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The Economics of Hospital Acquired Infection

by

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Economic Aspects of Hospital Acquired Infection

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Index

Introduction

1. The incidence and prevalence of hospital acquired infection

   1.1 Introduction
   1.2 Trends in HAI in the USA
   1.3 Trends in HAI in the UK
   1.4 Types of HAI

2. The cost of hospital acquired infections

   2.1 Introduction
   2.2 Data from the USA
   2.3 Data from mainland Europe
   2.4 Data from the UK

3. The collection of HAI data

   3.1 Introduction
   3.2 Data collection practices: a local example

4. Reducing the costs of hospital acquired infections

   4.1 Introduction
   4.2 Methods of reducing incidence and costs
   4.3 Identifying control programmes and their apparent savings
   4.4 Targeting high cost HAI

5. Prophylactic antibiotic use in hospital acquired infection

6. The cost of infection control programmes (ICPs)

   6.1 The costs and benefits of ICPs in the USA
   6.2 The costs and benefits of ICPs in the UK

7. Is infection control in hospitals cost effective?

   7.1 Introduction
   7.2 The characteristics of a good economic appraisal
   7.3 Alternative proposals to economic evaluation
   7.4 Some results of economic appraisal
   7.5 The strengths and weaknesses of economic evaluation

Conclusions

Bibliography

Abstract

Despite the decline in rates of hospital acquired infections (HAI) since the 1950s, the level remains high and a significant proportion of them are avoidable. International studies show that between 5.9 and 13.5 patients in every hundred are affected by hospital acquired infections, most frequently of the urinary tract, of the lower respiratory tract and in surgical wounds. The evidence from the UK is similar to that from the rest of the world eg one study (Meers et al, 1981) found a UK prevalence rate of 9.2 infections per hundred patients.

These rates appear to have been largely unchanged for two decades despite evidence that perhaps as many as 1 in 3 infections could be avoided. To reduce the costs and impaired quality of life associated with these infections it is necessary to improve surveillance methods, in particular add an economic (cost) component to identify the resource consequences of increased length of stay and increased medication, and identify cost effective methods of reducing HAIs.

It is estimated that hospital acquired infections in England cost the NHS nearly £115 million in 1987. With improved policies of demonstrated cost effectiveness, such as better hygiene and the selective use of prophylactic drugs, perhaps as much as £36 million of these costs to the NHS could be avoided. This would "free up" NHS resources for other patients waiting for beneficial care and would avoid much misery and reduced quality of life for patients unfortunate enough to acquire infections in hospitals.

THE ECONOMICS OF HOSPITAL ACQUIRED INFECTION

Introduction

Whilst there have been significant reductions in the rates of infections acquired in hospital since the streptococcal and staphylococcal epidemics of the 1930s and 1940s - 1950s, the level remains high and a significant proportion are avoidable (Meers et al, 1981; Haley, Morgan & Culver, 1985: 78). Thus for surgical wound infections, which are sometimes singled out as being representative of hospital acquired infections (HAIs) in general, Faver et al, for example, remark that "there is little evidence that rates of postoperative infection have changed over the past 20 years" (1981: 210). Furthermore in discussing the concept of an 'irreducible minimum' of HAI, Ayliffe comments that "overall infection rates in groups of hospitals or countries have tended to remain constant or to show a minimal decrease over the years despite improvements in treatment and control methods (Ayliffe, 1986: 95). However, the Study on the Efficacy of Nosocomial Infection Control (SENIC) found that as many as thirty two per cent of hospital acquired infections were avoidable with the implementation of effective surveillance programmes. Overall, however, the authors of the SENIC Study concluded that only six per cent were actually being prevented owing to the absence of systematic surveillance in many US hospitals (Haley, Culver, White et al, 1985: 198).

1) THE INCIDENCE AND PREVALENCE OF HOSPITAL ACQUIRED INFECTION.

1.1 Introduction

Statistics of hospital acquired infections (HAI) are published as either prevalence or incidence rates, although often it is not always clear from the extensive literature on the subject, which data are being presented. Prevalence studies indicate the proportion of patients suffering from a nosocomial infection at any one time within a hospital. Incidence rates depend on rather more long-term and detailed data gathering to assess the numbers of patients who actually develop a nosocomial infection compared to those who do not. Incidence rates are thus expressed either as the numbers of patients with an infection per thousand patients discharged (which is then reduced to a percentage), or as the number of infections per thousand patients discharged (also reduced to a percentage). The latter figures is almost always higher than the former, as it is not uncommon for an unfortunate patient to develop more than one HAI. Thus with an incidence rate of around five per cent, the prevalence rate is ten per cent or generally around twice the incidence (Meers, Ayliffe, Emmerson et al, 1981; Ayliffe, 1986).

Freeman and McGowan (in Sacks and McGowan, 1981:660) demonstrated a wide variation between the findings of diverse US prevalence and incidence studies and discussed the problems of drawing meaningful comparisons between them. In another article, they showed that an average prolongation of stay in a prevalence series of patients with HAI was 13.3 days, but that the corresponding average incidence for the same study group was only

7.3 days. They stressed the need to distinguish clearly the results of prevalence and incidence series to avoid confusion (1984: 285-300).

There have been a number of prevalence studies in different countries during the 1960s and 1970s which tend to indicate rather similar rates of hospital acquired disease at around ten per cent of all inpatients, with some dispersion around this mean. In their discussion on the general distribution of infection, Meers et al remarked that these international prevalence surveys of infection in hospitals are more remarkable for their similarities than differences, although one notes a range of between 5.9 and 13.5 per cent documented by them (Meers et al, 1981: 17; table 1). Scandinavian studies demonstrated a prevalence ranging between eight and eleven per cent (Bernander et al, 1978; Meers, 1980; Kallings, 1981).

1.2 Trends in HAI in the United States

The Centers for Disease Control, Atlanta carried out the Study on the Efficacy of Nosocomial Infection Control (SENIC) in 1975-6 and found 5.7 nosocomial infections per 100 admissions from a sample of 338 hospitals representing the 6,449 acute sector hospitals in the USA (Haley, Culver and White et al, 1985). Using a retrospective study of a further representative sample of 338 hospitals, the authors estimated that the infection rate had probably increased by around ten per cent over the five year period from 1970. Overall, they estimated that there were 2.1 million nosocomial infections in 1975-6 in the US, representing:

"the first sample-based estimates of the magnitude of the nosocomial infection problem in acute-care hospitals nationwide" (ibid: 165).

and that the total number of infections per year occurring in all health care institutions in the USA would be around 3.6 million and could be as much as 4 million. They pointed out that such a figure:

"would exceed the number of admissions for all cancers, accidents and acute myocardial infarctions combined (ibid: 166).

The increasing trend for nosocomial infections appears to be due to a combination of circumstances such as increasingly invasive and complex operative procedures, emergent strains of antibiotic resistant organisms and hospital budgetary constraint on the implementation of rigorous infection control programmes.

1.3 HAI Data in the United Kingdom

In 1980, the authors of the National Survey of Infection in Hospitals (Meers et al, 1981) surveyed 18,186 patients in 43 hospitals to determine the overall prevalence of HAI in acute hospitals in the UK. The survey found a 9.2 per cent nosocomial prevalence of all inpatients, with infections of the urinary tract, surgical wound and lower respiratory tract respectively being the most frequent.

1.4 Types of HAI

Overall incidence rates for hospital acquired infections conceal as an average percentage, a marked variation in terms of the different categories of infection which can have important implications for the cost-effectiveness of infection prevention strategies. The most common category of nosocomial infection are those of the urinary tract, accounting for between 42 - 45 per cent of total HAIs, followed by surgical wound infections representing another 24 - 29 per cent, respiratory tract infections accounting for a further 10 - 19 per cent and bactermias 2 - 5 per cent (Haley et al, 1985; Haley, 1986).

