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How do we evaluate the economics of health care?

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SUMMARY Economic evaluation has become an integral component of health service research in recent years and will no doubt become more influential. As resources are reduced in health services, more questions are likely to be asked on the costs and benefits of new treatments. Questions are also likely to be aimed at treatments that are currently provided.

Economics related to health care is complex and numerous methods of economic evaluation exist. Full economic evaluation involves the assessment of both costs and outcomes and is ideal for comparing the efficiency of treatments. Partial evaluations can also provide useful information on the contribution of component costs to treatment costs as a whole.

The aim of this review is to assess the various methods available to evaluate the economics of health care and to place in context how these methods may be used within dentistry.

What does economic evaluation of health care mean?

Economic evaluation can be defined as the 'comparative analysis of alternative courses of action in terms of their costs and consequences' (Drummond *et al.*, 1997). It is a collective term for a range of techniques that can be used to gather evidence and make comparisons on expected costs and consequences of different procedures. Economic evaluation in effect assesses the efficiency of a treatment. True economic evaluation involves a technique that was developed by economists to aid decision-making, but in the health care setting, economic evaluation on its own provides only part of the information for this process. In the future, economic evaluation is likely to become more important in orthodontics and health service purchasers will look for evidence on clinical effectiveness of treatments as well as information on 'value for money' when allocating resources (Buck, 2000).

Techniques for economic evaluation

A number of techniques have been described for full economic evaluation. Ideally, the evaluation should be linked with a clinical trial so that both costing and consequence data can be collected simultaneously. The latter is a lengthy and expensive process and evaluations often use existing medical literature in order to provide data on consequences. If this method is used, the data may not be accurate and certain assumptions may have to be made. Four main analyses exist for full economic evaluation:

1. cost-minimization,
2. cost-effectiveness,
3. cost-utility, and
4. cost-benefit.

Cost-minimization analysis

Cost-minimization analysis (CMA) is used when interventions or procedures are expected to have the same or similar outcomes (Robinson, 1993a,b). The costs of each intervention are assessed, and the least costly can be identified. An example of this is seen where the costs of laparoscopic and 'open' procedures to treat appendicitis are compared. Both types of procedure have an equivalent outcome but laparoscopic appendicectomy has a higher cost (Kald *et al.*, 1999).

CMA is often initially conceived as a 'cost-effectiveness analysis' (CEA) but the latter is more complex, involving full evaluation of both costs and outcomes of treatments. CEA can then be simplified to a CMA, if it is found that the outcomes for each intervention are equivalent. Few procedures are likely to have the same outcome, and therefore CMAs are considered to be of use in only a limited number of situations (Robinson, 1993b).

Cost-effectiveness analysis

CEA can be used where the outcomes may vary, but they are expressed as common units thus enabling comparison (Robinson, 1993c). As well as measuring the costs of the interventions, a measurement of effectiveness is required which is defined in appropriate units. For example, costs can be compared using common units, such as 'per lives saved' or 'per pain free day'. A CEA can therefore be used to compare heart surgery and kidney transplantation, when the common unit of measurement to be used is the number of life years saved. In summary, CEA studies express effectiveness in a single dimension in order to enable direct comparison of costs.

CEA cannot be used in the evaluation of procedures where units of outcome vary. It is not appropriate to compare a treatment for reduction of caries and a treatment for oral cancer since the measures of effectiveness are bound to be different. It can be argued that the one-dimensional outcome measure is a substantial flaw since only one consequence of the intervention is investigated. The outcome measure may not be a valid representation of the effectiveness of a treatment, because the patients' subjective experiences are not taken into account (Sandler and Braun, 1996).

