Medical Economics and the Assessment of Value in Cardiovascular Medicine: Part I

Daniel B. Mark, MD, MPH; Mark A. Hlatky, MD

Healthcare costs have been rising in the United States, as they have in the rest of the developed world, for decades. Although many factors contribute to this rise, a major cause is the continued development of new and more expensive medical technologies and treatments. Medical discoveries lead to new diagnostic tests, new pharmaceuticals, new devices, and new surgical procedures. The globalization of medical development through large international mega-trials and the spread of information via the Internet suggest that technological innovation will continue to increase patient expectations and medical costs across the world. The public wants improved medical technology, yet it also wants health care to be affordable and accessible to everyone, regardless of the patient’s ability to pay. How can these conflicting goals be reconciled? The principles of economics can be helpful in assessing when a medical innovation is worth the cost. Our goal in this 2-part series is to present a framework for economic evaluation in cardiovascular medicine (Part I), and to use this framework to evaluate recent work in the areas of coronary revascularization, cholesterol-lowering therapy, and treatment of heart failure (Part II). These topics are not only clinically important, but they also serve to illustrate issues centering around the economic evaluation of expensive one-time treatments, prevention, and ongoing therapy for chronic conditions, respectively. Finally, we will discuss future directions for the emerging field of economic evaluation. At the end of Part I, we have included a glossary of terms commonly used in the literature of medical economics (see the Appendix).

Medical Economic Concepts and Tools: A Brief Overview

Basic Concepts

A fundamental tenet of economic thinking is that society’s resources are finite and can never satisfy all societal wants. When resources are applied to health care, they are lost to other potential uses, such as education, defense, and transportation. Government officials and other policy-makers are charged by society with the task of allocating public resources among competing societal priorities. Within the area of medicine, specifically, policy makers must decide how much to invest in the research and treatment of cardiovascular disease, cancer, diabetes, AIDS, and other conditions. When viewed in this way, every dollar spent on cardiovascular disease has an opportunity cost—what we have lost by not spending that dollar on other forms of health care or even on other needs in society. This competition for resources is particularly keen for the last few dollars allocated, ie, “at the margin.” That is, as one reaches the limits of available funds for medical care, it becomes particularly important to ask if those dollars would not be better spent elsewhere.

Most goods and services in the United States are purchased privately, with prices set by market forces. Consumers feel comfortable evaluating the costs of buying a new computer, getting a haircut, eating in a restaurant, or seeing a movie. They can ask their friends, read reviews, or evaluate their own prior experiences to judge whether a contemplated purchase would provide good value for the money spent. Consumers are clearly motivated to make these judgments because they are spending their own money on these goods and services.

Health care is very different from the consumer market. Patients cannot readily evaluate the quality of the medical care they receive because the benefits of medical care are generally less tangible and immediate, and they require professional expertise to assess. Medical care also often involves life-and-death situations—hardly conducive to calm, rational decision-making or comparison-shopping. Finally, and most importantly, patients rarely pay the full cost of medical care, which instead is covered by private or public health insurance. When spending other people’s money, patients and their doctors are much less concerned about the size of the final bill. Thus, many decisions about medical care are made either by the government or by private insurers, the third party in the relationship between patients and doctors.

Different social systems handle the fundamental problem of resource allocation for medical care in different ways. In Canada, for example, hospitals are given a fixed budget each year by the provincial governments. In the short run, the money to pay for an advance in cardiovascular care must be found within this global budget, eg, by spending less on orthopedics or by reducing some other part of the cardiology budget. In the long run, the hospitals can argue that their...
Outcomes of Comparing a New Therapy and a Standard Therapy

<table>
<thead>
<tr>
<th>Clinical Effectiveness</th>
<th>Net Cost</th>
<th>New $&gt;$ Std</th>
<th>New $=$ Std</th>
<th>New $&lt;$ Std</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEA</td>
<td>New $&gt;$ Std</td>
<td>Standard Rx cost-saving</td>
<td>Standard Rx more effective</td>
<td>New $&lt;$ Std</td>
</tr>
<tr>
<td>Std</td>
<td>New $&gt;$ Std</td>
<td>New Rx more effective</td>
<td>Toss-up</td>
<td>Standard Rx more effective</td>
</tr>
</tbody>
</table>

Std indicates standard therapy; CEA, cost-effectiveness analysis; and Rx, therapy.

Analysis Methods

New therapies and tests in medicine are naturally compared against the current standard of care. The 2 dimensions in this comparison are clinical effectiveness and cost. Conceptually, the new technology could be either better than, equal to, or worse than the current standard of care in terms of clinical effectiveness, and the net cost of the new technology could be more than, equal to, or less than that of standard care. The 9 possible results of comparing a new and standard technology on clinical and economic dimensions are listed in Table 1. The choice among alternatives is straightforward for most of these options of cost and effectiveness, and if one alternative has better outcomes at lower cost, it is the dominant strategy. If clinical outcomes are equal, the cheaper treatment is preferred. If costs are equal, the strategy that yields the best outcomes is preferred.