The UK survey of infection broadly supports these findings, as do other studies (eg Brachman et al, 1980 : 18; Bernander et al, 1978 : 66-70). Depending upon the particular speciality or interest of the individual author, the nosocomial incidence rate of a particular hospital or survey may represent just one of these groups and this is particularly common with post-operative wound infections (eg Cruse and Foord, 1973; Green & Wenzel, 1977; Cruse, 1981 & 1986; Hunt, 1981; Krukowski, Stewart et al, 1984; Bucknall, 1985; Mayhall, 1987). The Atlanta Centers for Disease Control estimated over 300,000 surgical wound infections annually in the USA (CDC, 1976), and in the report of their National Nosocomial Infections study for the 1980-1984, the rate was 6.1 per 1000 patient discharges.

2. THE COST OF HOSPITAL ACQUIRED INFECTIONS

2.1 Introduction

There have been many studies in recent years which have attempted to quantify the cost of nosocomial or hospital acquired infections (HAI). Many of these, however, concern specific infections or prevention measures, rather than addressing the overall costs to a particular health care system as a whole.

2.2 Data from the United States

Researchers in the USA have generated most of the studies on HAI, some of which are either "spin-off" or pilot studies associated with the SENIC project. National statistics published by the Atlanta Centers for Disease Control (CDC) have also been used to calculate overall costs and results of findings from the main studies are detailed in Table 1. Using CDC data, Haley estimated that nosocomial infections, occurring in around 1.7 million patients (of an overall figure of 34 million patient admissions a year in 1973-4), cost more than $1 billion, (1973/4 prices) in excess hospitalisation alone, discounting suffering, death and lost of work (in Daschner, 1977: 93). Using SENIC project data, Larson and Oram et al quote a figure of 60,000 deaths caused or contributed to by nosocomial infections, costing around $4 billion of health care costs annually in the USA (1988:677).

Haley (1986) has discussed the different aspects of the costs of HAI, which include additional length of hospital

Table 1

STUDY/COUNTRY	NO. IN SAMPLE WITH HAI	% INCIDENCE	AVERAGE ADDITIONAL DAYS STAY	COSTS (1988 £s)
SENIC USA 1973-4 (HALEY, 1977)	1,700,000 NATIONWIDE	5%	4	£701 av. per case £3,845,884,000 TOTAL P.A.
SENIC USA 1980 (BRACHMAN, 1981)	1,700,000 NATIONWIDE	5%	7	£176 av. per day £2.10 billion TOTAL P.A.
USA 1975 (BRACHMAN, et al)	8329 IN 3 hospitals	5.4%	7.4 (0-68)	£951 AVERAGE £0 - £8959

Refs: The exchange rates used were taken from:

OECD : Measuring health care 1960 - 1983: purchasing power parities for GDP Table H7 (1985).

Department of Employment : Retail prices - general index. Employment Gazette, May 1988.

stay, increased hospitalisation costs and attributable patient mortality. He pointed out that in the USA, the average additional length of stay (LOS) is put between 4 and 10 days, but stressed that "of more significance from the human and financial viewpoint is the maximum prolongation of stay ....". The variation in added length of stay depends upon several factors and especially upon the category of the infection itself, with serious surgical wound infections adding up to 68 extra days (Haley, 1986: 5). He noted that until recently with the introduction of the DRGs and the prospective payment system, aside from the professional and quality of life concerns, the US medical system had little incentive to prevent nosocomial complications. Haley is one of the few authors who highlight the impact of such infections upon the patient's quality of life, for usually the costs of HAI are discussed in terms of the hospitalisation costs alone. If the resource costs address the additional burden of mortality, then nosocomial infection is eleventh in the leading causes of death in the USA and as high as fourth if contributing importantly to death as well as consulting the main cause (Haley, 1986 ibid: 8). It is harder to quantify the overall burden of morbidity due to HAI.

In a controlled study to evaluate six common operative procedures for comparable increases in hospitalisation and costs, Green and Wenzel found a doubling in length of stay and a significant increase in hospital expenses (1977: 264-268). Spengler and Greenough studied hospital costs and mortality attributable to nosocomial bacteremias and found up to 14 times greater mortality and an additional $3,600 in direct hospital costs (1987: 2455-58). Cruse examined the incidence and cost of surgical wound infections using the results of two different studies and concluded a 10.1 day extra stay at $400 per day, totalling $4000 for hospitalisation costs alone (1977 prices, in Bennet and Brachman: 424). Stone, Haney and Kolb et al, in their study on the relative costs and benefits of prophylatic antibiotic therapy, found an average additional expenditure of $2,686 (1977 prices) for each post operative infection (1979: 691-699).

Haley and Schaberg et al (1980) pointed out the importance of inappropriate methodology in estimating the extra charges and polongation of hospitalisation due to nosocomial infection, demonstrating that with physicians' assessment, the additional length of stay was estimated as 4.8 days, whilst matched analysis produced an estimate of 13.4 additional days and direct comparison of infected patients with uninfected controls gave 16.7 days (Haley, Schaberg, Von Allman & McGowan, 1980: 248-57). McGowan, discussing these findings, felt that matched analysis tended to overestimate and physician's assessments to underestimate the costs of HAI. In another study, however, they were able to show that differences in the size of a hospital had little effect when determining the extra length of stay and costs attributable to nosocomial infection, which were put at between 3.1 and 4.5 days at a cost of $590-$641 in 1976 (Haley, Schaberg, Crossley et al; 51-57).

2.3 Data from Mainland Europe

There have been few attempts to quantify the problem and cost of nosocomial infections within European countries as a whole. In 1977, an international workshop was held at Baiersbronn in Germany to discuss methods of infection control (Daschner, 1978), and reference was made to the need to cost HAI, with the caution that "it must be clear that monetary costs are not really meant to represent the total cost of a disease or condition in the sense of all the adverse effects that the disease (HAI in this case) may have such as pain, psychic trauma, reactions in the family, etc" (Wahba, A H W, 1978: 96-99). For Sweden, Nystrom attempted a crude estimate for the cost of hepatitis for the general population and for hospital staff (ibid 1978:100). Otherwise, little useful on costs appears to have emerged from the conference.

In 1980, the European Working Party on the recording of hospital infections, with representatives from eight countries met to collect data on the recording of HAI, discuss related policies and collective experiences and to recommend some standardisation of terminology and objectives. No attempt was made to address the economic aspects of the problem here either.

In one French study, Girard, Fabry et al detail the costs of nosocomial infection in a French neonatal unit, citing a twenty three per cent prolongation of stay with an increase of thirty two per cent in total hospital costs, at an overall cost of $1250 (US, 1978 prices) to the French social security system for each case.

The situation is clearer in Germany, however, where Daschner has published a number of articles on the costs of HAI estimating it to be between DM 500m and DM 1 billion annually (1984 prices) for Germany as a whole (1984: 27). He usefully compares the German data with that of the US Senic project, pointing out that with length of hospital stay in Germany around 2.5 times longer than in the USA, the risk of acquiring an infection is greater (and therefore there is the potential for a greater cost burden too).

2.4 Data from the United Kingdom

The most recent Departmental advice on hospital infection control in the UK was published by the joint DHSS/PHLS Hospital Infection Control Working Group in June, 1988 (DHSS, 1988). Using the generally endorsed average of 4 extra days of hospitalisation with a five per cent infection rate for acute hospitals, the authors calculated a total cost of £111m to the NHS in 1986, with 950,000 lost bed days.