Cost-utility analysis

The cost-utility analysis (CUA) aims to overcome the one-dimensional limitations of a CEA using utility-based outcome units to compare different interventions (Robinson, 1993d; Cunningham and Hunt, 2000). Utilities are cardinal values assigned to health states and are a measure that an individual holds for certain states of health or disease (O'Brien *et al.*, 1998; Fox *et al.*, 2000). The utility value is a number that represents a condensation of the biological, physical, sociological, and psychological parameters which influence a person's well-being. The value is based on a scale of 0 to 1, where 0 represents death and 1 perfect health. The utility-based measure can then be expressed in terms of 'quality adjusted life years' (QALYs) using a simple calculation, and the QALY acts as a common unit. A utility therefore attaches a number to an outcome, which in some sense represents the strength of preference for the outcome relative to others (Drummond *et al.*, 1997). If the utility value is multiplied by the life expectancy of the subject, a QALY is derived. The gain in QALYs as a result of a treatment can subsequently be assessed. Combining costs with gains in QALYs as a result of a treatment can then provide the cost per QALY gained enabling different treatments to be compared, even if the treatments have completely different outcomes. Importantly, life-enhancing treatments can be compared with life-saving treatments. Various techniques exist to calculate utility values. They all involve detailed and time-consuming intensive interviews with subjects (von Neumann and Morgenstern, 1944; Drummond *et al.*, 1997; Cunningham and Hunt, 2000).

League tables that prioritize interventions using cost per QALY, from the most important to the least important, have been used to guide resources. There is however controversy in the use of QALY league tables, and a draft priority list produced by the Oregon Health Services Commission study highlighted this (Hadorn, 1991).

This treatment priority list was heavily criticized, when it ranked splint use for treatment of tempromandibular dysfunction higher than appendicectomy. It also ranked pulp capping for dental pulp exposure higher than surgery for ectopic pregnancy. This order was established even though the surgical procedures were almost completely effective in treating the potentially life threatening conditions they were used for. By comparison, the dental conditions were minor and sometimes resolved without treatment. The ranking order in the Oregon study was influenced by the analysis. As an example, the overall value of treating 50 to 100 patients with splints or pulp capping was compared with saving a single life. It assumed that treating many patients for a minor condition was equivalent to, or better than, saving one life. The analysis therefore does not allow for human nature, which will always place a high value on life (Jonsen, 1986). In order to resolve this problem, a set of general categories was established which were ranked according to the necessity of the category and the perceived value to the individual and society. Examples of categories included: 'treatment of acute life-threatening conditions where treatment prevents imminent death with a full recovery and return to the previous health state' and 'preventive dental care'.

Individual treatments and their associated conditions were then ranked within each category. This ensured treatments that ranked at the top of a particular category would never rank above those in a higher category, or below those in a lower category. The treatment priority list that resulted was therefore more sensible than the original ranking.

Cost-benefit analysis

Cost-benefit analysis (CBA) is considered to be the most flexible method of economic evaluation (Robinson, 1993e). A CBA aims to place monetary values on both inputs and outputs, i.e. treatment costs and consequence costs. This allows health costs and consequences to be compared with not only other health-related costs and consequences but also non-health-related costs and consequences.

Since both costs and consequences are measured in monetary units, it is possible to calculate whether a treatment delivers an overall gain to society. CEA and CUA are unable to provide this information as costs and consequences are measured in different units. In a CBA, the effects of treatments, such as complications, number of disability days, and number of life years gained, need to be converted into costs. This is not easy, but ultimately allows the results of the analysis to be expressed in terms of either a ratio of cost to benefits or the net benefit (or loss) due to the treatment. CBA therefore provides an absolute cost of a treatment.

Two methods of assessing the consequences of treatment in monetary terms have been described:

The human capital approach. This method is based on the fact that humans are similar to pieces of equipment, and are expected to form a product or activity of some monetary value in future years (Mushkin, 1978). The value of the activity over a period of time is assumed to equal an individual's salary. The benefits of health care can be measured in terms of future income that would have been lost

due to ill health. Using a technique called 'time discounting', the amount of money foregone is adjusted according to the number of years over which it would have been expected to accumulate. This eliminates the influence of time.

