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Economics and Intensive Care: From General Principles to Practical Implications

by Alan Shiell

DISCUSSION PAPER 80

ECONOMICS AND INTENSIVE CARE : FROM GENERAL PRINCIPLES TO PRACTICAL IMPLICATIONS

by

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Abstract

Intensive care medicine is an expensive technology but, under certain circumstances also an effective one. Precisely how expensive and under what circumstances it is most effective are unclear. Studies purporting to address the question of the cost-effectiveness of intensive care medicine are inconclusive because of deficiencies in method.

In this paper, a case is made for an economic evaluation of intensive care. The research evidence is reviewed and shortcomings in the methods adopted are highlighted. Finally, the practical implications of this literature for both researchers and the managers of intensive care units are discussed.

Introduction

Resources are insufficient to meet the demands we place upon them. This forces us to decide how much of society's scarce resources should be allocated to the provision of which sorts of health care and how, when, where and for whom should this health care be provided? (Evans 1984).

If we are to make best use of scarce health care resources, it is essential that priorities be set. This paper explores the implications of this for health services in general and for intensive care medicine in particular.

General Principles

One response to the question posed above is to allocate resources according to the needs of the population. However, there are problems with this approach. Need is a difficult concept both to define and to measure (Culyer 1976, Williams 1974). More importantly, concepts of need ignore the existence of scarcity. Such is our technical ability to improve health that there will never be sufficient resources to satisfy everyone's need for health care. Consequently, we must choose which needs can and should be met and which unfortunately cannot.

The need to choose is inevitable and gives rise to the economic notion of opportunity cost. For example, if resources are used, to expand trauma and orthopaedic services then it is obvious that the same resources cannot be used to improve services for people with long-term disabilities. Faced with such a choice, the opportunity cost of devoting resources to the trauma service is equal in value to the benefits of the care that would otherwise have been received by disabled people. Opportunity cost is therefore equivalent to forgone benefit and the economist's interest in minimising cost constitutes a justifiable concern that such sacrifices are kept as small as possible. To judge this, the benefits of doing one thing must be compared with the benefits of doing something else whenever health-care resource-allocation decisions are being made. As it is not possible to do everything which is beneficial to health, resources must be concentrated on those health care activities which have the biggest positive impact on health (per unit of resource used).

This raises the question of how the benefits or outcome of health care should be measured. To determine the allocation of resources within the overall health care budget, it is necessary to compare the marginal benefits of treating one group of patients with the marginal benefits of treating another. It follows that the outcomes of each form of treatment must be measured in comparable terms. The relative merits of cancer treatment and hip replacement cannot be easily assessed if the outcome of the former is measured in terms of five-year survival rates while the latter is measured in terms of increased mobility. What is needed is a generic measure of health applicable across a wide range of conditions.

Health is a multidimensional concept but the different approaches to measuring it can be reduced to two main elements; improvements in life expectancy and improvements in quality of life. A summary measure of the benefits of health care therefore, is the quality adjusted life year or QALY. This is equal to a year of life expectancy adjusted for its quality (Torrance 1987). An extra year of life expectancy in full health would rate one QALY while one year spent in some degree of pain or disability or emotional distress would score less than one. Quite what weight or value should be given to different degrees of disability and distress in practice is a matter for further exploration and research.

The QALY approach has been criticised on theoretical and practical grounds (Carr-Hill 1989, Donaldson et al 1988, Mulkay et al 1987) but two points should be noted. First, health states are already valued albeit implicitly by clinicians and health service managers. Decisions are taken to allocate resources to one form of treatment rather than another suggesting that prominence is being given to one form of health care effect over another. Secondly, patients have been shown to have preferences between alternative treatments which are either life-enhancing or life-extending and to be able to express these preferences in a way which can influence clinical practice (McNeil et al, 1981). The important point is that in principle the QALY can be used as a generic measure of health, and used to rank the cost-effectiveness of different treatments for a wide range of conditions.