Other than this estimate, the few studies on costs of HAI concern specific infections at particular hospitals where small studies have been conducted. Davies and Cottingham analysed the costs to the NHS of bacterial infections in a cohort of 345 orthopaedic patients with a 8.4 per cent infection incidence. The added length of stay amounted to 17 days, which also accounted for around ninety seven per cent of the additional costs estimated at £775 per patient (at 1978 prices) (1979: 329-338).

Added length of stay itself carries additional 'hidden' resource costs in terms of those patients waiting for treatment who are denied it while bed space is taken by the patient with a nosocomial infection. Leigh made one of the rare attempts to quantify this aspect when he calculated that in addition to the £1,000 of extra hospitalisation costs accruing for an outbreak of staphylococcal wound infection, "at least five and possibly up to ten patients were denied hospital treatment (Leigh, 1981: 215).

3. THE COLLECTION OF HAI DATA

3.1 Introduction

There is no centralised system of data collection on HAI for the UK NHS as a whole, and at the regional and district level there is no general policy for the routine gathering of data. The figure of a five per cent incidence rate for HAI is postulated on the basis of very few national and various, usually small-scale, international prevalence and incidence studies, mainly originating from the US. The main UK study providing base-line data is still the 1980 National Survey of Infection in Hospitals (Meers et al 1981). Howard's recent summary of infection control in English hospitals revealed a still rather inconsistent spread of infection control teams, with marked variations in their composition and, for example, in the numbers of infection control nurses employed on a district by district basis (1988: 183-191).

3.2 Data Collection at the local level: the practices in York

At the York district hospital, the Chief Consultant Microbiologist and the Chief MLSO (Infection Control), with one part-time member of the microbiology department form the ICT; there is, unusually, no ICN here. A similar arrangement has been in place since 1964 and there have at times been up to three full-time staff employed in infection control at the hospital. They have operated their current surveillance programme based upon the Atlanta-Georgia system of infection surveillance (US, Department of Health, 1972) since 1976. The Chief MSLO (Infection Control) and his assistant conduct daily rounds of all wards in the hospital, listing each new incidence of infection and maintaining up-to-date cross-references to the microbiology department for appropriate laboratory reports. In this way, weekly, monthly and yearly incidence rates are documented and reference to a large wall chart displaying the incidence and type of infection data means that any emergent epidemic is readily apparent. It is regarded as their 'early warning system'. The nosocomial statistics for the hospital are complete back to 1976, but are not part of the routinely gathered Hospital Inpatient Enquiry (HIPE) data and are available for study only by special agreement, as the system is used purely for self-information and guidance. The statistics, indicate a fluctuating incidence of infection from 3.1 per cent to 4.7 per cent, giving an average of 3.9 per cent, which favourably compares with both the national and international rates.

Data on the prolongation of stay and the cost of nosocomial infection are difficult to quantify as they are 'buried' amongst the large quantity of HIPE data produced by the medical records department. Management advise detailed study of the records to subtract individual length of stay terms from the average expected per procedure to arrive at an estimate of additional bed days (and the problems with this method of estimation have already been discussed with reference to Haley and Schaberg et al (1980, ibid) but because nosocomial infection is not recorded on the patients' records as a matter of course (occasional encoded references to it are sometimes found), any final calculations may well still be inaccurate. It would apparently require a policy change for the necessary information to be routinely encoded for processing by the medical records department.

In order for there to be an accurate assessment of the HAI, it is necessary to collect data routinely at the ward level, incorporated into HIPE, now Korner records which can then be used firstly to measure and compare district and regional incidence rates of HAI and subsequently to enable a costing of it. A useful first step would be to conduct prospective studies in several different hospitals to evaluate the relative efficacy of different infection control procedures or programmes.

4. REDUCING THE COST OF HOSPITAL ACQUIRED INFECTION

4.1 Introduction

In order to reduce the cost burden of HAI to a health care system it is necessary first to quantify its incidence and prevalence and then its costs. The relevant question is then how much does it cost to introduce control policies which reduce HAIs? No evaluation of the costs of infection control programmes appear to have been attempted, so calculations on the cost-effectiveness of overall infection control programmes or different infection control strategies within them is not possible.

Wahba (1978: 96-99) discussed the direct and indirect disease costs, and the cost calculation included estimates of capital costs, the salaries of manpower and materials, including all drugs, laboratory tests and 'hotel' costs. Information on all of these aspects of the care process is difficult to obtain. The 'hotel' costs are particularly hard to quantify but are important, because it is additional length of stay (the 'hotel' cost aspect in particular) which accounts for over ninety per cent of the total extra costs (eg Davies and Cottingham, 1979: 329-338; Girard, Fabry et al, 1985: 365).

Ideally an economic evaluation would quantify not just this incomplete set of costs but the benefits of HAI prevention as well, in terms of, for instance, improved quality of life and earlier resumption of earnings. The cost effective policy is that least cost intervention which produces the greatest reduction in the cost burden of HAI. An effective approach may thus be to use only proven and cost effective disease prevention strategies and to target limited resources into the most costly and/or dangerous of avoidable nosocomial infections.

The question of how much HAI is avoidable and the achievable costs savings is uncertain. Given the enhanced complexity of invasive procedures which have enabled the treatment of patients who would certainly have died in the recent past, together with factors such as age and sex affecting an individual patient's susceptablilites (the risk of HAI increases substantially into old age, in the very young, and slightly with male sex), a proportion of nosocomial infection is probably unavoidable. Ayliffe confronts this when he discusses the concept of the "irreducible minimum" of HAI (Ayliffe, 1986: 92-95).

4.2 Methods of reducing HAI incidence and costs

The SENIC project concluded that up to a third of nosocomial infections could be avoided by implementing effective surveillance and infection control strategies, and using this study as a basis, estimates have been produced by several investigators seeking to demonstrate the potential cost savings.

At the International Workshop at Baiersbronn, Germany, 1977 participants discussed 'proven and unproven methods in hospital infection control' and gave as examples of proven methods:

- Sterilisation
- Handwashing/disinfection
- Disinfection of respiratory inhalation therapy equipment
- Isolation procedures
- Closed urinary drainage systems
- Careful nursing techniques (urinary catheter, tracheostoma, intravenous catheters etc)
- Non-touch dressing techniques
- Perioperative antibiotic prophylaxis in certain clean contaminated and contaminated operative procedures

Unproven methods are listed as:

- Disinfection of floors, walls and sinks
- UV lights
- Laminar air flow systems
- Disinfection mats
- Plastic shoe covers
- Antibiotic prophylaxis in clean operative procedures

Mayhall in Wenzel (1987) summarised and discussed many of the standard antispectic and aseptic methods used for surgery, concluding:

"there are many recommendations in the literature for measures to prevent postoperative wound infections ... (but) ... there are only seven types of intervention that are supported by epidemiologic studies of postoperative wound infection rates ... a) minimising the duration of preoperative hospitalisation; b) weight reduction for obese patients; c) eradication of remote infections; d) hair removal by depilatory agent, clipping with an electric razor, or shaving with a razor just prior to operation; e) minimising the duration of surgery; f) appropriate use of prophylactic antibiotics; and g) institution of a prospective postoperative wound surveillance program with feedback of postoperative wound infection rates to the surgeons. All other recommendations are based on incomplete data, laboratory studies, theory or tradition."

