6 Economic Analysis

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Importance of economic analyses

With rising healthcare costs, it is important for decision-makers to efficiently allocate resources. Between 1970 and 2008, the percentage of the United States gross domestic product (GDP) spent on health care has increased from 7.1% to 16%.[1] Economic evaluations are important because people, time, facilities, equipment, and knowledge are scarce resources, and choices need to be made in order to determine optimal utilization.[2,3] Economic analyses identify, measure, value, and compare alternative courses of action in terms of costs and consequences.[2,3] They provide standardized, quantitative estimates of the likely cost per unit of health benefit achieved by a given procedure, which help reach the primary goal of identifying procedures that produce the greatest health benefit for a given cost.[1] The breadth of outcomes considered varies according to the type of economic analysis performed. Furthermore, the costs and benefits considered vary depending on the viewpoint adopted in the analysis. Thus, economic analyses vary in scope, perspective, applicability, and complexity.[4] Economic analyses in orthopedic surgery are particularly important, as this field has experienced tremendous growth and innovation over the past two decades.[4]

Top six questions

1. What are the different types of economic analyses?
2. Which costs are included in an economic analysis?
3. What perspective is adopted in an economic analysis and how does this affect the costs included?
4. What is the time horizon adopted in an economic analysis?
5. What are sensitivity analyses?
6. How are economic evaluations interpreted?

Question 1: What are the different types of economic analyses?

The four types of economic analyses most commonly reported in the literature are cost-minimization, cost-effectiveness analysis, cost-utility analysis, and cost-benefit analysis. Each of these analyses involves the systematic identification and valuation of the relevant costs and consequences of healthcare interventions.[4]

Cost-minimization analysis

A cost-minimization analysis (CMA) is used to compare cost differences among competing alternative procedures when these treatments produce equivalent outcomes.[3,4] Only the costs of each alternative procedure, which are selected based on the chosen perspective, are considered and the least costly alternative is supported. While CMAs may provide useful information by identifying all of the costs associated with a particular treatment, they can be used to compare treatments only when there is strong clinical evidence that patient outcomes are the same or similar. Otherwise, inclusion of only costs can lead to misleading results.[4]

An example of an appropriate use for a CMA is a comparison of absorbable internal fixation devices (N = 994) and conventional metallic devices (N = 1173) in fracture patients.[5] Several randomized controlled trials (RCTs) comparing these devices have shown no significant difference in outcomes, therefore a CMA is an appropriate analysis

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to conduct. The costs included in the CMA resulted from the patients' medical care and their time lost from work. When the costs for an implant removal procedure after metallic fixation were included, the average cost saved per patient by using absorbable implants in fractures of the olecranon was $410. Due to this cost saving, the authors concluded that absorbable implants should be the standard treatment.[5]

Cost-effectiveness analysis

In cost-effectiveness analysis (CEA), both the costs and consequences of health programs are examined.[2] A CEA compares procedures in terms of their monetary value per natural unit of health outcome (i.e., cost per life saved, cost per limb salvaged, etc.).[6] When conducting a CEA, a perspective is selected to identify which costs are included, and the measure of effectiveness is established. It is important to provide a thorough description of the categories of costs included and how the effectiveness data are to be obtained. The medical literature is an important source of effectiveness data; however, an appraisal of the quality of the data is important. In situations where limited or no clinical evidence exists, the CEA may proceed by making assumptions about the clinical evidence, and then undertake *sensitivity analyses* of the economic results with differing assumptions. A sensitivity analysis is a statistical method used to account for uncertainty in an economic analysis.[7] If such analyses reveal that the final result is not sensitive to the estimate used for a given variable, then the inferences made using these data are more robust.[8]

Cost-effectiveness is typically expressed as an *incremental cost-effectiveness ratio (ICER)*. An ICER is an estimate of the additional cost per additional unit of effectiveness of using one treatment in preference to another. In estimating an ICER, the numerator of the ICER is the difference of the mean cost of each procedure, and the denominator is the mean difference of the effectiveness.[3,4,6] The equation for the ICER is:

$$\text{ICER} = [\text{Cost}_{(\text{Treatment A})} - \text{Cost}_{(\text{Treatment B})}]/ [\text{Effect}_{(\text{Treatment A})} - \text{Effect}_{(\text{Treatment B})}]$$

Cost-effectiveness studies do not consider subjective factors such as patient preferences and the value of a particular treatment or health state to a patient. One advantage of this technique is that, with a common unit of outcome or effectiveness, different procedures can be compared and can be expressed in terms of cost per unit of outcome. However, CEAs are not helpful for choosing between treatments that have different outcomes or for which the outcomes were measured with different techniques.[4] For example, a study which uses the outcome of life-years saved cannot be easily compared to a study where the outcome is disability days avoided, as these are not common units of effect.