Table 1 shows a list of activities ranked according to the cost of achieving the equivalent of one QALY. The table shows that to achieve the equivalent of one year of life in full health would cost £200 by home-based chiropody services, £1580 by coronary artery by-pass graft (CABG) in a person with left main disease and moderate angina or £16600 by haemodialysis based in hospital. To put this another way, for a budget of £50,000 it would be possible to achieve 3 QALYs by haemodialysis, 33 QALYs by CABG and 250 QALYs by chiropody. The table also allows one to put some substance on the concept of opportunity cost introduced earlier. The cost of haemodialysis for example may be expressed in financial terms but is actually the lost opportunity to improve the health state of others by other means. If the £50,000 resources is invested in hospital haemodialysis one gains 3 QALYs but loses the

Table 1 Illustrative table of cost/QALY rankings

Treatment	Cost/QALY (1988 prices)
Chiropody at home	200
GP anti-smoking programme	240
Pacemaker implantation	830
Hip replacement	890
CABG (severe angina left main disease)	1230
CABG (moderate angina, left main disease)	1580
Kidney transplant	3560
Heart transplant	6070
Haemodialysis at home	13070
Haemodialysis in hospital	16630

Source: Bryan et al, 1988.

equivalent of 250 because patients awaiting chiropody services must go without. The opportunity cost of expanding renal services is therefore 250 QALYs which is substantially greater than the benefits of such expansion.

One may, of course, disagree with the values expressed in the table and the derivation of these weights is one of the areas in the QALY method requiring more research. Giving greater weight to survival over quality of life will reduce the cost per QALY of treatments which are life saving rather than life enhancing. This will alter the relative placing of treatments in the table, improving the apparent cost effectiveness of dialysis relative to chiropody, but it does not alter the basic implication which is that one should seek to expand the provision of services where the cost per QALY is high <u>only</u> if there are no untreated patients where the cost per QALY is low (Williams 1985). Referring back to the table, priority for new resources should be given to activities and treatments towards the top of the list with demonstrably low costs per QALY. A further implication is that we should be seeking to transfer existing health care resources from activities which have high costs per QALY to those where costs per QALY are lower. In this example, this would mean shifting resources out of haemodialysis and into hip replacement, anti-smoking programmes and chiropody. As a result, existing resources would be used to greater effect i.e. the beneficial impact of health care resources on health would be higher.

Practical Implications

Of what practical importance is this for the managers of intensive care facilities? Assuming that such managers are motivated primarily by a desire to improve health, the challenge posed to them by the scarcity of health care resources is to demonstrate the cost-effectiveness of intensive care medicine. Where on the cost per QALY table would intensive care be placed? Or, more accurately, given the heterogeneity of intensive care, where would intensive care for patients with particular presenting characteristics be placed?

The answer to this question depends on the answers to three further questions; of what additional benefit is intensive care over and above alternative forms of managing the critically ill patient? How much more does intensive care cost than these alternatives? And, finally, is the additional benefit from intensive care greater than the additional benefits we could otherwise obtain if the same resources were used to expand some other area of health care activity?

The focus of these questions on the cost and outcomes of intensive care relative to alternative forms of managing the critically ill patient can be made more tangible in the context of clinical decision making if one considers part of the process of admission to and discharge from intensive care units. This discussion has been adapted from the work of Spangenberg and his colleagues (Spangenberg et al 1990). Spangenberg identifies three admissions decisions and two discharge decisions which he labels as 'errors' because they lead to low effectiveness or low efficiency. On admission, a patient may be too healthy so that he or she could easily be managed in a less intensive setting. The result of admission to ICU is overtreatment and therefore efficiency in the use of ICU resources is low. Alternatively, a patient may be too ill so that the effectiveness of care is low. The third 'admission-error' is an extreme case of the second and occurs when patients who will die shortly irrespective of the care they receive are admitted to the unit. In this case, effectiveness is zero. At discharge, possible errors are that patients may be kept in the unit for too long, leading to overtreatment and low efficiency, or they may be discharged too soon leading to low effectiveness over the total episode of care.

The major difficulty in applying such ideas to the practice of ICM in the UK, apart from prognostic uncertainty which makes it difficult to predict whether or not an individual will or will not benefit from intensive care, arises because it is likely that few patients for whom intensive care is totally ineffective will be admitted. The relative shortage of ICU beds in the UK already means that patients who are unable to benefit at all from admission are unlikely to gain access to a unit or stay for very long, if admitted. The admission and discharge decisions therefore focus on those groups of patients on the margins of admission for whom intensive care is likely to be effective but less so than for other groups of patients in need of ICM or for other non-ICM uses of health care resources.

Research Evidence

A number of published evaluations purport to address the question of the cost effectiveness of intensive care medicine though it is argued that none do so satisfactorily. Thibault and his colleagues (1980) have compiled an extensive database containing information on 2963 consecutive admissions to a combined coronary care/medical intensive care unit in Massachussets. Nearly 80 per cent of all admissions were for non-invasive monitoring, reflecting the joint responsibilities of the unit. Of these only one in ten developed subsequent need for more intensive intervention such as intubation or insertion of an arterial line. The patients admitted for immediate major intervention accounted for disproportionate shares of total charges and mortality during hospitalisation.