The human capital approach places a monetary value on human life and, in the past, ethical objections have been raised (Mooney, 1977). In addition, using an individual's salary as a measure of value may not be valid. Salary only relates to productivity when there are no restrictions within the labour market. Finally, benefits, which do not necessarily result in payment, are excluded in this approach to value human life. There is no measure of the benefits of not having to actually go to work, or of the benefits of reduced pain and suffering due to illness.

Willingness to pay approach. With the 'willingness to pay' approach, observations or stated preferences of individuals are used to value benefits. Using interviews or questionnaires, subjects are asked how much they would be prepared to pay, in order to obtain the benefits of a treatment, or to avoid the costs of ill health. For example, an opening bid is made which the subject can accept or reject. Thereafter, bids are either raised or lowered until the subject's maximum willingness to pay is reached. The starting point of the 'bidding' process may however influence the subject when making choices, and, therefore, the interviewer needs to use discrete questions. The subject is often presented with a series of prices and is asked to offer a yes/no answer depending on their willingness to pay (Robinson, 1993e). Problems may arise because the amount different people are willing to pay for a benefit is variable and influenced by their income. There is also the interesting issue of who judges the willingness to pay. If it is a 'user' (i.e. a patient), they are likely to raise the stakes compared with members of the public. There is excellent data to support this view and the concept that some malocclusions may be 'worth' more than others (Smith and Cunningham, 2004).

Full versus partial evaluations

The four methods of economic evaluation outlined above are termed full economic evaluations because the following criteria are met:

1. there is a comparison of two or more alternatives;
2. cost data are assessed; and
3. consequence data are assessed.

Health care evaluations do not always need to fulfil all three of these criteria and altering the inclusion criteria results in a partial evaluation which can help in the understanding of individual aspects of the costs and consequences of health services.

Identification of costs

Any form of economic assessment requires the identification and measurement of costs relating to the treatment or programme under investigation. Various types of cost can be identified within the health care setting and can be categorized (Donaldson, 1998):

Direct costs

1. Health service costs,
2. other related services, and
3. costs incurred by patients and their families (inputs to treatment and expenses).

Indirect costs

1. Costs incurred by patients and their families (loss of productivity), and
2. costs borne by the rest of society.

Direct costs are the primary costs of a particular health care programme. Indirect costs are secondary costs that relate to paid and unpaid productive activities. Indirect costs can arise when a treatment results in the confinement of patients to hospital or home. They result from a reduction in productive activities, such as those arising from participation in the labour force and from housework.

Health service costs

Individual categories of health service costs need to be assessed separately. Measurement methods for each category are described below.

Staff costs and consumables

Direct costs relating to the use of resources such as professional staff and consumables are generally straightforward to assess. Staffing costs are most often measured in units of time, and consumables by the amounts used. The resource can then be valued or 'costed' by multiplying the unit cost of the resource by the number of units used. For example, the cost to a programme of a particular member of staff can be calculated by multiplying the number of hours that the staff member worked by their hourly salary (Kendall *et al.*, 2000). Using this method, resources used can be translated into costs in different areas or countries where resource use is similar, but where local costs per unit differ. However, difficulties can arise if these calculations are used where resources are shared. For example, one nurse on a ward may care for several patients simultaneously. When assessing the cost of treatment for an individual patient, the costs of the nurse's time need to be allocated to each patient precisely and not arbitrarily.

Capital costs

Costs of capital assets such as land, buildings, and equipment require special consideration. These costs arise at a single

point in time, but the assets tend to be used over a period of time. This means that the opportunity costs (i.e. there is always an alternative use for the capital) are spread over time. An annual equivalent cost can be calculated to aid capital cost assessment, which takes into account the time period of its use. To derive this, the initial cost of a capital asset is converted to an annual sum that is paid for over a number of years. The annual equivalent costs tend to add up to the capital cost plus the opportunity cost of resources used in acquiring that asset. This is similar to the concept of paying off a mortgage, where the original cost of the house plus the interest over the loan period have to be considered. This is reflected in the regular monthly payments.