(C G Mayhall in Wenzell, 1987: 354-359)

Findings from the US SENIC study clearly show that the site-specific infection rate increased by nine per cent to thirty one percent in hospitals where ineffective infection control programmes were practised and that the overall infection rate at a sample of these institutions increased by around eighteen per cent over the five year study period. From this they concluded that there was an increasing trend in HAI in the absence of effective surveillance and control programmes. Hospitals where very effective infection control programmes were implemented had a corresponding decrease in the site-specific infection rate by seven per cent to forty eight per cent and among hospitals with the most effective all-round infection control programmes (ICPs), the overall infection rate decreased by around thirty six per cent. With moderately effective Infection Control Programmes (ICPs), infection rates remained stable over the five years (Hayley, Culver and White et al, 1985: 197-8).

Haley et al "were unable to determine precisely which methods and schedules should be used in performing surveillance", but recommended the reporting back of surgical wound infections to surgeons, supervision of the control programme by the physician or microbiologist and an infection control nurse (ICN) per 250 beds (1985, : 200-1). They note that "the exact constellation of measures that seems to be the most effective varies somewhat for the different sites of infection", with prevention of infection at all sites requiring the most intensive programme. The lack of such an effective programme of surveillance in many US hospitals is held to be responsible for the fact that, of a figure of thirty two per cent of nosocomial infections preventable through the application of an effective surveillance programme, only six per cent were being prevented in 1975-6 (ibid: 1985). Later, in a random sample of US hospitals in 1983, Haley, Morgan and Culver et al find that despite increase surveillance and control activities, only nine per cent of infections were being prevented and they blame the probable failure to implement "certain specific critical components", such as adequate staffing ratio or surgeon-specific wound rates (the reporting back to individual surgeons what their post-operation infection rate is) (Haley and Garner in Bennet and Brachman, 1986: 39-49).

In his article on the irreducible minimum of HAI, Ayliffe concludes that although "it seems unlikely that nosocomial infection can be eliminated with the finances available now, or likely to be available in the future ... reductions in infection still could be made in most hospitals using knowledge available" (Ayliffe, 1986 ibid: 95).

What is needed in the UK is a study (or studies) similar to that of the US SENIC project to show not only the overall incidence of HAI countrywide, but to match incidence rates to particular hospitals/health authorities to see where and what effective ICPs are deployed (and where, when higher than average levels occur, whether this is owing to the need for implementing more effective programmes/strategies). For example, the York District Hospital has an overall average infection rate of 3.9 per cent which is below the national average of five per cent and this may well be due to the implementation of a particularly effective infection control programme, although without the benefit of evaluative studies, there is no way of knowing whether this is the actual case, or whether the lower infection incidence is due to other underlying causes.

4.3 Identifying cost-effective control programmes and their apparent savings

Considerable uncertainty remains about whether available methods of infection control are effective or whether they are used simply as a matter of tradition or routine. It is clear that significant cost reductions could be made by dispensing with unproven or non cost-effective methods but this aspect of the evaluation of HAI control programmes is rarely confronted. When it is, the approach tends to be illustrative rather than definitive. Thus Daschner has confronted the issue and shown, in a series of articles, what savings have been achieved by the discontinuation of such unnecessary/unproven infection control procedures or by use of cheaper methods. For the Department of Hospital Epidemiology, University Hospital, Freiburg, Germany, he has showed a total cost saving of 2,276,290 DM over the five years between 1977 and 1982 by application of the following measures:

- No installation of UV lights in operating theatres
- No routine environmental cultures
- No disinfection mats
- Less plastic shoe covers
- Resterilisation of angiography catheters
- Resterilisation of endotracheal tubes
- No in-line filters
- Ponchos instead of gowns

He also discussed the question of use of prophylactic antibiotic therapy, arguing that twenty five per cent of total antibiotics costs can be saved by:

- Only senior doctors/heads of departments prescribing new/expensive drugs
- Review of all 'green' (ie unquestioned) prescriptions
- Reduction of all unnecessary prophylaxis
- One shot prophlaxis
- Replacement of local antibiotics by antiseptics
- One-dose therapy of uncomplicated urinary tract infections
- Yearly analysis of antibiotic usage
- Information about prices of specific antibiotic regimens

(Daschner, 1984: 34 ibid)

This approach demonstrates that significant cost savings can be achieved at unknown cost in one hospital by challenging previously unquestioned practices and entrenched tradition in the use of certain infection control procedures and equipment. Infection control programmes are often implemented by non cost-conscious medical personnel, who may be unaware of, or unconcerned about the costs of the methods or equipment they are using and to change these behaviours it is necessary to have good HAI incidence data, good monitoring of these data and information about the cost-effectiveness of competing and expensive HAI control methods.

4.4 Targeting High Cost HAI

One of the main problems with estimating the costs of HAI and calculating averages is that the distribution of infection and associated costs is concealed. Pinner et al (1982) argued for the need to concentrate limited infection control resources into the more costly of the nosocomial infections, pointing out that the average charge of $693 due to HAI were concentrated in a very few of the 183 patients in their study, with the Medical and Surgical services accounting for eighty six per cent of the attributable charges. Although surgical wound and respiratory tract infections accounted for forty six per cent of the infections, they represented seventy seven per cent of the total cost. The CDC, National Nosocomial Infections Survey of post-operative wounds showed a cost distribution from $400 to $2600 per case, whilst Haley, Schaberg et al (1981), in their study of three different hospitals, demonstrated a cost range of $0 - $12,885 for patients with a nosocomial infection from hospital A, and a comparable range for hospital B.

Similarly, Scheckler noted that the relatively high proportion of "low-cost, low stay" nosocomial urinary tract infections can skew a study on costs and prolongation of stay (Scheckler, 1980: 150-152). Haley, demonstrated the point effectively by use of pie charts which showed that whilst urinary tract infections represented around forty five per cent of site of infection frequency, they accounted for only eleven per cent of extra stay and thirteen per cent of the actual extra charges. Surgical wounds which accounted for twenty nine per cent of infection incidence generated fifty seven per cent of the extra bed-days and forty two per cent of the extra cost, followed by respiratory infection accounting for twenty four per cent and thirty nine per cent respectively. With these data, Haley argued that 'surveillance by objective', with limited resources allocated to the most costly infections would be more cost-beneficial (Haley, 1986 ibid: 50-52). A further, slightly different angle was suggested by the authors of the SENIC project (who include Haley) who noted from their study that "One appealing approach to reducing the expense of surveillance while maintaining its continuous hospital-wide scope is to limit surveillance efforts to groups of patients who can be predicted to be at high risk of developing infection" (Haley, Culver and White et al, 1985 ibid: 200-1).

5. PROPHYLACTIC ANTIBIOTIC USE IN HOSPITAL ACQUIRED INFECTIONS

One component of infection control practice is the prophylactic use of antibiotics during surgery and it can also usefully demonstrate the potential for cost-containment or reduction, when abuses in usage are curtailed (see Daschner 1984).

It seems that the appropriate use of antibiotics in surgical prophylaxis is beneficial in the prevention of surgical wound sepsis and that in procedures carrying high risk of contamination such as colorectal surgery, antibiotic prophylaxis is unequivocal. Feathers, Lewis and Sagor et al (1977) demonstrated the prophylactic value of gentamicin and limicomycin/metronidazole in 52 patients undergoing colorectal surgery, with a wound infection rate of four per cent in the intervention group, compared with forty eight per cent and one death in the placebo control group. Hill, Flamant et al (1981) similarly demonstrated the efficacy of antibiotic prophylaxis on 2137 patients undergoing hip replacement, with 0.9 per cent infection incidence in the treatment group as opposed to 3.3 per cent in the placebo control. However, they used the regimen over five days which may be unnecessarily prolonged.