The effectiveness of the unit, measured only in terms of mortality, is shown in Table 2. Long-term mortality is substantially higher than at discharge from hospital and, not surprisingly, increases with age.

Table 2 Mortality Rates (%) In Combined CCU/ICU in Massachussetts

Age	Discharge from ITU	Discharge from hospital	Follow up* (15 months)
Under 50 years		5	7
60-70 years		9	13
Over 70 years		14	27
All ages	6	10	25

* Based on the first 1230 patients admitted to the unit.

Hospital charges (excluding physician fees) averaged US $5325 but ranged from less than US $2000 for those discharged with a diagnosis of precordial pain to more than US $17000 for those in respiratory failure. The variation in actual patient costs (i.e. in real resource-use) is likely to be greater than that reported here for charges because patients tend to be billed a standard daily charge irrespective of their level of dependency and need for nursing care (Finkler 1982, Wagner et al, 1983). Charges will therefore understate the costs of highly dependent patients whilst overstating the costs of less dependent patients.

Although the authors do not do so it is possible to combine the data on charges and the data on mortality to calculate average charges per survivor. A selection of the results are shown in Table 3. At 15 months the average

A selection of the results are shown in Table 3. At 15 months the average charge per survivor (excluding the costs of subsequent hospital treatment and outpatient visits) is US $7200 but the range increases significantly because of the high mortality amongst those with a diagnosis of sepsis or renal, respiratory or hepatic failure.

Table 3 Charges Per Survivor

Primary diagnosis at discharge (number of patients)	Average charge per patient (US $)	Average charge per Survivor	
		Discharge from Hospital	At 15 months*
Acute myocardial infarction (527)	5690	6616	7902
Precordial pain (192)	1879	1898	2020
Congestive heart failure (191)	5655	6081	9750
Primary pneumonia (63)	8014	10545	16355
Cardiopulmonary arrest (41)	7235	22609	22609
Sepsis (39)	12823	18857	21372
Renal failure (34)	10708	14470	20203
Respiratory failure (25)	17201	33077	47781
Hepatic failure (14)	9445	32569	47225
All classes (2693)	5325	5917	7100

* Based on the first 1230 patients admitted to the unit.

The table shows diagnosis at discharge but the relationship between charges and diagnosis is slightly spurious. While only 192 patients were discharged with a diagnosis of precordial pain (mortality at follow-up equalled 7 per cent) nearly 1050 patients were admitted with this diagnosis. The difference between these two figures presumably represents those patients for whom a more specific diagnosis was made during their stay in the unit. The authors conclude that before more rational decisions can be made about the allocation of resources to intensive care better prognostic models are required to define the trade-offs between costs and effectiveness.

Chassin (1982) also used patient charges in his evaluation of the care received by 489 people admitted to either the respiratory intensive care unit or the medical intensive care unit of a large teaching hospital in Los Angeles. Charges averaged US $1120 per day in ICU, equivalent to US $5700 for an average length of stay, rising to US $14600 if all treatment over a six month period is considered. After adjusting for inflation these results are considered comparable with those found by Cullen et al (1976) but higher than those found by Thibault et al (1980), probably because the latter study included less severely ill coronary care patients. As in Thibault's et al's study, patient charges vary with diagnosis. At six months the average charge ranged from US $9900 for people suffering from diabetic ketoacidosis up to US $31700 for people in chronic renal failure.

Mortality averaged 14 per cent at discharge from hospital and 28 per cent at follow-up six months later. Using life-tables the author suggests this indicates a one-year survival rate of 66 per cent. Functional status of survivors was little different before and after admission. Of all the patients for whom functional status data were available; 42 per cent reported no change, 8 per cent some improvement in functional status and 20 per cent reported worsened functional capacities. The remaining 30 per cent had died.