Annual equivalent costs can be derived from published tables and therefore do not need to be calculated individually. However, problems can arise when assessing the annual equivalent cost of assets that have already been purchased and were in place before the treatment programme under investigation was started. In these cases, the cost of replacing the asset, its rental cost or its market value at the time, can be used as a basis for the calculation.

Overhead costs

Overheads are often shared between departments within a hospital and individual departments may consume differing amounts of the same resource. As a result, difficulties may arise when calculating costs for shared resources. Methods have been devised in order to allocate costs according to resource useage (Drummond *et al.*, 1997). A commonly used 'direct method' is to calculate the overhead use in the department as a proportion of total overhead use for the hospital. This produces a figure that can be multiplied by the total overhead cost for the hospital, to give the cost of that resource to the department. An 'allocation basis' needs to be assigned to the overhead in question to allow this calculation. For example, the allocation basis for housekeeping is often square metres of floor space, and for laundry weight in kilograms.

Other methods of shared cost allocation exist, such as step down and simultaneous allocation. Although these methods can provide more accurate figures they are more complex, as they take into account interactions between the departments supplying the overhead services.

Per diem costs

When assessing costs relating to a treatment, an accurate figure can only be derived by measuring resource consumption for each patient. However, patient-based costing is expensive and problems may arise when trying to apportion shared costs. In order to simplify cost measurement, Hull *et al.* (1982) described the use of *per diem* or per bed day costs for patients staying in hospital. This cost excludes those directly related to medical care, such as drugs and special consumable items. A bed day cost simply includes costs relating to the hotel aspect of staying in hospital. However, it assumes that all patients consume the same amount of resources when staying in hospital and this provides only an average cost per bed day. This may not reflect the actual resource use by a particular patient, especially if the cost per bed day is based on an entire hospital's workload. It is better to isolate a cost per bed day that is related to the particular department or speciality involved in the assessment. The method can also be applied to non-hospital or out-patient clinics in order to calculate costs per patient visit.

The Chartered Institute of Public Finance and Accounting (CIPFA, 2000) maintains a health database and publishes figures on expenditure in various hospital medical specialities. Individual specialities in each hospital trust provide data for the CIPFA and these can be used to establish in-patient bed day costs and out-patient per visit costs. The figures from each hospital trust in the United Kingdom are readily available to the public, and can be useful when costs need to be quickly established.

These issues are best demonstrated by considering the prospective study on surgical treatments of menorrhagia conducted by Sculpher *et al.* (1993). Here, all consumable products were valued using market prices including value added tax (VAT). The study used hospital-estimated unit costs to value routine tests. Drug costs were based on the British National Formulary (2000) prices plus VAT, but a 20 per cent additional cost was added to allow for pharmacy costs. The cost of blood transfusions was assessed using the contract price of red cells plus the handling costs. Operative staff time was valued using the mid-range salary for each relevant member of staff and increased by 11 per cent to allow for employer costs. The cost of equipment that was not considered to be routine was estimated separately, and per patient costs were discounted to take into account the fact that money spent in the future should not weigh as heavily as money spent in the present day.

For routine theatre equipment, costs were taken from figures published in the Bevan Report (Bevan, 1989). These figures were in the form of a cost per minute of theatre time and were adjusted to present day levels. Similarly, the cost of anaesthetic time and theatre overheads were derived from published figures and expressed as a cost per minute.

The total operative costs per patient could then be divided into

1. a fixed cost per patient comprising the costs of non-routine equipment, some staff, drugs, and consumables; and
2. a variable cost per minute of theatre time comprising the costs of routine equipment, routine staff, anaesthesia, and overheads.

The hotel cost of a patient's stay in hospital was estimated by multiplying the daily hotel cost of a patient staying on a

general ward with his/her length of stay. For patients who were admitted to intensive care, the average daily cost for a 'breathing' patient was used to derive a cost.