There has been much debate, however, about the way antibiotics are often overused in surgical prophylaxis, with authors such as Hirschmann and Inui (1980), Nichols (1981), and Noone (1988) discussing the hazards of such misusage. All note the importance of limiting use of antibiotic prophylaxis to certain specific high-risk surgical procedures, or in low-risk cases where any infection would be disastrous. Nichols noted that in the past, errors occurred in the widespread use of prophylaxis in clean surgery, together with bad timing or administration of the drugs, whereas now the common error lies in the continuation of prophylaxis beyond the time necessary for maximum benefit (ibid: 686). Shapiro et al commented that "despite indications that prophylaxis, when useful at all, is effective only when given concurrently with and for 24-48 hours after operation, it was usually continued throughout hospitalisation". They remark that limiting prophylaxis to these time periods "would substantially reduce expenditures for antimicrobial drugs in hospital".

There are several recent studies which indicate that short-term pathogen specific antibiotic prophylaxis given preoperatively is as effective as multi-dose/continued use of these drugs. One such study on the relative merits of short versus long-term antibiotic prophylaxis in total hip replacement demonstrated that three doses of cephaloridine proved to be as effective as a two week course of flucloxacillin in reducing the incidence of infection to a level comparable with that obtained in ultra-clean-air operating theatres (Pollard, Hughes & Scott et al, 1979: 707-709).

The recent publication of the interim results of the trial of a single dose cefotaxime and metronidazole regimen against three doses of cefuroxime and metronidazole in the prophylaxis of colorectal surgery (Rowe-Jones & Cole, 1988), confirms the findings of other studies, that multiple doses of antibiotic drugs for surgical prophylaxis are not significantly more effective than a single dose, timed to give maximum protection at the time of bacterial challenge.

Given the cost implications for over-use of expensive drug regimens, it is useful to calculate the potential savings using the single dose Cefotaxime and Metronidaxole against the three dose regimen of Cefuroxime and Metronidazole in colorectal surgery for the NHS as a whole, using the most recent HIPE statistics available (for 1985).

- Single dose Cefotaxime and Metronidazole £4.95
- Three doses Cefuroxime and Metronidazole £10.57

HIPE, 1985 (1 in 10 sample)

PROCEDURE	NO	£s SAVED
COLECTOMY	1420	£7980
OTHER COLON	967	£5434
EXIS RECTUM	841	£4726
OTHER RECT	724	£4068

TOTAL £22,210

GRAND TOTAL (x10) £222,102

Total possible savings (including sigmoidoscopy (3009), haemorrhoids (1207) and 'other anal' procedures (3133)) £775,116

6. COST OF INFECTION CONTROL PROGRAMMES (ICPs)

6.1 The costs and benefits of ICPs in the USA

There are few data on the cost burden of HAI to patients, health care systems or third party payers. Even less is known about the costs and relative cost-effectiveness of infection control programmes and their various component measures or equipment.

McGowan (1981) discussed the need for improved methods of measuring cost and benefit and specifically addressed the problem of comparing the results of different studies which use different patient groups, different methods of data collection and different formats for reporting results. It is difficult to estimate the increase in hospital length of stay, and this is the greatest proportion of the costs of HAI. McGowan felt that "no study method has yet been devised that approximates the absolute value of the economic consequence of nosocomial infection, either overall or for specific subsets".

The US SENIC project is the most detailed study available on nosocomial infections and related issues. It has generated several analyses of the avoidable financial costs of nosocomial disease and some useful but limited cost-effectiveness analyses. (Haley (in Daschner, 1978 ibid: 93-95), Dixon (in Wenzel, 1987: 19-25), and Pinner et al (1982: 143-149) all use the SENIC data to present various cost permutations of HAI and cost-effectiveness calculations for disease prevention strategies.) For an 'average' US hospital, based on 1984 figures, Dixon calculated $800,000 per year in excess hospital charges incurred by nosocomial infection, which could be reduced by $246,706 with an effective infection control programme (ibid: 23-24). The authors of the SENIC study have calculated that a reduction of only 6.3 per cent in excess hospitalisation would result in cost-benefit balance (Haley, Culver & White, et al, ibid: 1985), with Haley demonstrating that a reduction of twenty per cent in HAI would yield a net saving of $155,266,000 and a fifty per cent reduction in HAI would give $495,926,000 (ibid: 95).

Haley is one of the few authors who has costed an infection control programme (ICP) and set the result against the overall costs of nosocomial infections. He advocates an average ICP of one infection control nurse (ICN), one part-time hospital epidemiologist appropriate clerical assistance and miscellaneous expenses per 250 hospital beds, a ratio unlikely to be achieved with the more limited resources of the NHS (and also in other countries, such as Sweden: Nystrom, 1978). The overall cost of the ICP was put at $20,000, giving a total of $71,840,000 (at 1977 prices) for all community hospitals nationwide.

6.2 The costs and benefits of ICPs in the UK

Using a combination of DHSS health and personal social services statistics for England (1987) and the health services costing returns (1987), a similar exercise for England, albeit on a rather crude level, can be conducted.

In 1985-6, for England as a whole, there were 6,353,813 discharges and deaths from all hospital sectors (DHSS, 1987). Using the average infection incidence rate of five per cent, this would give 317,690, cases of HAI for all services. Based upon the generally accepted average of 4 bed days of extra hospitalisation (DHSS/PHLS), 1988) at an average cost of £90 per in-patient day (average of acute sector 50-500 bed hospitals, DHSS, 1987), this gives a total of £114,368,610. This figure probably disguises much variation at regional level, but to date, no study has been carried out to assess the rate of nosocomial infection on a comparative health authority basis.

The following cost savings for the NHS in England by reduction of the incidence rate of HAI are thus:

4% incidence (20% reduction) £22,873,722

3.4% incidence (32% reduction) £36,588,355

2.5% incidence (50% reduction) £57,184,305

These figures, however, do not take into account the offsetting cost of the infection control programme, because there are no overall estimations as to the cost of the 'average' ICP. Therefore, using the SENIC project calculations of a reduction of 6.3 per cent in excess hospitalisation due to nosocomial infection giving a cost-benefit balance and by subtracting 6.3 per cent of £114,368,610 = £7,205,222,4 from the figures quoted above, the real (estimated) savings would be:

20% HAI reduction ... £15,668,500

32% HAI reduction ... £29,388,133

50% HAI reduction ... £49,979,083

7. Is infection control in hospitals cost effective?

7.1 Introduction

The existing studies of the costs and benefits (cost savings) of infection control policies in hospitals are imprecise and incomplete. They give a general indication of the characteristics of the problem but do not identify clearly the costs and benefits of competing control policies. In the first part of this section, a checklist is outlined by which evaluations can be judged. Examples are given to illustrate the need for good economic evaluations. There are a number of different types of economic evaluation and these are briefly described in the second part of the section and the results of some economic appraisals are then examined. Finally both the benefits and limitations of economic evaluations are discussed.

7.2 The characteristics of good economic appraisals

The purpose of economic evaluation of alternative policies is to identify which option gives the greatest benefit at the least cost. The objective of this approach is to identify, measure and quantify the characteristics of alternative policies. In economic evaluations it is necessary to examine the inputs, processes, and outcomes and their relationships with one another. For evaluating infection control activities, this involves estimating the resources consumed in infection control, the infection control activities and the outcomes in terms of improvements in health. This process is illustrated in more detail in Figure 1, and the terms defined in this figure are used throughout this section.

A number of authors have outlined problems that can occur with inadequate evaluations. The check list of questions which are described in turn below are similar to those provided in standard references on the subject (eg Drummond, Stoddart and Torrance, 1987).

