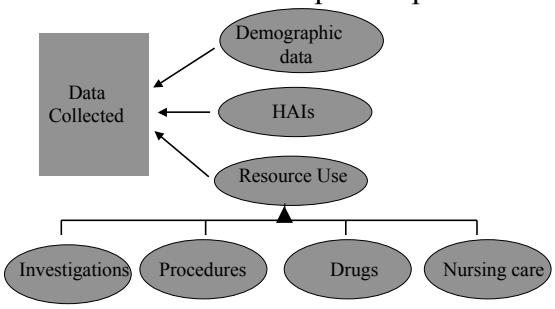
Aims and objectives of Our Study

3. Determine the type of patients who incur the highest costs for specific infections

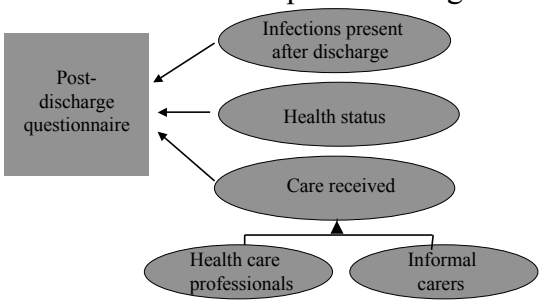
Methods

- Between April 1994 and May 1995 adult, non day case patients admitted to selected specialties of an NHS hospital were invited to participate in this study
- Cost profiles were developed for each patient whether or not they had an HAI
- Statistical techniques estimated how much of observed variation in costs incurred by infected compared to uninfected patients could be explained by the presence of an HAI

Data collection - in-patient phase



Data collection - post-discharge



Analysis

- Statistical techniques determined how much of the observed variation in costs could be attributed to the presence of an HAI
- This controlled for the effects of:
  - Age, sex and diagnosis
  - number of co-morbidities
  - admission type and specialty
  - time of return of questionnaire

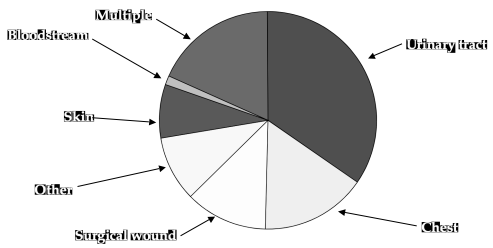
Results

- 4000 were patients
- Complete in-patient data sets for 3980 patients
- 1449 patients were selected for follow-up after discharge of which 215 (14.8%) had an HAI identified in hospital
- 71% of patients selected for follow up returned the questionnaire

Incidence of HAI

- In-patient phase:
  - 7.8% with one or more HAIs
- Post Discharge:
  - 19% (symptoms/signs): interpretation of association and diagnosis difficult!
  - 30% of in-patients with an HAI met the study criteria for one or more infections present after discharge

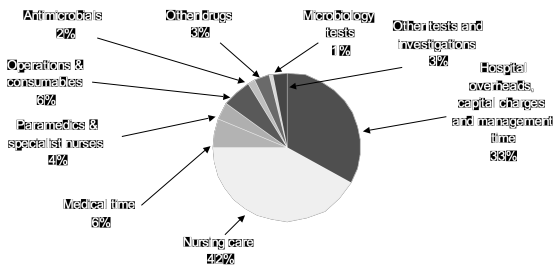
Frequency of infections by site



Cost to hospital sector

- Patients with one or more HAIs presenting during the hospital stay on average:
  - In hospital 2.5 times longer than uninfected
    - equivalent to an additional 11 days per case
  - Incurred costs 2.8 times higher than uninfected
    - equivalent to an addition £2917 per case

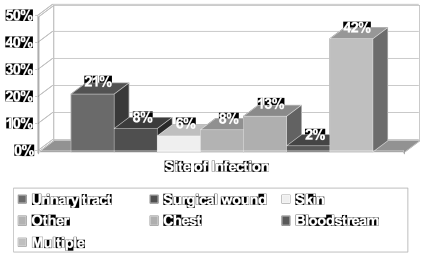
Additional in-patient costs incurred by patients with one or more HAIs