This study therefore calculated costs in detail and shows the advantages of a prospective study design. The use of *per diem* hotel (an average figure for a hospital ward) does not take into account specialist aspects of care required for patients on an obstetrics ward. In addition, the use of published figures on operating theatre costs may not have been representative of costs in the hospital where the study was conducted. Capital costs were not included in this study, which may underestimate the true cost of treatment, but their omission was probably of little significance since the study compared two different treatments within the same hospital setting.

Costs incurred by patients and their families

Cost data can be gathered according to the following:

Out of pocket expenses for services

Out of pocket expenses can be itemized according to market prices of individual items or services purchased by the patient or family. Items such as special foods and medication, which are not reimbursed to the patient, may be included in this category.

Labour costs of caregivers

Family members who provide care can be asked how many hours per day are spent providing tangible care. Time spent for the sole purpose of keeping the patient company is not included in this figure. For caregivers who sacrifice paid employment, the value of their care services can be calculated using lost earnings. For those who do not lose any earnings, the value of their caregiving can be estimated using the average salary of a health care worker.

Patient's lost earnings

By using the patient's salary and the number of unpaid days or hours taken off work, loss of income can be assessed. Adding these costs will then provide a total cost to patients and families.

These points are illustrated in a study designed to assess the cost of home cancer care to families (Stommel *et al.*, 1993). In this, they placed monetary values on the loss of income and out of pocket expenses of patients and family carers. Values were additionally assigned to the caregiving aspects of home care. Costs were estimated by using lost wages of those family caregivers who gave up work. A set value for the time was used for those caregivers who did not give up any earnings and this equated to the average hourly wage of a home health aide. However, because the study was unable to distinguish between skilled home care services that were provided by caregivers, it is likely that the hourly rate was a low estimate. A number of problems are encountered when assessing the cost of treatment or illness to patients and their families:

1. loss of home production, such as cooking and 'do it yourself' has ramifications, including increases in take-away food costs and for home maintenance or improvements. These costs are very difficult to measure and cannot be easily taken into account;
2. measures for the psychological costs of treatment or illness are not available; and
3. the methods may not take into account future promotions at work, which may be lost due to treatments or illness.

The described methods tend to underestimate the patient and family costs, due to the fact that certain intangible costs cannot be easily assessed (Jacobs and McDermott, 1989).

Discounting costs

In health care, costs often occur immediately, whereas benefits tend to occur at a later stage (Kobelt, 1996). This is seen, for example, in vaccination programmes and anti-hypertensive treatments used for the prevention of illness. In addition, costs and benefits can occur at different times where treatment continues over a long period, such as with treatments for chronic illnesses. Difficulties can arise when comparing costs that occur over a protracted time period, and cost discounting methods have been introduced to overcome them. It is important to understand that cost discounting is not performed to account for changes as a result of inflation. Instead, it works on the principal that people prefer to have benefits sooner and pay costs later. Cost discounting should therefore be considered when assessing costs in health care.

Economic evaluation within the dental specialities

Economic evaluation is used less frequently in dentistry than in medicine (Cunningham, 2000). Most published economic studies are cost-effectiveness and cost-benefit investigations, with a handful of utility-based studies (Dodson and Pfeffle, 1995; Severens *et al.*, 1998). Studies in dentistry have focused on the costs of restorative materials, fluoride supplements, and caries prevention (Marynuik *et al.*, 1988; Mjör *et al.*, 1997). An example of a cost-effectiveness study is that by Severens *et al.* (1998) who assessed the short-term cost-effectiveness of pre-surgical orthopaedic treatment in children with complete unilateral cleft lip and palate. This study was a three-centre randomized clinical trial comparing children who received pre-surgical orthopaedic treatment with those who did not. The short-term cost-effectiveness was analysed based on the time taken for surgical lip closure as well as medical and non-medical costs until lip closure at 18 weeks. There was no difference in the duration of lip closure procedures.