One aim of this study was to test whether data are available at the time of admission to ITU to identify subgroups of patients with an especially low rate of survival. Chassin concludes that it is not possible to identify such subgroups and therefore it may be impossible to reduce ITU costs by controlling admissions. This conclusion appears to have been reached following consideration of the characteristics of a subgroup of high-cost patients (which did not differ from the unit population as a whole except in terms of cost) and the relationship between a variety of characteristics of patients and their survival. The group with the lowest survival (14 per cent) comprised patients with cancer and low pre-admission function status. Chassin claims that the survival rate for this group of patients is ... "clearly not low enough to justify systematic exclusion from ICUs". Whether or not this is clearly so, as Chassin asserts, is questionable. More importantly, the value-judgement cannot be made on the basis of this data alone. Consideration must also be given to the quality of life enjoyed by the few survivors, to the differential effect on both quantity and quality of life achieved by admission to ICU over and above any alternative treatment and finally to the opportunity costs of achieving any such improvements.

One further factor, recognised by the author and contributing to his inability to identify subgroups for whom admission is of little benefit, is statistical. The relationship between case-mix, treatment and outcome is complex and attempts to control for the large number of variables involved subdivides any sample of patients into very small groups. This makes it difficult for statistical tests to attain conventional levels of significance and adds to the uncertainty surrounding prognosis.

Turning to European studies, Bams and Miranda (1985) report a retrospective follow-up of 238 consecutive admissions to a surgical intensive care unit in the Netherlands. Patients were categorised into four groups (see Table 4) based on the Therapeutic Intervention Scoring System (TISS) devised by Cullen et al (1974). As is indicated by its name, TISS is a measure of therapeutic intensity though it was used initially as a measure of severity.

Table 4 Severity of Patients Admitted to Surgical ICU in Holland

Category	TISS Score	Number of Patients (%)
I	Under 10	14 (5.8)
II	10 - 19	13 (5.4)
III	20 - 39	81 (34.0)
IV	Over 40	140 (54.8)

Mortality was 7.5 per cent at discharge from hospital and 15.1 per cent two years after discharge. Of the survivors, 55 per cent were fully recovered, 18.5 per cent had resumed their former activities albeit with some incapacity, 10 per cent could not resume their usual activities but were able to care for themselves and only 1.3 per cent were totally dependent on others.

Costs per survivor (ICU plus subsequent hospital stay) ranged from US $3340 for those in category I to US $8230 for those in category IV. Patients admitted for coronary artery bypass graft (CABG) constituted an homogeneous subgroup of category IV with an average cost of only US $4315. For the remainder of category IV the average cost was US $14270. However, standard average costs per day in both the ICU and the general hospital wards were used to arrive at these figures. The variation in cost is therefore solely due to differences in the lengths of stay of patients in each category and not to differences in the intensity of treatment which each group of patients might have received.

The authors conclude that the low mortality and high degree of rehabilitation is evidence of the effectiveness of intensive care and the high costs of such treatment is easily "repaid" by the earnings of successfully treated patients generated over the remaining span of their working lives.

Both conclusions should be treated with some caution. In the absence of a suitably matched control group, it is impossible to say whether or not intensive care per se is responsible for the successful outcomes, although the claim may have some validity for those people requiring ventilation, of whom Tomlin (1978) has claimed 80 per cent would otherwise die.

The question of how to treat subsequent earnings raises two important issues. The first relates to the objectives of treatment. If income, as a measure of economic production, is considered part of the benefits of health care then it becomes harder to justify extending treatment to the old or unemployed. It is not yet policy to restore the high-earner to full health before the low earner even though clinical decision makers may take an individual's employment status into account when determining priorities and therefore it is debateable whether income should be counted as a benefit of health care. The value of treatment is perhaps better measured solely in terms of the gains in health state achieved by its recipients. The second issue is more technical and relates to the time horizon over which costs are incurred and income is generated. If subsequent earnings are considered important it is necessary to adjust their nominal value to reflect the delay in their receipt before they can be compared to the current costs of treatment. This process, known as discounting, reduces the present value of income (or costs) arising in the future.

Loes and his colleagues (1987) reviewed 961 patients admitted to a general intensive care unit in Norway, 419 of whom were observed for an average period of 20 months after discharge from hospital. Mortality was 13.4 per cent in the ICU and 31 per cent, 20 months after discharge from hospital. As in Thibault's study there was a marked age differential (see Table 5).