(a) What is the objective of the appraisal?

It is essential to identify what alternative policies are to be evaluated. A question such as "are infection control policies in the hospital worthwhile?" is not useful because it does not specify the alternative interventions or indicate who gains from the policy. A more useful specification of this question might be: "From the point of view of (i) the individual, (ii) the NHS and (iii) society, is infection control policy intervention 'A' preferable to existing policies (eg doing nothing)?" This approach would require the quantification of the costs to (i), (ii) and (iii) for each option and the identification of their effects in some health, economic or value measure, (see Figure 1).

(b) Are the competing policies described fully?

For the results of the evaluation to be useful, a full description is essential. Without such details it may be impossible to identify the nature of the intervention and thus a judgement about its relevance in other settings may be difficult and replication may be impossible. Also a full description of the options enables the use of the study's results to determine whether all relevant costs (C1, C2, C3 in Figure 1) are included.

Any description should:

i) indicate who does what to whom?

ii) where and how often

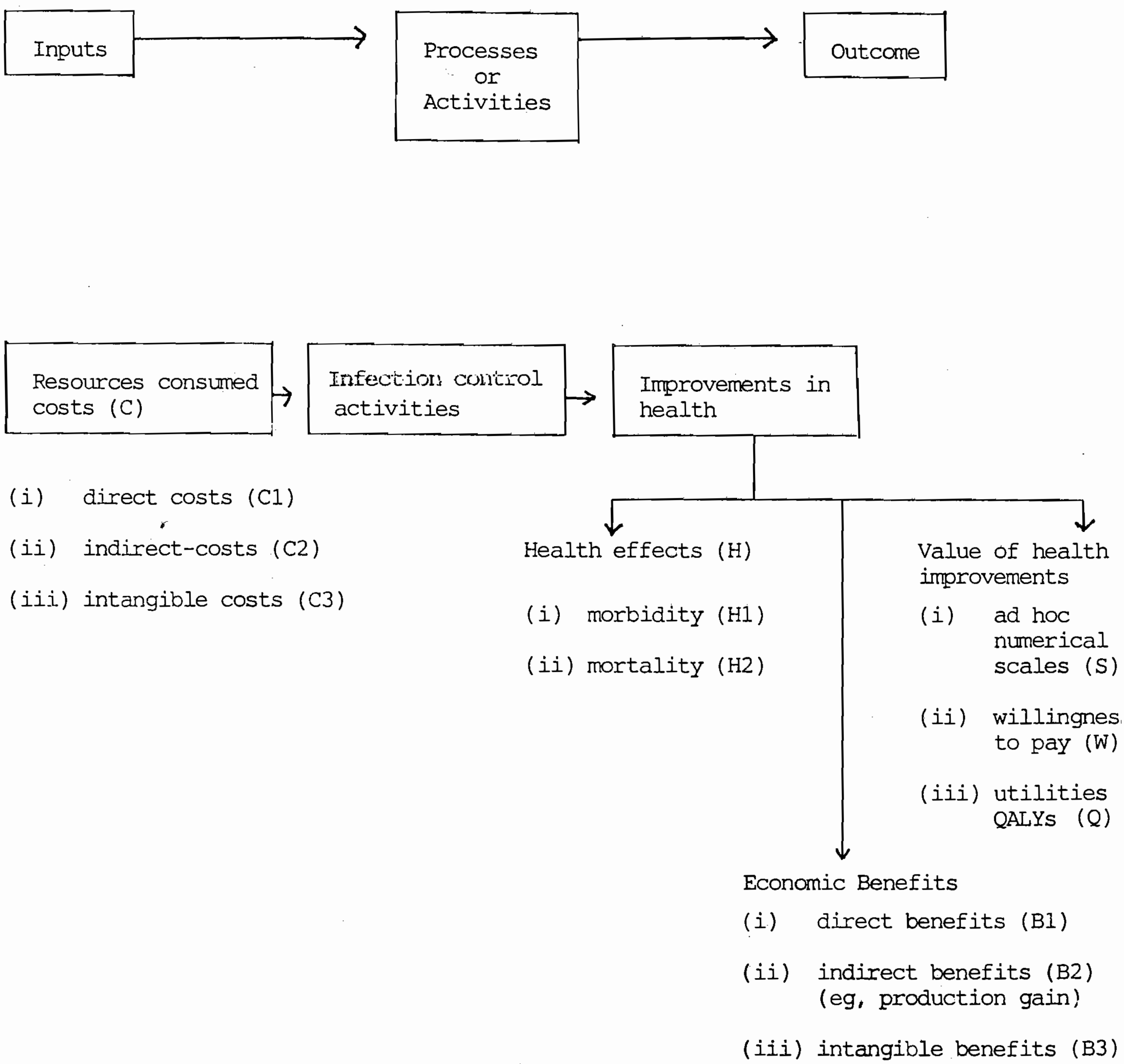
iii) with what effects for whom?

(c) Were the costs and outcomes identified, measured and valued adequately?

The costs of options will be borne by

(i) the infection control department of the hospital (eg professionals' time, supplies, equipment, capital costs).

Figure 1 The Nature of Economic Evaluation



Source: Derived from Torrance, G. (1986), Measurement of Health State Utilities for economic appraisal, Journal of Health Economics, 5, 1, 1-30.

(ii) the recipient and their family (eg inputs by the recipient and her relatives and time lost from work or leisure for all relevant actors).

(iii) costs to those other than the infection control sector, the individual and her family, e.g. private agencies.

The outcomes will be changes in physical, psychological and social well-being. These outcomes can be measured in terms of resource consequences (B1, B2, and B3 in Figure 1), in enhancements in the length and quality of life (QALYs) for individuals and their families and in other ways discussed in the literature (Drummond, Stoddart and Torrance (1987)).

For both costs and outcomes, each part of the processes of identifying, measuring (in suitable units) and valuing is complex and must be done explicitly and with care. There are a variety of "cook-books" to facilitate such work (eg Drummond, Stoddart and Torrance (1987)).

(d) Other questions

i) Were costs and outcomes adjusted for time preference? We prefer benefits today and costs tomorrow. Different health promotion programmes may have differing time profiles for both costs and outcomes. To ensure that pounds spent or saved in the future should not be counted equally to pounds spent and saved now, the estimates of these flows are discounted.

ii) Was marginal analysis performed? Results showing the effects of small (marginal) changes in infection control policies may inform decisions more usefully than average data (an excellent demonstration of this can be found in Neuhauser and Lewicki (1976)). Asking the question what is additional (marginal) cost of acquiring an additional (marginal) benefit - can be very valuable in illuminating the nature of choices. Whilst there are additional benefits to be gained from additional action, the costs may be exorbitant and it may be efficient to do nothing about some deviant health behaviours and treatable diseases.

iii) Was sensitive analysis performed? Because of uncertainty about the nature of future costs and outcomes and the imprecision of their measurement, it is essential to provide an array of possible results derived from plausible alternative values for the cost-outcome streams being evaluated.

7.3 Alternative Approaches to Economic Evaluation

(a) Costing. One approach, which is incomplete but common place in the HAI field, is to measure the costs of infections. A comprehensive costing would involve the measurement of direct costs (eg the cost in terms of professionals' time required for controlling infection in the hospital), indirect costs (eg the value of the time lost from production whilst the worker is infected) and intangible costs (eg the costs of pain and suffering associated with the infection. Thus the cost of the programme is $C = C_1 + C_2 + C_3$ in terms of Figure 1.

(b) Cost-effectiveness analysis.

