Costs of Healthcare Associated Infection

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Econometrics: an increasing priority in Healthcare

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

Increasing Complexity and Cost of Treatment

- "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
- 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)

“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 and 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

Cost Utility Analysis
Compresses 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)

**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 HAI
- 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)

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 SSIs

<table>
<thead>
<tr>
<th>Year</th>
<th>Setting</th>
<th>Stage of infection</th>
<th>Acute costs</th>
<th>Delayed costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1979</td>
<td>National</td>
<td>Secondary care</td>
<td>£8,000</td>
<td>£12,000</td>
</tr>
<tr>
<td>1982</td>
<td>Local</td>
<td>Primary care</td>
<td>£6,500</td>
<td>£10,500</td>
</tr>
</tbody>
</table>

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
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 specialities 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

- Demographic data
- HAIs
- Resource Use
  - Investigations
  - Procedures
  - Drugs
  - Nursing care

Data collection - post-discharge

- Infections present after discharge
- Health status
- Care received
  - Health care professionals
  - Informal carers

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 additional £2917 per case

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

<table>
<thead>
<tr>
<th>Site of Infection</th>
<th>Hourly Rate</th>
<th>Total Costs</th>
<th>Bed Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical Site</td>
<td>£50</td>
<td>£1000</td>
<td>£500</td>
</tr>
<tr>
<td>RenalSite</td>
<td>£30</td>
<td>£600</td>
<td>£300</td>
</tr>
<tr>
<td>ThoracicSite</td>
<td>£40</td>
<td>£800</td>
<td>£400</td>
</tr>
<tr>
<td>OtherSite</td>
<td>£20</td>
<td>£400</td>
<td>£200</td>
</tr>
<tr>
<td>Staff/ OtherSite</td>
<td>£10</td>
<td>£200</td>
<td>£100</td>
</tr>
</tbody>
</table>

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

- 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

Implications for policy and practice

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 £6bn a year

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
  – Meticillin 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

- Swab taking
- Swab storage
- Direct identification methods (4)
- Group C
  - Selective incubation media (6)
  - S. aureus identification tests (36)
- Group B
  - Methicillin susceptibility tests (56)
- Group D

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

- 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

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

<table>
<thead>
<tr>
<th>Isolation ward beds</th>
<th>Total 10 year costs</th>
<th>Cost saving (compared with no isolation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>24.4</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>14.8</td>
<td>9.6</td>
</tr>
<tr>
<td>10</td>
<td>15.8</td>
<td>8.6</td>
</tr>
<tr>
<td>15</td>
<td>19.6</td>
<td>4.8</td>
</tr>
<tr>
<td>20</td>
<td>25.8</td>
<td>-1.4</td>
</tr>
</tbody>
</table>

High transmissibility and low virulence: 11d extra stay
Scenario III: savings (£m) when isolate ward for infected and colonised cases

<table>
<thead>
<tr>
<th>Isolation ward beds</th>
<th>Mean time to detection of colonised patients</th>
<th>Total 10 year costs</th>
<th>Cost saving (compared with no isolation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>(no screening)</td>
<td>24.4</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>6.2</td>
<td>18.2</td>
</tr>
<tr>
<td>5</td>
<td>50</td>
<td>6.2</td>
<td>18.2</td>
</tr>
<tr>
<td>5</td>
<td>100</td>
<td>6.3</td>
<td>18.1</td>
</tr>
</tbody>
</table>

High transmissibility and low virulence: 11d extra stay

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
- Surprisingly 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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- Ros Plowman, Nick Graves and co authors
- Takeaki Kinori and co authors
- Ben Cooper and co authors

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
References

- Collaborative Centre for the Economics of Infectious Disease (CCEID)
  www.lshtm.ac.uk/php/hsrc/cceid
- 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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with Margaret McKenzie

July 14, July 19, August 11, August 25 – Free Teleclass Series

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