Table 5 Mortality Rates in a General ICU in Norway (%)

Age	Discharge from ITU	Follow-up (20 months)
0 - 29	9.0	14.0
30 - 59	10.0	31.0
Over 60	19.3	44.0
All Ages	13.4	31.3

ICU costs averaged US $5760 per patient, equivalent to US $6650 per survivor from ICU and $8385 per survivor at 20 months. To apportion costs to individual patients the authors assumed a linear relationship between cost and the nursing ratio required by different types of patient. Thus, the care of a patient whose condition warranted observation and treatment by two nurses was deemed to cost twice as much as a patient requiring a ratio of one to one. As nursing staff are the largest single component of ICU costs, comprising something like 70 per cent of the total recurrent budget for the unit under study, the assumption may have some validity. Using this method, the cost per patient was found to vary from less than US $1500 for patients treated for acute epiglottitis to US $21500 and US $28500 respectively for those requiring mechanical ventilation for longer than 48 hours and for those treated for septicaemia.

Another feature of this study was the authors' ability to cost the total treatment received by each patient throughout the follow-up period. Mean total cost over the whole episode was US $18140 of which care in the ICU and the subsequent period of hospitalisation accounted for 31 per cent and 26 per cent respectively. The remaining 40 per cent was divided equally between the costs of re-hospitalisation or other institutional care and the costs of caring and maintaining individuals in their own homes.

One problem common to each of these studies has been how to apportion the shared costs of units to individual patients. In the two North American studies, patient charges were used while in the two European studies costs were apportioned to patients arbitrarily. The deficiencies of the latter method are obvious but it was noted earlier that even patient charges include an arbitrary element which results in some "cross subsidisation" of patients and so reduces the variation in individual costs.

In their study of 100 consecutive admissions to an intensive care unit in New South Wales, Australia, Slayter and his colleagues (1986) attempted to overcome such problems by estimating costs which "vary at the bedside rather than the accounting office". Overheads, capital costs and the intangible costs of pain and suffering were therefore excluded.

Patients were categorised into one of four groups based on the TISS classification system devised by Cullen et al (1976). Mean total costs whilst in ICU ranged from US $415 for patients requiring simple wake-up observations to US $3705 for those requiring the constant attention of at least one nurse. Labour costs comprised 54 per cent of the total, with nursing staff making up 38 per cent and medical staff the remainder. Diagnostic tests explained another 25 per cent of total cost with drugs and disposables each adding another 9 per cent. There was a strong correlation (0.89 $p<0.001$) between total TISS points and total costs suggesting that Cullen's scoring system may provide a useful proxy for more complex patient costing exercises.

Inpatient mortality was 8 per cent rising to 11 per cent one month after discharge. Amongst survivors, quality of life at one month was little different than before admission. Of all patients, 52 per cent were described as freely ambulatory, 26 per cent reported some limitation to their activities, 9 per cent were bedridden but able to carry out basic self-care tasks and 2 per cent were dependent on others.

The authors conclude that the relationship between cost and outcome is complex. There is an inverse relationship with high costs associated with poor outcome but if patients amongst the high risk/high cost group do survive then their subsequent quality of life and presumably their life-expectancy depend more on their pre-admission health status rather than the costs of their treatment. Although it is possible to postulate what the likely outcome will be for a given group of patients it is not possible to do so on admission for any particular individual. As in the other studies, Slayter suggests that prognostic uncertainty currently limits the extent one can control ICU costs through the control of admissions.

Evidence from the United Kingdom

Intensive care units comprise only 1 per cent of acute hospital beds in the United Kingdom compared to 15 per cent in the United States (Jennett 1984). There are also substantial differences in the number of ICU beds amongst European countries (Reis Miranda 1986). Such differences in the availability of facilities and the consequent effect this has on case-mix, costs and outcomes may mean that the experience of other countries cannot be applied directly to the UK. At best, it provides some indication of the relationship between costs, treatment processes and outcome. Unfortunately, there is little evidence relating costs to outcomes in British ICUs. A number of authors have examined the outcome of ICU for specified groups of patients but none have considered costs (Nunn et al 1979, Jennett 1984, Searle, 1985). The lack of evidence on the costs and effects of intensive care medicine in British Units prevented the expert panel, recently convened by the King's Fund, from reaching a conclusion (Kings Fund 1989) though to assist in their enquiry a small exploratory study was initiated in a number of ICUs.

This study (Shiell et al 1990) adopted a similar method to Slayter et al in estimating costs which varied at the bed side. Of necessity, capital costs, hospital overheads and the costs of treatment outside of the ICU were excluded. Clinical activity data was extracted retrospectively from the case-notes of one hundred consecutive admissions to each of two units in England (one a combined CCU/ICU, the other a general adult ICU) and used to cost the care received by each patient during their stay in the units. The outcome of care was measured in terms of survival and quality of life six months after admission.