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	1593	3611		
Urinary tract	2938	107	1.8 (1.7 to 1.9)	1127 (1022)
Surgical wound	3246	38	2.0 (2.0 to 2.0)	1418 (1324)
Skin	3218	25	2.1 (2.0 to 2.3)	1720 (1518)
Other	3892	30	2.4 (2.3 to 2.6)	2363 (2465)
Chest	4077	28	2.5 (2.3 to 2.7)	2528 (2030)
Bloodstream	7076	4	4.3 (3.8 to 4.8)	5527 (6702)
Multiple	10780	37	6.6 (6.3 to 7.0)	9152 (8631)
Any infection	4732	302	2.9 (2.8 to 3.0)	3152 (2917)

Percentage of Total Costs for different HAIs



Costs incurred post-discharge

- Patients with an HAI identified in hospital and/or had an infection identified post-discharge on average had more contact with their:
  - general practitioner
  - district nurses
  - doctor/nurse at the hospital
- The level of increase varied depending on whether the patient had an HAI identified in hospital and/or an infection identified post-discharge

Costs incurred by patients and informal carers

- On average patients who had an HAI identified in hospital and/or an infection identified post-discharge:
  - incurred higher personal expenses
  - took longer to resume normal daily activities and/or return to work
  - received more care from informal carers
  - had a lower health status 4 weeks after discharge from hospital

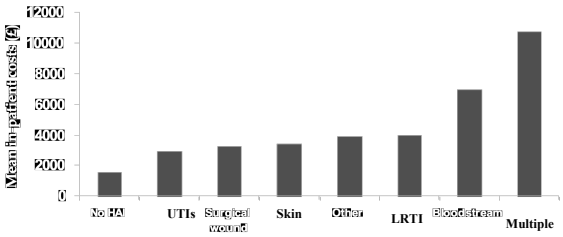
English National Estimates of Adult HAI burden

- Patients admitted to the specialties covered in this study - approx. 70% of all adult non-day case admissions
- HAIs cost the health sector in England £986.36 million annually and utilise 3.64 million bed days

English National Estimates of Adult HAI Burden

- In-patient hospital costs £930.62 million
- General practitioners £8.40 million
- Outpatient hospital costs £26.83 million
- District nursing services £20.51 million

Mean in-patient costs by site of HAI

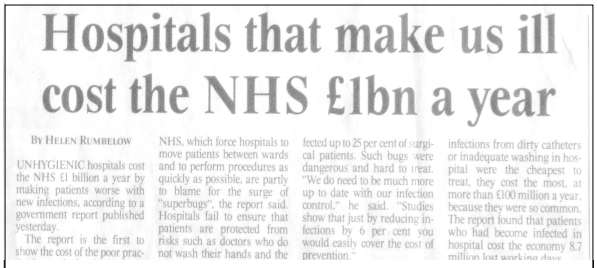


Implications for policy and practice

- Estimates demonstrate the substantial HAI burden on limited health sector resources and the gross benefits of prevention
- Estimates suggest that between 15% and 30% of HAIs could be prevented through improvements in infection control
- A 15% reduction in the in-patient incidence rate may result in the release of:
  - health sector resources valued at £150 million
  - 546,084 bed days = to ~71,853 consultant episodes

Impact on health status

- delayed recovery
- infected patients had lower health status 4 weeks post-discharge than uninfected patients
- in-patient death rate was considerably higher in patients who had an infection



Hospitals that make us ill cost the NHS £1bn a year

By Helen Rumbelow

UNHYGIENIC hospitals cost the NHS £1 billion a year by making patients worse with new infections, according to a government report published yesterday.

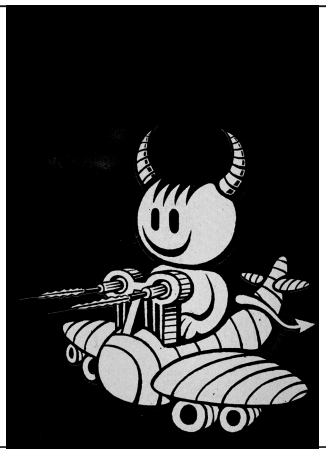
The report is the first to show the cost of the poor prac-