An example of an appropriate cost-effectiveness study would be an evaluation of the cost per successful union in the treatment of open tibial fractures. The first treatment option of intramedullary nailing without reaming may cost $25,000 per patient, whereas treatment by external fixation may cost $20,000. Recent studies report that intramedullary nailing yielded a much lower rate of nonunion (15%) than did external fixation (42%). Thus, even though intramedullary nailing is more costly, it is more cost-effective for the treatment of open tibial fractures because of the lower cost per successful union.[4]

Cost-utility analysis

The cost-utility analysis (CUA) is a form of evaluation that focuses on the quality of the health outcome produced or forgone by health programs.[2] A CUA differs from a CEA because the incremental cost of a program from a particular perspective is compared to the incremental health improvement attributable to the program expressed in terms of a single *utility-based* unit of measurement and not natural units as in a CEA. Examples of utilities include *quality-adjusted life-years (QALYs)* gained and *disability-adjusted life-years (DALYs)* gained, thus the results are expressed as a cost per QALY or DALY gained.[2] An *incremental cost-utility ratio (ICUR)* can be calculated, which is similar to the ICER in a CEA.[2] To value health utility, or benefit, a variety of approaches are adopted, including the *standard gamble (SG)*, *time trade-off (TTO)*, and *visual analog scales (VAS)*. All are based on the value individuals place on not having a particular disease.[5] The consideration of quality recognizes that individuals have different preferences for certain states of health.[5]

Definitions

- **QALY:** Quality-adjusted life-years is a measure of life expectancy weighted by the quality of life.[3] A QALY is computed as a year of life gained, multiplied by the utility score during that year, which is expressed on a scale of 0 to 1.[6]
- **Standard gamble:** Respondents considering a particular health state find the balance between a chance of returning to perfect health and a risk of possibly dying in the process.[6]
- **Time trade-off:** Respondents find the point of balance between a shorter life in perfect health vs. a longer life in the health state under investigation.[6]
- **Utility:** A term used by health economists for the strength of preference for a state of health, attribute, or procedure.[3,4,6] A higher value is placed on time spent in good health and a lower value is placed on time spent with impaired physical and emotional function.[4] The values range from 0 to 1 (perfect health).[3,7]
- **Visual analog scale:** Respondents indicate the desirability of a health state on a line with well-defined endpoints, usually from 0 to 1.21.[6]

By converting effectiveness data (i.e., Harris hip score) to a common unit of measure (i.e., QALYs gained) a CUA is able to incorporate simultaneously both the changes in the quantity of life (mortality) and the changes in the quality of life (morbidity).[2] Also, the measurement of utilities allows for valid comparisons among multiple treatment options, particularly when alternative treatments produce different outcomes or when longer survival is acquired at the expense of reduced quality of life.[4]

Haentjens et al. provide a practical example of a CUA in which they compare the costs and health outcomes of standard versus prolonged prophylaxis with low molecular weight heparin (LMWH), among patients undergoing elective total hip or knee replacement.[6] The study adopted the perspective of a societal healthcare payer, in this case the Belgian Federal Ministry of Health. Costs were obtained from a panel of orthopedic surgeons and from the Federal Ministry of Health, while QALYs were based on utility scores found in the literature. The authors found that prolonged prophylaxis with LMWH was associated with a cost-utility ratio of €6,964/QALY after total hip replacement and €64,907/QALY after total knee replacement.[9] According to European guidelines, an intervention costing less than €20,000/QALY exhibits strong evidence for adoption while one costing €20,000–100,000/QALY exhibits moderate evidence for adoption.[9] The authors therefore concluded that there is strong evidence for adoption of prolonged enoxaparin prophylaxis among total hip replacement patients, but only moderate evidence for adoption among total knee replacement patients.[9]

Cost-benefit analysis

Cost-benefit analyses (CBA) provide an estimate of the monetary resources consumed by each procedure under study compared to the value of resources the procedure might save.[8] In a CBA both the costs and health outcomes are valued in monetary units.[2–4,6] One method of assigning values to health consequences is by determining a patient's willingness to pay.[4] In practice, it is difficult to quantify health consequences in monetary terms, and ethical issues exist in assigning an amount of money to the value of human life, pain, and suffering.[6] After the costs and consequences are quantified in monetary terms, a direct comparison can be made between the program's incremental costs and its incremental consequences in equal units of measurement.[2] To compare treatment options CBA commonly uses two comparators, the *net present value* and the *cost-benefit ratio*. The net present value is the value of health benefits minus costs, and the cost-benefit ratio is the ratio between the two.[6] CBA has the advantage of allowing direct comparisons across programs. Also, the analysis of a single program can determine whether it is economically worthwhile.[4,6]