Mortality at discharge from the units was 25 and 15 per cent rising to 31 and 38 per cent respectively six months after admission. Between one third and one half of patients alive at six months reported that their health continued to restrict various aspects of their daily activities. One fifth of survivors reported serious levels of disability and distress.

ICU costs (excluding overheads) averaged £2000 and £2280 equivalent to £525 and £465 per inpatient day (1987-88 prices). Higher costs were associated with increased severity and advanced age. Costs per patient were heavily skewed. One-half of all patients incurred costs of less than £1000 while 10 per cent of patients were responsible for 45 per cent of total expenditure. The large number of primary diagnoses prevented any analysis of the relationship between diagnosis, costs and outcomes. The mean cost of achieving a survivor in each of the two units was £2900 and £3675. Patients who did not survive to discharge incurred higher costs though the difference was not significant at conventional levels. Unlike experience elsewhere, the small differences in cost between survivors and non-survivors arose from greater intensity of treatment rather than longer lengths of stay.

As with the other studies described above, the heterogeneity of patient mix, compounded in this instance by small sample size, limited the analysis and prevented the identification of sub groups of patients for whom intensive care may not be effective. The study did, however, demonstrate the feasibility of carrying out such work in a British setting.

Summary of Research Findings

Intensive care is undoubtedly an expensive technology costing some three to five times as much as care on a conventional ward. The time spent in ITU will account for something in the order of 50 per cent of the costs of the initial period of hospitalisation and 30 per cent of the costs of all care delivered over the whole patient episode. Not surprisingly, staffing costs are the most important single component but no more so than in other areas of clinical activity. There is a wide variation in cost between individuals, with many costing much less than the average and a few patients costing substantially more.

In the USA, mortality at discharge from hospital ranges from 6 to 14 per cent and increases significantly as one extends the follow-up period. In the two UK units, mortality at discharge exceeded 25 per cent. Poor outcome has been associated with pre-admission health status, advanced age, diagnosis and severity. The first of these suggests that intensive care cannot normally reverse any damage done before the onset of the emergency which precipitated the current admission. The second contradicts the findings of Fedullo and Swinburne (1983) and may simply be an artefact of poor statistical analysis (Wu et al 1990). Age may have no independent effect, if other factors such as severity and co-morbidities are adequately controlled. Whatever its independent effect on survival, advanced age will certainly be an important factor if the effectiveness of ICM is judged by criteria based on life-expectancy rather than survival.

The role of diagnosis is unclear. The presence of malignant disease and septicaemia is associated with poor survival but most authors stress the role of severity of illness rather than diagnosis. Most studies report an inverse relationship between cost and survival with patients who are more severely ill, whatever the cause, likely to have poor outcomes and incur high costs. However, the relationship between costs and survival may be more complex. Scheffler et al (1981) describe a 'U' shaped rather than a linear relationship and Detsky et al (1981) suggest that it is unexpected and not simply poor outcomes which contribute to high costs. Thus, high costs are associated not only with patients who are expected to die yet survive, but also with those who are expected to survive but do not. The development of more sensitive prognostic models would therefore appear to be one way by which more cost-effective use could be made of intensive care facilities.

Criticisms of Research Evidence

While providing interesting information on the costs and the outcomes of intensive care from particular units, none of the studies discussed above adequately address the questions outlined previously and so none shed any light on the cost-effectiveness of intensive care medicine (Williams, 1986).

Each study is descriptive in nature simply reporting the performance of a single unit over time. There are no studies which compare intensive care with any realistic alternative means of managing the critically ill patient or which consider alternative methods of treating the same condition whilst in intensive care. For some groups of patients, such as major trauma or respiratory arrest following drug overdose, there may be no alternative either because there is an accepted view on the best method of treatment or because the response to intensive care is so positive. For many other groups of patients, including those whose condition is not severe enough to warrant admission to the unit and those whose prognosis is poor whatever course of treatment is adopted, the benefits of intensive care are less certain. In such cases, there may exist a variety of ways of managing the patient and consideration can therefore be given to research techniques which seek to identify what intensive care adds by way of costs and outcome over and above the alternative treatments (Fineberg et al 1984).

The outcome of intensive care has been measured mainly in terms of survival at discrete points in time. This ignores the quality of life of survivors and assumes that the life-years of people who die before the cut-off point have no value. Where quality of life is considered it is often measured in terms of work status or continued morbidity. Few studies consider the capacity to perform tasks of everyday living or emotional status and no study relates quality of life to survival or allows the calculation of quality adjusted life years.