However, those who did not receive pre-surgical orthopaedic treatment had a significantly reduced mean medical cost. The study was limited, in that it only assessed one parameter regarding short-term effectiveness, which was the duration of the surgical procedure. Other parameters, such as appearance after closure, continuity of the vermilion border, and function of the orbicularis muscle should also be taken into account. This is an ongoing study which will yield significant information on both the clinical and cost-effectiveness of care (Kuijpers-Jagtman and Prahl-Andersen, 1997; Prahl *et al.*, 2005).

Pietilä *et al.* (1998) conducted a cost and productivity analysis of orthodontic care in Finland. They found that there was a wide range in the cost of providing orthodontic care and that general dentists who had little orthodontic experience were associated with the highest costs. They concluded that savings could be made by devolving treatment to experienced orthodontists. The study was limited, in that it was largely based on information from questionnaires with no measurement of the benefits of treatment.

There have been some recent studies in the orthodontic literature which relate to issues associated with cost utility in orthognathic treatment (Cunningham *et al.*, 2003), willingness to pay for orthognathic treatment (Smith and Cunningham, 2004), and cost-effectiveness of orthodontic treatment (Richmond *et al.*, 2004). These data will become an increasingly important part of health care planning, particularly if state funding is a major stakeholder.

Ethnicity and cost

Patient factors such as gender and ethnicity may well influence costs but much variation exists, depending on the condition or illness and type of treatment involved.

To assess the variation in the cost of diabetes due to ethnicity and race, Jacobs *et al.* (2000) performed a retrospective study on a Canadian aboriginal population. North American Indians were found to use more resources than other Americans. The excess costs because of higher disease prevalence in North American Indians added 15.9 per cent to total costs, while excess costs as a result of utilization added 14.9 per cent to the costs.

Staffing costs

The various categories and grades of staff may well influence the costs of treating a patient. In a prospective study on the cost and outcome of treatment of chalazia (eye cysts) by medical and nursing staff, the cost of treatment by a nurse was found to be 18 per cent lower than when treatment was performed by a senior house officer. This was even though the nurses were paid a higher salary (Jackson and Beun, 2000). This study assumed that all staff took the same amount of time to perform the treatment. This is however unlikely. A previous 10-year study on 2858 patients undergoing thyroidectomy (Martin *et al.*, 1989) demonstrated a 15 per cent increase in operating time when surgical trainees operated instead of a consultant. This study suggested that differing demands on time and operative facilities by different grades of operator influence costs.

Length of hospital stay

Cost analyses in a number of specialities have found that the length of hospital stay is highly influential on the total cost of care. For example, in a study on the cost of fractures of the neck of the femur, the acute ward costs accounted for 68 per cent of the total acute care costs and the operation itself for only 28 per cent (French *et al.*, 1995). Therefore, the fact that patients on average stayed on the acute ward for 17 days is of significance.

Complications of treatment

Costs relating to surgical treatment are based not only on the treatment charge itself but also on the costs of complications arising from it. A complication such as perioperative infection may be treated with antibiotics at little cost, whereas one related to surgical fixation may necessitate a further operation at considerable cost. A cost-effectiveness study on the use of different types of fixation to treat mandibular fractures (Dodson and Pfeffle, 1995) found that treatment of post-operative complications varied from $3700 to almost $30 000. This study used complication rate data as its measure of effectiveness. The study incorporated a threshold or 'break-even' analysis, in order to estimate at what difference in complication rates the study became indifferent to the choice in fixation alternatives. The findings indicated that rigid fixation was more cost-effective than non-rigid fixation, given the probability of complications.

Conclusion

The current pressure to deliver health care in a cost-effective environment needs to be supplemented with studies which evaluate the economics of health care. This review has highlighted the main methodologies available and the progress that orthodontics is making in this area.

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