Vasen et al. provide an example of a CBA.[10] They compared the total cost of open vs. endoscopic technique for the surgical treatment of carpal tunnel syndrome, from a societal perspective. The costs included those incurred from medical procedures and complications as well as from lost wages. The authors hypothesized the two procedures could have different complication rates and different amounts of time off work. For this study design, outcomes were given a dollar value. Outcomes such as infection and nerve injury were translated as a cost in dollars. All complications except nerve laceration were assigned a cost of the operative correction of the complication plus 1 year's wages, because it is assumed that patients with complications would not return to work for 1 year. Patients with nerve lacerations were assigned the present value of their wage replacement throughout the remainder of their life expectancy in addition to cost of the operative procedure. In the base case, the cost (including surgery, complications, and wages) of the open technique was found to be $6,315 and that of the endoscopic technique was found to be $5,896, indicating that the endoscopic technique is the less costly alternative.[10]

Question 2: Which costs are included in an economic analysis?

The costs included in an economic analysis will vary on the basis of the time frame and perspective being considered in the study. Ideally, a thorough economic analysis measures direct, indirect, and intangible costs. Direct medical costs include all costs that are directly related to the procedure, including those for personnel, supplies, and the facility involved in the treatment. Direct nonmedical costs include costs borne by patients and their families in the course of treatment (i.e., transportation).[4] Indirect costs include costs associated with lost productivity, usually valued as lost wages or a monetary value of time. For determination of intangible costs, an attempt is made to assign a dollar value to reductions in quality of life. Those costs are often included in the measurement of QALYs. It is also important to consider the downstream costs of resources that will be consumed in the future but are still attributable to the procedure.[4] An allowance for the differential timing of costs and consequences due to time preference is also required. Thus, economic analyses should discount costs, and the rates of three and five percent are recommended.[2]

Question 3: Which perspective is adopted in an economic analysis and how does this affect the costs included?

Before beginning any economic analysis, the perspective of the analysis needs to be determined and explicitly stated.

Perspectives that can be adopted include that of the government, the hospital, the primary payer, or society.[7] If the economic analysis is completed from a governmental perspective, an interest in identifying the employment costs may be apparent.[8] The hospital perspective includes only costs that are incurred by the hospital, such as the costs of the surgery, costs of diagnostic tests, the cost of the medical device, the cost of the medications the patient takes during their hospital stay, and the cost of staying in the hospital ward. In contrast, the perspective of the primary payer includes all medical costs that are covered by the primary payer, in addition to those incurred in the hospital. For example, both in-hospital costs and costs after the patient has been discharged are included (e.g., home care and medications).[7] The societal perspective includes all costs related to the treatments and is not limited to medical costs. Examples of additional costs include time lost from employment and all patient expenses.[7] The societal perspective is generally recommended, especially if the analysis will otherwise overlook an important financial burden to the patient, their family, and society in general.[7]

Question 4: What is the time horizon adopted in an economic analysis?

The time horizon of a healthcare economic evaluation is the period of time for which the costs and outcomes are measured. The time horizon should be specified and justified as being appropriate for the clinical condition being studied. Other time-sensitive issues that should be considered include technological improvements and overall societal well-being that occur over time, as well as the learning curve effect that follows the introduction of a new technology.[4]

Question 5: What are sensitivity analyses?

Sensitivity analyses are a method of accounting for uncertainty in an economic analysis.[7] Sensitivity analyses are utilized to assess the impacts of various model parameters or assumptions on the study results.[2,4] There are three key elements to consider when conducting a sensitivity analysis: (1) how the uncertain parameters are identified; (2) how the plausible ranges for the variables are specified; and (3) whether an appropriate form of sensitivity analysis is used.[2]

There are five different forms of sensitivity analyses. The simplest is the *one-way analysis*. Estimates for each parameter are varied one at a time in order to investigate the impact on study results.[2] A *multi-way analysis* recognizes that more than one parameter is uncertain and that each could vary within its specified range.[2] In a *scenario analysis*, a series of scenarios is constructed to represent a subset of the potential multi-way analyses. The scenarios typically include the most realistic (best guess), optimistic (best case), and pessimistic (worst case). The analyst may also include scenarios that they feel are applicable.[2] A *threshold analysis* identifies the critical value(s) of a parameter or parameters central to the decision. The analyst can then assess which combinations of parameter estimates could cause the threshold to be exceeded.[2] Alternatively, the threshold values for key parameters that would cause the program to be too costly or not cost-effective could be identified.[2] The fifth form of sensitivity analysis is the *probabilistic sensitivity analysis*. In this type of analysis, probability distributions are applied to the specified ranges for the key parameters. Samples are then drawn randomly from these distributions to generate an empirical distribution of the cost-effectiveness ratio.[2] If the sensitivity analysis for an economic evaluation reveals that the final result is not sensitive to the estimate of a given variable, then the inference made using these data are stronger.[8]

Question 6: How are economic evaluations interpreted?