Costs also tend to be poorly measured, especially in US studies where the use of hospital charges understates the variation in costs amongst patients because of cross-subsidisation. The relation between costs, capacity and intensity of treatment is never explored and so the marginal costs of policies to alter patient throughput, treatment practice or admission and discharge criteria is unknown.

Each study acknowledges the interaction of factors which are considered important in explaining costs and outcome but none employ appropriate multivariate statistical techniques to tease out the differential effects of each factor. Instead, the studies rely on pair-wise analysis of the correlation between sets of variables. This will lead one to attribute too much explanatory power to one factor (e.g. age) because the confounding effects of other factors such as severity are left uncontrolled (Wu et al 1990).

In addition to these deficiencies in method, the heterogeneity of patient case mix results in stratified samples with small numbers of patients in each diagnostic category. Resulting estimates of the influence of different variables have large confidence intervals and subsequent statistical tests often fail to reach significance at conventional levels. Even in studies with large samples, such as Thibault et al (1980) which had over 2900 patients, it is often difficult to draw conclusions from the results.

Management Implications

In the absence of research evidence, one must turn instead to the data being routinely collected by ICU directors. Assessment of the performance of intensive care units has, up to now, depended on such data often collected by staff of the units for the purposes of internal audit. Practice in this respect in the UK is patchy. In a survey of each district health authority in England, from which replies were received from 130 units (a response rate of 70%), 15 per cent of units kept no descriptive details of their annual workload, 30 per cent reportedly had no budget and 55 per cent had no information on the final outcomes of treatment after the patient had left the ICU. In part, the lack of management information is a function of the remoteness of routine systems of costing and patient administration which either ignore the ICU or report at too high a level of aggregation to be of any specific use. However, it is also clear that the management structure within ICUs varies amongst units and is often diffuse so that in many units there is no one person with clear responsibility for the direction of the unit or the collection and use of management information (King's Fund 1989).

The use of agreed protocols and standard definitions would better inform self-evaluation and also facilitate comparison of performance between units as the data needed for one is obviously the same as that required for the other. The European Intensive Care Society (Loirat et al 1990) have recently suggested minimum and desirable data sets which all ICU directors are recommended to collect (see figure 1). Independently, the King's Fund Consensus panel recognised '... the urgent need for intensivists to agree what data (clinical and economic) should be collected by every ICU to allow proper audit' (King's Fund 1989). In addition to which, they recommended that each unit should identify someone to be responsible for collecting and evaluating data on the clinical outcome and costs of intensive care medicine.

Figure 1

Routine Data-Sets for Evaluation of Intensive Care Medicine

Patient Characteristics	Number of admissions Age/Sex Admitting speciality Type of admission Diagnosis Severity score	Further diagnostic data Changes in diagnosis Previous health status
Referral	Source	
Facilities	ICU beds	Equipment Personnel Costs
Treatment	Ventilation Dialysis	TISS/OMEGA points
Outcome	Length of stay Destination Mortality	Hospital mortality Iatrogenic events Late survival Health status

Source: Reis Miranda et al, 1990.

Future Research Issues

In 1983, the US Consensus Conference on Critical Care Medicine concluded "The combination of life threatening diseases, finite resources, invasive therapeutic and monitoring techniques and high costs makes the need for adequate data on which to base decisions a high priority" (National Institutes of Health 1983). This review of the research literature demonstrates the continuing lack of such data in 1989 which prevented the equivalent UK consensus panel reaching any conclusions about the costs and effects of intensive care medicine. The panel strongly recommended 'as a matter of urgency' that priority should be given to extending prospective studies which attempt to relate in a systematic manner data on workload, treatment, costs and outcome (King's Fund, 1989).

Any future study will need to address the issues raised in the critique of past research. The problems of measuring both costs and outcome may be difficult to overcome but they are by no means insurmountable. Measurement techniques exist and the difficulty of assessing the cost and effects of ICM in Britain is more one of resource constraints. Standard NHS systems of accounting and measuring outcomes are not sufficiently developed and so the data will have to be collected as a special exercise. The costing of intensive care units may be simplified in the future as a result of the NHS reforms and the introduction of new management information systems though costs will still need to be identified to individual patients or groups of patients if the information is to be of use in assessing cost-effectiveness. Scoring systems such as the Therapeutic Intervention Severity Scale may simplify the measurement of patient-costs but the relationship between TISS points and costs needs validating in a number of UK settings before the system can be used with any confidence. In the immediate future, therefore, cost estimates will still have to be generated from primary data.