NHS, which force hospitals to move patients between wards and to perform procedures as quickly as possible, are partly to blame for the surge of "superbugs", the report said. Hospitals fail to ensure that patients are protected from risks such as doctors who do not wash their hands and the

fected up to 25 per cent of surgical patients. Such bugs were dangerous and hard to treat. "We do need to be much more up to date with our infection control," he said. "Studies show that just by reducing infections by 6 per cent you would easily cover the cost of prevention."

infections from dirty catheters or inadequate washing in hospital were the cheapest to treat, they cost the most, at more than £100 million a year, because they were so common. The report found that patients who had become infected in hospital cost the economy 8.7

The Study made the front page of the Times and was quoted by the House of Lords and Commons and by the National Audit Office



Benefits and costs of MRSA Control

- Benefit of interventions: reduction of direct, indirect and intangible costs of hospital MRSA infection
  - Knock on effects of reducing other HAIs?
- Cost of interventions: includes screening tests, isolation strategies, and disposables, extra staffing.....
- Little has been done to unravel these or to determine the cost effectiveness of alternative strategies

MODELLING

ALL MODELS ARE WRONG

BUT SOME ARE USEFUL!!!

(IF ONLY TO SHOW YOU HOW DIFFICULT THE REAL WORLD CAN BE)

Aims of Study

Kunori et al, J Hosp Infect 2002: 51;189-200

To determine the most cost-effective method of screening tests for MRSA using mathematical modelling based on the published data from a systematic review.

Methods

- Systematic MRSA literature review:
  - Selective staphylococcal isolation media
  - Direct *S. aureus* identification
  - Methicillin susceptibility testing
  - Sensitivity of patient sampling sites
- Effectiveness of tests
  - Sensitivity (X), Specificity (S), Time of each stage from patient to result (T)
- Royal Free Hospital materials & labour costings

Methods: Assumptions used in Modelling

- All patients entering an intensive care unit are screened: Length of Stay 7days **(Sensitivity analysis of 2d & 10d)**
- Positive MRSA patients isolated
- Infected cases reduced from 0.27 **(Sensitivity analysis of 0.13 and 0.54)** to 0.017/primary colonised patients/day
- Secondary spread only detected clinically (30% of cases), isolated and treated immediately for an average of 17 days
- Tertiary spread not considered

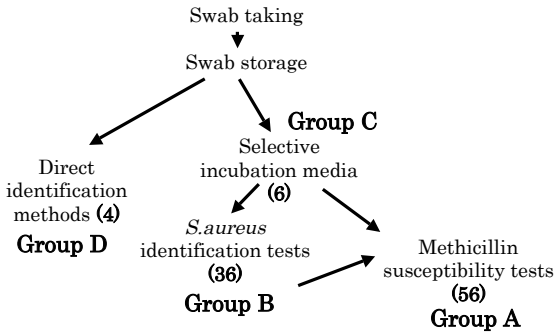
Borderline Prevalence Rates

- The Prevalence of MRSA positive patients (P) in the Number of Screened patients (N) at which the benefit of screening is equal to the cost of the tests used

Assumptions for Microbiological Methods

- Microbiological methods were classified into four groups
- Data from the systematic review or where this was not forthcoming from the Royal Free Hospital were integrated to produce Sensitivity, Specificity and Time data for the various approaches
- Cost Effectiveness Ratio data were analysed within each group and then common data from this were used for the next stage

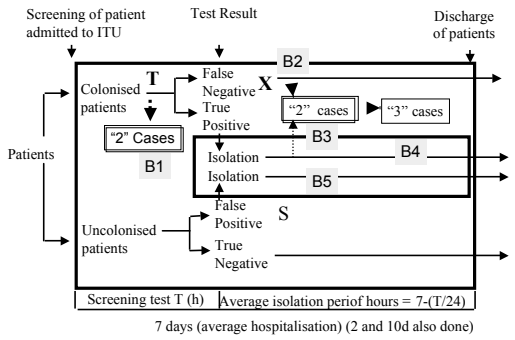
Stages of Screening Tests



The Process of comparing the Cost Effectiveness Ratio (CER) among different screening tests

- Calculation of cost avoided (the benefit)
- Calculation of cost of intervention (the test)
- Calculation of CER = Benefit/Cost

Modelling of Primary and Secondary Cases



Borderline Prevalence Data

- If the proportion of MRSA colonisation exceeds 2% the money saved on MRSA control measures more than covers the cost of screening programmes
- For Ciprofloxacin Baird Parker 88.2% of MRSA had to be Quinolone resistant (QR)
- Sensitivity analyses have been performed for LoS of 2d and 10d and infected rates 0.13 and 0.54

Advantages of the modelling

- Easy calculation and one can modify readily for local costings and other modelling scenarios (including ways of working in the laboratory)
- Cost effectiveness ratio of any combination of the screening tests can be calculated.