The costing approach informs decision makers about the cost of each option but gives no information about its benefits in terms of health improvements. The cost-effectiveness approach seeks to identify the net economic cost to society C1 + C2 - B1 - B2, where B1 are the direct savings to society arising, for instance, from increased work productivity. This cost estimate is then divided by a measure of the effects on health of the programme being evaluated. Thus an infection control programme in a hospital could be evaluated in terms of cost (eg pounds) per infection avoided or pounds per life year saved.

This approach enables the evaluator to bring together both costs (input) and health benefit (outcome) data. Unfortunately the outcome measures used in cost-effectiveness analysis are not always in the same units, and are thus non-comparable.

(c) Cost utility analysis

Attempts to resolve these problems have explored a variety of solutions (eg see Torrance (1986)) and the preferred approach is cost utility analysis where the objective is to estimate the costs of producing a measure of the effect of the programme, the quality adjusted life year (QALY) or a well year (WY).

7.4 Some Results of Economic Appraisal

The objective of economic evaluation of alternative hospital infection control policies using a cost utility approach would be to identify the policy which is efficient ie produces the maximum benefit (eg QALYs or well years) at the least possible cost. The work of Kaplan, Atkins and Wilson, (1988) shows that pneumoccial vaccination for adults from a budget of $516500 would produce 344 well years whilst a coronary artery by pass graft for a patient with single vessal disease would produce only 1 well year from the same budget. Some other results, taken from Goel and Detsky 1989, are shown in table 2 and from these it is clear that some producers, eg liver transplants and some neonatal intensive care, is of limited cost-effectiveness.

7.5 The Strength and Weakness of Economic Evaluation

The economic approach to the evaluation of alternative infection control policies provides a logical and explicit framework (Figure 1) in which to assess the costs and effects of these policies. The limits of this approach are obvious. The cost data in all the studies reviewed in this paper tend to be incomplete. This defect is obvious if the user of the results carefully appraises them and provides an incentive for all to strive to identify better data. The benefit data in many studies are poor and rarely extend to systematic outcome information (eg QALYs). These are experimental but they do provide a stimulus for improvement : if these data are criticised as unacceptable the critic is obliged to produce alternatives if choices are to be informed by explicit "best-guesses" rather than rhetoric and unsubstantiated advocacy of "pet" policies.

A powerful argument in favour of the economic approach to evaluating policy options in infection control is that without

Table 2

The Cost Utility of Comparing Interventions

	Cost ($ US 1987) per well year
Pneumococial vaccine, older adults	1,500
Phenlketonuria screening	7,000
Screening for severe hypertension (diastolic blood pressure above 105)	9,200
Behavioural intervention in NIDDM	10,870
Screening for mild hypertension (diastolic blood pressure 95-105)	18,600
Oestrogen replacement in post menopausal women	23,500
Rehabilitation in chronic obstructive pulmonary disease	24,600
CABG, two vessel disease	32,700
Pneumococial vaccine, young children	114,900
CABG, single vessel disease	516,500

Source: Kaplan, Atkins and Wilson (1988), Table 5, p.337.

the data from such studies it will be impossible to prioritise alternative policies and it will be difficult to convince hospital managers and medical peers that prevention is better than cure.

Conclusion

Hospital acquired infections use scarce resources which could be used to treat patients who would benefit from care and they impose significant burdens on individual patients and their families. The magnitude of these infections is significant with average incidence rates in both the USA and the UK averaging five per cent of all hospital admissions.

It seems that the cost of HAI in England is about £115 million per year. A significant amount of HAIs are avoidable by using often simple surveillance and infection control programmes.If this rate could be cut by twenty per cent which appears to be feasible from US evidence, a cash saving of £22.8 million may be possible. However such control programmes cost money and, again using US evidence, it is likely that the net cost saving would be of the order of £15.6 million.

These global estimates are "ball-park figures" rather than precise estimates. The collection of data about the incidence and prevalence of HAIs is incomplete and rarely, in the UK, identifies the resource consequences of these infections. The cost effectiveness of alternative infection control programmes are poorly evaluated with incomplete costings and little attempt to advance from simple financial analysis of selective resource flows.

The efficient management of scarce resources necessitates the careful collection of incidence and prevalence data, the matching of these data to resource consequences inside the hospital and beyond, and the monitoring of these clinical and economic data. The systematic collection and management of these data would permit the appraisal of competing infection control policies. Such behaviour would save scarce resources and enhance patient welfare.

Appendix

HOSPITAL ACQUIRED INFECTIONS - A DIGEST OF FACTS

The following important points emerge from a review of some of the extensive literature on the subject of nosocomial infections:

- Current incidence of HAI in the UK are around 5% and average additional length of hospital stay about 4 days.

- HAI may be costing the NHS in England around £115 million per annum, although no detailed study of costs has been carried out to date and estimates vary considerably.

- The apparent lack of any significant reduction in hospital acquired infection rates in the last twenty years may largely reflect the 'success' of modern medical technology in facilitating more complex and invasive procedures. The increase in cardiovascular and neurological nosocomial infections could be an example of this.

- Duration of hospitalisation per se increases the likelihood of nosocomial infection.

- Risk of HAI increases with duration of operation and preoperative period.

- Infection rates are higher in large hospitals and higher also in teaching institutions.

- Infection rates may be significantly underestimated by a policy of early discharge (with HAI developing at home).

- Infection rates vary according to the individual susceptibilities of the patient and to factors such as age and sex.

- Nosocomial rates are probably underreported.

- Nationally, incidence rates are around 5%, but may be higher or lower depending upon the size and nature of the hospital, as well as the different infection control strategies employed (or lack of them).

- Nosocomial urinary tract infections are the most frequent, at around 40% of HAIs, but in general they are the least severe and least costly (although one study has recently claimed a 19% fatality in a study of 1458 catheterized patients).

- Postoperative and respiratory tract infections can be the most costly and involve the greatest prolongation of stay.

- Nosocomial bacteremias are both costly and potentially the most fatal (> 10% mortality).

- Perioperative antibiotic prophylaxis is effective in reducing the incidence of nosocomial infection, but prolonged post-operative use does not significantly reduce infection rates further and may encourage the development of antibiotic resistant strains of pathogens.

- Implementation of cost-effective infection control programmes could save the NHS around £15.6m.

