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Reviews

An introduction to economic analysis in medicine — the basics of methodology and chosen terms. Examples of results of evaluation in nuclear medicine

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Abstract

This article overviews the basic terms and methodology approaches in economic analysis in medicine: cost-benefit analysis, cost-effectiveness analysis, cost-utility analysis and cost-minimisation analysis. Particular emphasis is put on nuclear medicine economic evaluation, e.g. FDG - PET studies, sestamibi breast cancer imaging and radioiodine therapy of hyperthyroidism.
Key words: economic analysis, cost-benefit analysis, nuclear medicine

Introduction

Health care reforms introduced in most Central and Eastern European countries after 1989 caused the need to improve economic evaluation on every management level of medical decision-making and medical technology decision-making. The transition from a state-financed health care system to a semi-market system forced the implementation of economic evaluation of medical technology. Medical technology is interpreted here as drug dispensing, usage of medical equipment, choosing surgery methods or any other medical intervention, etc. For example — on the American market, every Health Maintenance Organisation has a separate team devoted to the economic evaluation of medical technology, particularly with new technologies. This review presents the basic methods of economic analysis in medicine, with particular emphasis on nuclear medicine applications.

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Forms of evaluation

The aim of health economics is to identify the interventions that produce the best health output with the available resources. Economic evaluation analysis compares at least two alternative interventions or activities with regard to costs and consequences.

There are five commonly used forms of economic evaluation of medical procedures:
— cost-benefit analysis (CBA);
— cost-effectiveness analysis (CEA);
— cost-utility analysis (CUA);
— cost-minimisation analysis (CMA);
— decision analysis (DA).

Cost-benefit analysis

Cost-benefit analysis (CBA) evaluates benefits of health care, comparing competing alternatives of medical procedures in monetary terms. It is most commonly applied when the benefits of competing investments are quite different. To express benefits like saving life or relief of pain in monetary terms in this mode of analysis is a very complicated problem. Also the market price is not always equal to that which we are able or willing to pay in a particular situation (the so-called consumer surplus — for example we are willing to pay more for water when we are thirsty).

If medical intervention prolongs the life of the patient, the benefits of health care are valued in monetary terms, using the human capital approach. By the human capital approach we derive a valuation for the extended lifetime by the assumption that the wages paid to individuals represent a value of the extra life. The usefulness of this approach is, however, limited, because how are we to value the health improvements for retired or unemployed people?

Using the willingness-to-pay analysis, there are two main ways of estimating benefits from the programme:

— revealed preference — this is the maximum which individu als would hypothetically pay; most often revealed preference concerns health risks e.g. for automobile safety belts or reducing indor radon exposure [1];
— expressed preference — this is how much the individual is able to pay for health state improvement e.g. for hypertension treatment [2].

Cost-benefit analysis is conducted either by interviews (face to face or by telephone call) or mail questionnaires used to determine the willingness to pay. Sometimes it is argued that these questions are often difficult and ethically hardly acceptable.

Medical applications of cost-benefit analysis are rather in experimental stage and are not so widely applied, as remaining four other modes of economic analysis.

Cost-effectiveness analysis

Cost-effectiveness analysis (CEA) is the most suitable technique when the benefits of competing interventions can be expressed in the same natural units. Sometimes instead of the final outcome we use an intermediate marker to measure a benefit. For example, if two diagnostic strategies are being compared, the "cases detected" parameter might be chosen.

Using this kind of technique for analysis, we are looking for an answer to the question "what is the most efficient way of spending a given budget?" So in other words what is the cheapest way of producing effectiveness units. The results are expressed as cost-effectiveness rate, which show costs achieved by the effectiveness unit;

CER = costs/health effects (e.g. years of life gained)

The denominator of a cost/effectiveness ratio is reserved for the improvement in health associated with an intervention. The numerator captures changes in resources used associated with an alternative intervention, expressed in monetary units.

The incremental cost-effectiveness ratio (ICER) is one of the most general ways to compare a newly emerging strategy with an existing one. This ratio compares the difference in costs between the two strategies, divided by the difference in their effectiveness [3].

The main categories of resources used that should be included are: the costs of health services, the costs of patient time expended for the intervention, costs associated with care-giving and other costs associated with the illness (e.g. child care or travel expenses) [4]. In spite of the widespread application of cost-effectiveness analysis in practical use in health care, in fact there is still a lack of well-defined standards. These disparities can be traced to a misunderstanding between decision-makers. This fact was the main motivation for the Panel on Cost-Effectiveness in Health and Medicine in order to develop the consensus-based recommendations guiding the conduct of a CEA to improve the comparability and quality of studies. The Panel's recommendations define a reference case, a standard set of methods to serve as a point of comparison across studies [5, 6].

CEA is important from many different aspects. These include the following:

— helping nuclear medicine physicians to understand how a given medical procedure fits into the overall management of a patient;
— providing objective data that justify the role of a particular study;
— allowing the physicians to understand how effectively/poorly the test can perform, e.g., how low the sensitivity can get, and yet still be cost-effective;
— allowing the obtaining of answers to "what if" questions, e.g., how expensive can a newly emerging technology be, if it should remain cost-effective in a given set of applications?
— helping nuclear medicine physicians to understand what portion of the receiver-operator characteristic curve we should operate to be most cost-effective;
— allowing nuclear medicine physicians to present objective evidence to hospitals, insurance companies and regulatory agencies, leading to a more rapid acceptance and reimbursement for newly emerging technologies [3].