The first issue to consider is obviously the purpose of the evaluation. Each of the studies discussed earlier took as their focus the operation of the adult ICU in its entirety. The question underlying this approach, though not adequately addressed in practice, is what is the cost-effectiveness of intensive care as it is currently practised. An alternative, more micro, approach is to assess the cost-effectiveness of specific interventions within intensive care medicine such as positive pressure ventilation or the use of Swan-Ganz catheters or to examine the cost-effectiveness of treatment for particular types of patient. The macro approach, by considering the variation in clinical practice amongst ICUs in general can include within it a number of micro questions though it loses much of the precision obtainable from smaller scale studies.

Related to the question of purpose is one of study design. The greatest challenge in assessing the cost-effectiveness of intensive care is not in the measurement of costs and outcomes but in discerning what intensive care adds to alternative means of managing the patient. Critically ill patients will be treated somehow, either in intensive care units or elsewhere. To demonstrate the cost-effectiveness of intensive care medicine or of particular procedures within intensive care medicine, one must be able to compare it with the most likely therapeutic alternative. Ideally, the efficiency of medical interventions should be assessed by means of a randomised control trial. Given what is known about the effectiveness of intensive care for some conditions, randomised entry into ICUs cannot be considered ethical. A macro study of the operation of ICUs will therefore have to rely on observational data of the natural variation which exists amongst units. The scope for randomised trials increases in micro studies if there is a lack of consensus about the best course of action. Unfortunately there is so little information about the costs and effects of different aspects of intensive care that few practices currently seem amenable to randomised trials. By focusing on variations in practice, an observational study of intensive care medicine may at least highlight areas of uncertainty and therefore identify potential candidates for more stringent evaluation.

The main advantage of randomised trials is the elimination of bias caused by confounding variables. To assess the impact intensive care has on costs and outcome in an observational study it will be necessary to control for these other factors statistically. The two main influences will be the context in which the unit is operating and the characteristics of the patients moving through the unit. The first of these factors will include the type of hospital, its location, the presence of referring departments (trauma centre, transplant centre etc) and the availability of support or substitute services such as a high dependency unit or coronary care unit. The second factor relates to case-mix and includes patient age, diagnosis and severity of illness. The main difficulty is in assessing the validity of the instruments used to measure these factors. For example, dummy variables can be used to indicate the presence of a supporting service but not the quality of care provided therein. As the quality of care in supporting facilities is likely to be as important as their availability, the omission may be significant. Controlling for differences in the severity of disease is likely to prove more contentious. A number of measures based on physiological disturbance or organ system failure which have been developed to predict mortality (Lemeshow et al 1985, Le Gall et al 1983), the most widely used of which is the APACHE system developed by Knauss and colleagues (Knauss et al 1985). This has been validated in a number of settings and is currently being validated in a multi-centre evaluation in the UK (Rowan et al 1989). Yet, however well the system performs in predicting mortality, there is no test of its validity in measuring severity of illness. Consequently, there will always be some residual doubt as to whether observed differences in cost or outcome are the result of treatment methods or unmeasured severity.

Finally, and related to the question of the statistical control of confounding variables is the issue of sample size. Assuming a throughput of 70 patients per bed an average ICU of six beds will admit between 400 and 500 patients per annum. To obtain samples of reasonable size, one must therefore either stretch the study period in a single unit over a number of years or recruit a number of units into a multi-centre trial. It would be difficult to generalise from the results of a single centre and extending the study would delay dissemination of results and run the risk of changes in clinical practice being introduced during its course. It is easier to generalise from the results of a multi-centre trial though obviously by increasing the number of units in the study one also increases the number of factors to consider in any subsequent analysis.

Conclusions

For some categories of patient, intensive care medicine is of undoubted benefit in reducing morbidity and mortality. For other types of patient, the benefits of intensive care are less certain. For all patients, admission to intensive care units is expensive though it is not known how much more expensive is intensive care compared with the most likely alternative means of treating the critically ill patient.

The scarcity of health care resources poses a challenge to the directors of intensive care to demonstrate and improve upon the cost effectiveness of intensive care medicine. In order to meet this challenge a number of practical and methodological problems must be overcome. This points to the need for better information on the activities of intensive care units and for collaborative research between units and academic research centres. Success in this joint endeavour will help identify those health care procedures which have the most beneficial impact on health status. This will result in more efficient use of resources, more effective health care and therefore better health outcomes.

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