The goal of an economic evaluation is generally to compare two treatment options in order to select the one that provides the maximum health benefit for a given increment of cost. There are nine possible outcomes when comparing one procedure to another in a CEA (Figure 6.1).[2] In particular, cell 1 in Figure 6.1 shows that the new procedure is less expensive and more effective than the standard treatment, and should be adopted. In cell 2, the new procedure costs more and is less effective than the standard treatment, and should not be adopted. The most common case is when a new procedure is both more effective and more costly (cell 7). In this case, the hospital administration, surgeon, and patient need to determine if the increased effectiveness is worth the additional cost.[2] When the result falls into a nondominance cell (cells 7–9) it may be useful to calculate the ICER or ICUR of the new procedure.[4] Additionally, guidelines exist to recommend whether to adopt or reject a new procedure. For example, in North America US$50,000/QALY is often recommended as a threshold for a cost-effectiveness procedure. Procedures which have an incremental cost higher than this are likely to be rejected.[7] For example, in the study by Haentjens et al. described previously,[9] the European guidelines for CUAs indicate that a procedure costing less than €20,000/QALY exhibits strong evidence for adoption, whereas one costing €20,000–100,000/QALY exhibits moderate evidence for adoption. Thus, according to these standards, the authors found strong evidence for adoption of prolonged prophylaxis among total hip replacement patients, and moderate evidence for adoption among total knee replacement patients. Sensitivity analyses incorporating 20% changes from the base-case analysis showed this outcome to be robust.[9]

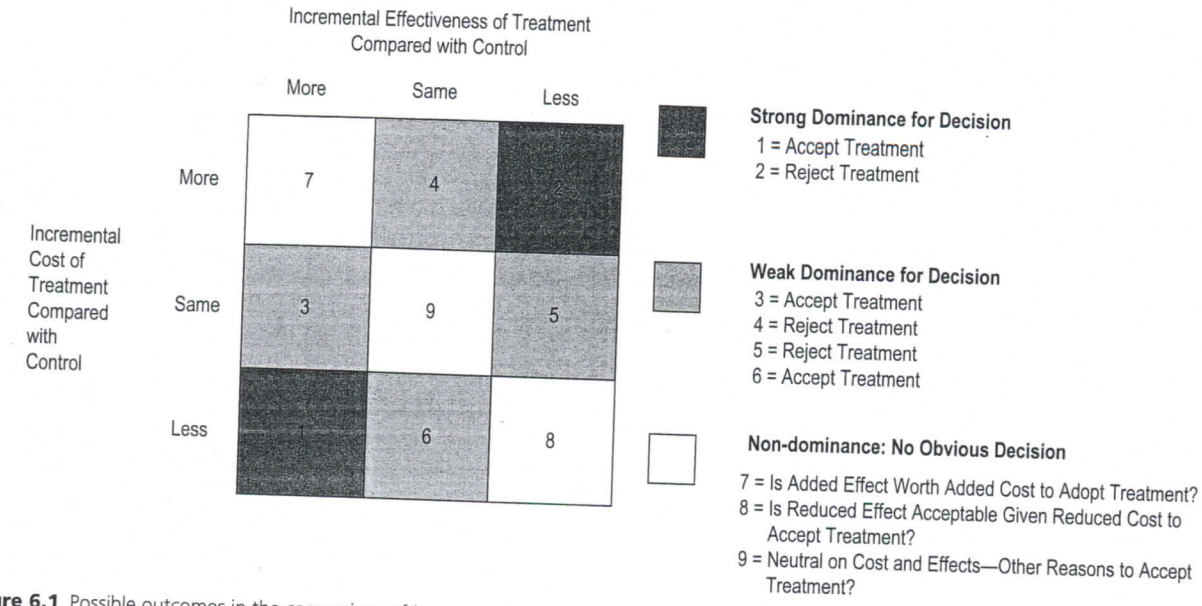

Figure 6.1 Possible outcomes in the comparison of incremental costs and incremental effectiveness of two procedures. (Reproduced from Methods for the Economic Evaluation of Health Care Programmes (Third Edition) by Michael F. Drummond, Mark J. Sculpher, George W. Torrance, Bernie J. O'Brien and Greg L. Stoddart (2005), Figure: Box 2.2, p. 13. By permission of Oxford University Press.)

Lastly, it is important to assess whether the conclusions of another study are applicable to the clinician's own practice (i.e., in terms of patient population, practice patterns, level of resource consumption, and relative costs).[4]

Conclusions

In view of rising healthcare spending, it is becoming increasingly important to use the most cost-effective health program that fits within the available budget. The use of economic analyses can help determine which health program provides the greatest effect at lowest cost. It is important to carefully consider the perspective, time horizon, discount rate, and sensitivity analyses when interpreting economic analyses. High-quality economic analyses are important for orthopedic research.

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