The application of cost-effectiveness analysis generally focuses on the quantity parameters of patient outcome (e.g. number of pain-free days, number of lives saved or number of metastases detected, etc.).

Cost-utility analysis

With reference to quantity analysis in CEA, quality analysis has been created in a form of cost-utility analysis (CUA).

Cost-utility analysis compares results of medical interventions mentioned in utility units. Usually it expresses the number of additional years of life produced by medical intervention, with special regard to the quality of these years. The most commonly used measure in cost-utility analysis is Quality Adjusted Life Years (QALY) — 1 year of life gained with medical intervention equals 1 of QALY. Two years of life in a healthy state judged to be halfway between full health and death would be equivalent to one year in full health [2]. In general, health state is scaled from 0 (dead) to 1 (optimal health). It is not easy to measure the value of a healthy state and there are different methods used for this purpose: standard gamble, time trade off or Visual Analogue Scale, where the respondent is asked directly. Indirect methods for estimation of health state rely on health classification systems such as Quality of Well-Being Scale, Health Utilities Index or Euro-Qol.

Cost-minimisation analysis

If the health effects of two alternative interventions are known to be equal, and only the costs need to be analysed we use cost--minimisation analysis (CMA). This least costly alternative is the most efficient, for example goitre resection or radioiodine therapy for hyperthyroidism [7–9].

Decision analysis

This is applied when only the health effects of medical intervention are important. Alternative intervention has the some cost, or costs are not important in a particular decision situation.

Table 1. Main differences between the modes of economic analysis

	Costs measured	Benefits measured	When most appropriately used
CBA	All relevant costs associated with the intervention	Benefits valued in monetary terms	To compare alternatives that produce quite different benefits
CEA	All relevant costs associated with the intervention	Benefits expressed by some common measure of effect	To compare alternatives where the outcomes can be expressed in a common natural unit
CUA	All relevant costs associated with the intervention	Benefits expressed by changes in patient utility. Normally a composite of the extension of life weighted by an index of utility or quality (QALY)	To compare alternatives with quite different benefits but relies on the measurement of QALYs
CMA	All relevant costs associated with the intervention	Benefits assumed to be identical	When two alternatives have the same outcome
DA	No	Benefits measured in units comparing different types of medical intervention	When only the results of the intervention are important

The main differences between the modes of economic analysis in medicine are presented in the Table 1.

Important problems in economic analysis in medicine

The choice of the object of the study

A full economic evaluation should compare at least two alternative interventions. Each of them should be real and well--defined. The aim of such a study should be well defined, as well as the patient group on which the study is conducted. Each study should consider both costs and outcomes.

The perspective of the analysis

It is very important to state the perspective from which the study will be valued. The strategy most economic from the perspective of a hospital may not be the best suited to the health care system as a whole [1]. Studies based on different perspectives are not comparable and can lead to misunderstandings. Because health care provides benefits to society as a whole it is the perspective of society that should be represented in any evaluation. The societal perspective is the most pragmatic choice because it represents the public interests rather than those of any particular group.

Modelling

To conduct an economic analysis we often use data provided by randomised controlled trials or observational studies. Unfortunately clinical studies do not always include economic data or do not follow up patients for long enough after intervention. We can complete such insufficient data by modelling.

Modelling techniques enable the extension of evaluation to beyond what has been observed. They can be used to extrapolate the clinical outcomes (like survival) beyond a point observed in a trial — for example the progression of disease in patients with asymptomatic AIDS or to transform final outcomes from intermediate measures — for example, survival and coronary heart disease events from cholesterol concentrations [2].

Modelling is often used in pharmacoeconomy, where health benefits are likely to occur in the future and there is no prospective date yet.

Time preference and discounting

In many medical interventions benefits and costs may occur in the future. For example, heart surgery may provide benefits for patients in the future, but also may create additional future costs, such as consultations of specialists and additional pharmacotherapy. Costs and benefits that occur in the future should be reduced (discounted) to their present value because of "time preference". This means that we would rather have something now than in the future, because the present time has more value for us. The recommended discounted rate varies between 3 and 6% [1].

Uncertainty

Uncertainty often exists around an economic evaluation. There are three types of uncertainty: uncertainty related to observed data inputs, uncertainty in relation to modelling and uncertainty in relation to analytical methods.

Choice of the proper economic analysis mode

The choice of the proper economic analysis mode depends on the kind of question which we want to be answered. If we want to know if the benefits are greater than the costs, then CBA should be used. If we have an established goal and a budget for this goal, we are looking for a form of evaluation which will give us an answer as to which medical intervention will give us maximum returns within a given budget. Cost-effectiveness analysis or cost-utility analysis are most suited in this case. If the outcomes of two or more alternative methods are equal, we use the cost-minimisation analysis.