STUDY, PROJECT DATE, PLACE AUTHORS	NUMBER IN SAMPLE & TYPE OF INFECTION	% HAI	INCIDENCE (or PREVALENCE) RATE	ADDITIONAL LENGTH OF STAY	COSTS & COMMENTS + ADDITIONAL DATA/FINDINGS
NIC Project 75-6 aley, Culver et al) 35	6,449 acute hospitals 338 hospitals (rep) URINARY TRACT SURGICAL WOUND PNEUMONIA BACTEREMIA OTHERS	 42% 24% 10% 5% 19%	5.7% = 2 million for study or 74 million nationwide per annum		
NIC 73 data from the erican Hosp. Assoc. nual Survey. aley in Daschner, 77)	34,000,000 patient admissions in USA per year = 1,700,000 with HAI		5%	4 days	£701.3 $600 average per case = $1,020,000,000 TOTAL in excess hospital charges £3,845,884,000 (1973/4)
NIC data 75-6 n Brachman, Dan, ley et al, 1980)	Surgical Patients in 276 hospitals 48,648 operations all infections SURGICAL WOUND	4.9%			SURGICAL WOUND infections increased risk with age to 8.3% at 65+ and males more at risk than females. Infection rate x4 for patients with infection prior to surgery. Risk higher for longer periods of hospitalisation or longer duration of operation.
NIC & USA atistical data - 1980 rachman, in Sacks d McGowan, 1981) ompare to Haley, ove)	ALL INFECTIONS 34 million patient admissions = 1,700,000 with HAI		5%	7 days average = +12m extra days nationally	£176.78 $200 average hospital cost of HAI per day = $2.38 billion (£2.10 billion) total, of which Approx $1 billion could be saved if 50% of all infections were prevented. (1980)
achman, Dan, Haly et 1980 NIC data 76 hospitals) IS data 2 hospitals) C special epidemic ta	SURGICAL PATIENTS All infections URINARY WOUND AND SKIN RESPIRATORY BACTEREMIA CUTANEOUS BURNS	 39% 32% 16% 4% 4% 1%	Municipal = 7% University = 5.7% Federal = 5.6% Community = 4.3%		Overall decline in HAI since 1974, with a shift from predominantly gram-positive to gram-negative organisms.
30-84 C NNIS ational Nosocomial fectious Survey)	POST OPERATIVE WOUND % frequency of pathogens isolated: S. aureus 15.7 E. Coli 12.5 P. aeruginosa 7.6 S. faecalis 6.4		6.1 per 1000 patient discharges = .61% incidence		$400-$2600 per case £353.56-£2298.14 = $130m-$845 million a year for postoperative wound infections. £114,907,240-£746,897,120 (1980)
75 TRA CHARGES AND OLONGATION OF STAY JDY LOT FOR SENIC) aley, Schaberg, ossley et al) 31	3 different sized hospitals: A/ Teaching with 1000 beds B/ Teaching with 500 beds C/ Non-teaching with 350 beds 8327 patients All infections		A = 5.95 B = 9.57 C = 1.94 = 5.82 average	A = 4.5 (0-44) B = 3.7 (0-112) C = 3.1 (0-12) (per infections) = 3.76 average	A = $590 £76496 (0-12,885) 0-£16706.08 B = $598 £775.33 (0-12,261) C = $641 £831.09 (26-2757) £33.71-£357459 Costs per infection = $609.6 average £790.37 Occurence of Secondary bacteremia associated with substantially increased LOS and higher charges: = 11.7 days + $1,815 average per infection £2353.24 (1975)

HOSPITAL ACQUIRED INFECTIONS : INCIDENCE & COST STUDIES - USA

STUDY, PROJECT DATE, PLACE AUTHORS	NUMBER IN SAMPLE & TYPE OF INFECTION	INCIDENCE (or PREVALENCE) RATE	ADDITIONAL LENGTH OF STAY	COSTS & COMMENTS + ADDITIONAL DATA/FINDINGS
1975-6 Extra charges & prolongation of stay study Brachman et al's reworkings/ summary of findings	All Infections in : 8329 patients in 3 hospitals. Surgical Wound = 3.2% per 100 patients undergoing surgery	5.4% (All Infections)	7.4 days (0-68)	gram-neg more prevalent than gram-pos organisms £951.48 $839 average for surgical wound 0-$7900 = 25% <u>0-£8959.18</u> 25% of total bills on average (0-100%) (1975)
Grady Memorial Hospital 1975 (Pilot forsenic project) (Pinner et al 1982)	1067 bed major teaching hospitals 215 nosocomial infections in 183 study patients		not given	Average change of $693 £898.5 per patient, but 5% of patients accounted for nearly $^1/_3$ total changes $126,769 <u>£164362.68</u> total costs for 183 patients 17 most costly infections in surgical wound & lower respiratory tract = 46% of total infections & 77% of total charges. (1975)
Grady Memorial 1976-1977 Antibiotic Prophylaxis (Stone, Haney, Kolb et al, 1979)	3 matched groups of 110 patients surgical incision: pentoneal infections:	 -8 & 9% -4 & 5%		Average additional costs of a post-operative wound/peritoneal infection $2,686 <u>£2804.44</u> $140,500 savings through antibiotic prophylaxis in 100 operations <u>£42,285.95</u> (at $15 cost per treatment yielding 5-20% reduction of infection rate £15.66) (1977)
Foothills Hospital Study 1977 (Cruse in Bennet & Brachman 1986)	Surgical Wound Study 62,939 operations: Clean 1.5% Clean/contaminated 7.7% Contaminated 15.2% Dirty 40.0% Wound infection rates	4.7%		
Charlottesville Virginia 1973-5 (Green & Wenzell, 1977)	Post Operative Wound for Different Procedures 1) Appendectomy 2) Cholecystectomy 3) Colon resection 4) abdom. hysterect 5) Caesarian sect. 6) Coronary artery bypass		 + 6 days + 7.1 days + 13.8 days + 6.5 days + 5.8 days + 13.8 days	 $ 688.97 <u>£ 831.27</u> $ 443.19 <u>£ 534.51</u> $1591.19 <u>£1919.85</u> $ 788.85 <u>£ 951.78</u> $ 527.5 <u>£ 635.85</u> $2602.68 <u>£3140.26</u> (1974)
John Hopkins Hospital, Baltimore 1972-74 (Spengler & Greenhough, 1978)	Bacteremias 435 patients matched controls (81 case-controlled for costs)			Mortality x 14 + $3,600 in direct hospital costs <u>£4343.58</u> + $5.800 for total costs 24% of total excess costs to these patients are preventable (= $125,000) <u>£150,818.97</u> $522,000 per year (1972-4) <u>£607,348.2</u> (1974)
St. Mary's Hospital Wisconsin (Scheckler, 1980) 3 month prospective 1978	390 bed hospital 123 nosocomial 65 urinary 26 surgical wound 17 pneumonia 15 others (often complex)	2.7% overall	3.0 average 0.6 6.5 3.8 7.0	$636 average <u>£ 631.58</u> $146 <u>£ 144.98</u> $1329 <u>£1319.77</u> $878 <u>£ 871.90</u> $1289 <u>£1280.05</u> (1978)

<u>£</u> = 1988 UK prices.

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HOSPITAL ACQUIRED INFECTIONS: INCIDENCE AND COSTS STUDIES - THE UK AND EUROPE

STUDY, DATE, PLACE, AUTHORS	NUMBER IN SAMPLE & TYPE OF INFECTION	INCIDENCE (OR PREVALENCE) RATE	ADDITIONAL LENGTH OF STAY	COSTS & COMMENTS AND ADDITIONAL DATA
1978 Cambridge University & Norfolk H.A. (Davies & Cottingham, 1979)	345 Orthopaedic patients (Matched controls)	8.4%	+ 17 days	£775 (of which 97% was increase LoS) £1673.08 (1978)
Wycombe DGH (2 hospitals) 8-year study 1971-78 (Leigh, 1981)	Post-operative wound 29,941 patients Clean: 2.9% rate Clean/Cont: 8.6% Contaminated: 12.9% 39% S. aureus	Overall = 5.4% 7.1 in 1972 - 3.6 in 1978		S. aureus infection of x 5 male surgical patients resulted in £1000 total cost for prolonged hospitalisation & 5-10 patients denied treatment in 1979 at Wycombe Hospital £1974,4 (1988)
Aberdeen 5-year study 1977-81 (Krukowski, Stewart, 1984 Al Sayer & Matheson)	1,504 abdominal surgical wounds	42 = 2.8% wound 12 = 0.8% intraperitoneal		For testing efficacy of antibiotic prophylaxis
France 1978 Neonatal unit (Girard, Fabry, Meynet et al, 1983)	122 neonates (=61+61 controls) All infections		+ 23%	+ 32% (1978) Total hospital costs increased by an average of 6000 FF (US $ 1250) 93% of costs as a consequence of 28% increased LoS £1241.32
Germany (Daschner, 1984)	All infections			DM 500 M - 1 billion per year 1984 price

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