Some of the limitations of the modelling

- More dynamic models needed
- More sophisticated consideration of laboratory costs, including training and ease of use of PCR
- Socio-Economic Benefit ignored
- Being used in two further real life studies now

Modelling of MRSA Containment

Cooper et al, HTA Systematic MRSA Review, 2004

HTA MRSA Systematic Review (2003) Papers relating to costs of MRSA

- Disparate places at different times
- Ranged widely in the comprehensiveness of costs & methods used to calculate them.
- More useful to estimate the cost components used in the model from a common source using up-to-date costs.
- Data from the Royal Free Hampstead NHS Trust for the year 2000/01 were used.
- Cost vectors used in this study in Appendix so could be adapted by using data from other settings.

Scenario 1: no isolation

- The results indicates that costs can be expected to be very sensitive to the attributable length of stay (increasingly so for higher transmissibilities), and also to the proportion of patients who become infected (the virulence/patient vulnerability).

Scenario II: savings (£m) when isolation ward for infected cases

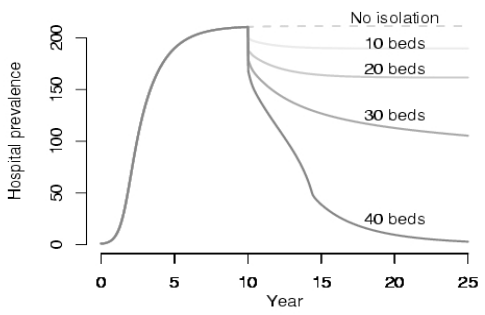
Isolation ward beds	Total 10 year costs	Cost saving (compared with no isolation)
0	24.4	-
5	14.8	9.6
10	15.8	8.6
15	19.6	4.8
20	25.8	-1.4

High transmissibility and low virulence: 11d extra stay

Scenario III: savings (£m) when isolate ward for infected and colonised cases

Isolation ward beds	Mean time to detection of colonised patients	Total 10 year costs	Cost saving (compared with no isolation)
0	(no screening)	24.4	-
5	20	6.2	18.2
5	50	6.2	18.2
5	100	6.3	18.1

High transmissibility and low virulence: 11d extra stay



Isolation ward is introduced after ten years. φ=0.04, R_0=1.3.

Conclusions of Mathematic Modelling of introductions of MRSA to a hospital

- Increasing the detection rate reduces the endemic prevalence
- Effectiveness of intervention can depend critically on timing (the earlier the better)
- Isolation policies that do not scale with the MRSA reservoir are vulnerable to failure
- The ability of the MRSA strain to persist in the patients and to transfer between them can be key factors in the long-term dynamics

Conclusions

- Isolation policies can result in cost savings over ten years
  - prevent endemic levels from becoming established.
  - reduce the endemic prevalence to lower levels.
- Valid over a wide range of transmissibilities and virulence levels
- **S**urprisingly insensitive to capital costs.
- UNLESS extended periods with large number of unused isolation beds, when reduced isolation ward staffing will be more cost-effective
- Or low infections without control measures.

Problems assessing impact of increasing Lengths of Stay

- Largest contribution to costs due to extra length of stay caused by infections
- Patients infected with MRSA often the most ill: with many factors predisposing to longer lengths of stay and to acquiring MRSA.
- Longer the patient's stay, the more likely they are to acquire MRSA.
- More research using more reliable methods of attribution needed

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- Useful introduction is in:
  Schmid G.P. Understanding the essentials of economic evaluations *J Acquired Immune Deficiency Syndromes and Human Retrovirology* 1995: 10 (Spl 4); S6-13

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