Examples of the results of economic evaluation in nuclear medicine

As nuclear medicine physicians, we are often not informed how the result of particular imaging modality fully affects a particular patient's entire medical/surgical management. This is perhaps best exemplified by oncology management, which is complex and with rapidly changing management options [3]. We would like to present below some examples of utilising economical analysis in nuclear medicine.

FDG-PET

In patients with non-small cell lung cancer (NSCLC), FDP-PET is considered superior to CT in detection of hilar and mediastinal lymph node metastases [10–13]. Gambhir et al. [14] used decision tree analysis to assess the cost-effectiveness of a PET-based strategy for the staging of NSCLC. Their first decision tree was constructed conservatively, requiring mediastinoscopy and biopsy to confirm pathological CT or PET results, so that no patient with a surgically curable disease would miss the opportunity of receiving surgery. By avoidance of unnecessary surgery the CT and PET strategy showed a saving of $1154 per patient without a loss of life expectancy as compared with the alternative strategy of CT alone. A less conservative decision tree, in which only patients with non-concordant imaging results had the biopsy, was also analysed in this study. Then CT and PET strategy showed savings of $2267 per patient but missed 1.7% of the potentially curable patients. A possible loss of QALYs in this algorithm was not analysed in this study.

In patients with radiographically indeterminate solitary pulmonary nodules, PET is useful for determining the probability of cancer. Although the specificity of PET seemed to be lower than its sensitivity, better specificity of PET over CT leads to its greater potential utility in avoiding unnecessary surgery in patients with benign solitary pulmonary nodules [15].

Although PET was more expensive than CT, the additional cost of PET would be minuscule compared with the cost savings achieved through the avoidance of unnecessary thoracotomy. If there were only a 1 in 20 chance that a patient with a negative PET study would have a malignant solitary pulmonary nodule, most clinicians would opt for watchful waiting rather than proceeding immediately with an unnecessary diagnostic thoracotomy.

Both indications for FDG-PET (NSCLC and solitary pulmonary nodules) were met with acceptance by the Health Care Financing Administration in the United States [16, 17].

Sestamibi breast cancer imaging

The decision tree analysis by Hillner [18] compared sestamibi breast imaging, stereotaxic core biopsy and surgical biopsy as breast evaluation strategies for hypothetical cohorts with non-palpable breast lesions. Since sestamibi imaging was the lower-cost strategy, the incremental cost-effectiveness of core biopsy was estimated at $18,000 for each early invasive and in situ detected cancer. The sestamibi strategy delayed diagnosis for 6 months in 2.5 out of 100 invasive cancers. The consequences of a 6-month delay in diagnosis for patient survival through an increased risk of micrometastatic disease are unknown. The clinically relevant cost-effectiveness ratio therefore remained unclear. A contrary conclusion from the decision tree analysis might be drawn: the incremental cost of $18,000 for the additional early diagnosis of cancer might be acceptable in comparison with the costs of annual mammographic screening of $10,000–$190,000 per QALY.

The assumption of 90% sensitivity of sestamibi breast imaging for invasive cancer and in situ cancer seems however too optimistic, judging by the average findings presented in the other clinical data. Thus, the use of sestamibi breast imaging as an alternative to biopsy is only applicable in a selected patient population [1].

Radiodine treatment of Graves' disease

Another interesting example of cost-effectiveness analysis concerns radioiodine or antithyroid drugs as first-line therapy of hyperthyroidism due to Graves' disease [19]. As first-line therapy of hyperthyroidism caused by Graves' disease, antithyroid drugs are preferred in Europe, whilst radioiodine therapy is preferred in the USA. Radioiodine therapy has been considered to be more economic in Germany, since the new recommendations by the Federal German Radiation Protection Committee (SSK) for patient discharge guidelines. This analysis took into account the long-term relapse rate of conservative or radioiodine therapy, costs and sensitivity of diagnostic tests, drops in productivity and a discount factor. Costing models included the costs of follow-up care over 30 years. The costs of the hospitalisation for radioiodine therapy were calculated for 300 patients, discharged with 250 MBq I-131 residual activity. Antithyroid drugs were considered cost-effective when they achieved a relapse rate of 50% or less, a cut in the number of tests needed and reduced working hours. Failure to meet any one of these conditions made primary radioiodine therapy more cost-effective in 1593 of 1944 calculated costing models. Repeated conservative therapies will increase clearly the overall costs. The conclusion is that radioiodine is a cost-effective, first-line therapy in patients with a special risk of relapse after primary conservative therapy.

Summary

Decision-making in medical financing of technologies requires the best information and medical expertise based on credible evaluation. In the near future, especially in larger hospitals, hospital information systems will track patients through every aspect of their medical care [3]. It should be a standard that every decision about financing a new or old medical technology will be made after the conducting of economic analysis, based on evidence and not on opinions or persuasions.

The idea of evidence-based health care is becoming more and more popular in the world. It is obvious we have to conduct an economic analysis to provide more benefits for patients and society in a modern health care system. But it is also very important that as physicians we must accept that some applications of our imaging studies are not cost-effective and should not be utilised purely for economic gains.

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