The most interesting and difficult questions arise when one of the treatments costs more but yields better outcomes. The question here is whether the better outcomes are worth the higher costs. In this situation, cost-effectiveness analysis is a useful tool. A cost-effectiveness ratio can be calculated as:

\[ CE = \frac{C_{\text{New}} - C_{\text{Usual Care}}}{HB_{\text{New}} - HB_{\text{Usual Care}}} \]

where CE represents cost-effectiveness; C, costs; and HB, health benefits.

The health benefit could, in principle, be measured in any sensible units, such as millimeters of blood pressure reduced, myocardial infarctions averted, or the minutes of exercise increased. Use of these measures of health benefit would, however, make it quite difficult to compare results across therapies, especially if one is deciding whether to fund therapies that are as different as implantable defibrillators and a new drug therapy for heart failure. The convention adopted by medical economists is to measure clinical benefits as the number of added life-years (LYs). This measure of benefits is most useful when the primary therapeutic goal is to prolong life expectancy. Because many therapies are used primarily to improve quality of life rather than to increase longevity, a broader measure of benefits is the quality-adjusted life-year (QALY). Implicit in this measure is the assumption that patients are willing to trade freely between improvements in quantity and quality of life, an assumption that is supported by the observation that patients are willing to take the risk of surgical procedures to reduce symptoms and improve quality of life. The QALY sets the value of 1 year of life in excellent health to the value of 1.0 QALY, which reflects the product of the quantity of survival (1 year) and the utility or preference weight assigned to that year (excellent health has a utility weight of 1.0 on a 0 to 1 scale). If a patient with severe chronic angina had a utility or preference weight of 0.8, then a year of life in this state would have a value of 0.8 QALY (1.0 LY×0.8 utility=0.8 QALY).

Improved quality of life is a significant therapeutic goal, so it is important to have a method to account for this health benefit when performing cost-effectiveness studies. Although many studies have used a variety of standard instruments to measure quality of life (eg, Short Form 36), these scales do not yield results that can be applied directly in a cost-effectiveness analysis. The best direct measure of patient utility from a theoretical perspective is the “standard gamble,” but this measure is complex and cumbersome to administer in large patient trials. Rather than measure utility directly, most economic analyses now assign utilities to outcomes with the use of health utility indexes (eg, Euro-QoL). In these indexes, patient health states are defined by a number of explicit dimensions, such as physical functioning, and previously measured preference or utility weights from patients (ie, those with the condition of interest) or the general public (ie, those who are at risk for getting the condition of interest) are assigned to each possible health state. Neither approach is ideal. Patients tend to adjust to disease and disabilities by altering their life expectations and may give themselves rather high utility weights despite severe impairment. Conversely, nondiseased members of the general population may fear disease and provide overly pessimistic utility weights. Therefore, although most observers agree that it is important to account for improved quality of life when performing economic analyses of new therapies, the methods to do so are in need of further refinement.
Data for Economic Analysis

There are 2 major methodologies used in economic evaluation of health care. The first approach uses a model to project the economic and clinical outcomes of alternative strategies. Contemporary models tend to be quite sophisticated and base projections on the best available evidence from a variety of sources. The most credible models are based on meta-analyses of randomized clinical trials to estimate efficacy, as well as on outcomes of large, representative patient cohorts that estimate the prognosis of untreated patients and the cost of care. The advantages of these models include the flexibility to examine cost-effectiveness under many different assumptions about risk, benefit, and cost, and to show plainly how the cost-effectiveness of a therapy may vary when applied to different groups of patients. The disadvantages of these models include the need to synthesize information from disparate sources that may be inconsistent or subject to biases of one sort or another. Furthermore, the very complexity and sophistication of these models may make them a “black box,” limiting peer review and independent verification of the findings. If special care is not taken, these models may be extrapolated beyond the empirical data without explicit recognition that this has occurred.

The second major approach to economic evaluation is to measure economic cost as an end point in a randomized clinical trial. This approach capitalizes on the strengths of randomized trials, including prospective, complete data collection; a rigorous protocol; and the use of random assignments to eliminate selection bias and to balance patient characteristics that might affect outcomes. There are several distinct advantages to economic evaluations conducted within a clinical trial. First, the economic and clinical data in these trials are collected in the same patient populations, alleviating concerns about inconsistencies among data sources. Second, the economic and clinical outcomes are measured directly, with few assumptions and little modeling. A potential disadvantage of trial-based economic analyses is that, by definition, they do not include the results of the other pertinent trials and thereby do not include the totality of evidence about a given treatment. Trials with small sample sizes may give unreliable estimates of economic outcomes, as they do with clinical outcomes. Trials may mandate protocol-driven care that deviates from usual clinical practice, which can distort resource use patterns and make them unsuitable for economic analysis (eg, a protocol angiogram may be used to assess treatment efficacy, but its results may trigger changes in clinical management). Finally, patients enrolled in trials are highly selected, and the clinical outcomes (especially of procedures) may not be readily achieved in routine clinical practice, rendering the cost-effectiveness calculation a best-case scenario.

These alternative approaches to economic evaluation are not mutually exclusive, inasmuch as it is feasible to build an economic model with the use of a clinical trial database. This hybrid approach allows the investigator to project results of various alternatives not tested in the trial or to highlight strategies not evaluated directly (eg, treat only selected high-risk patients with the new therapy, and give the standard therapy to everyone else).

Measurement of Costs

A fair economic evaluation should completely account for all relevant costs. These costs should include not only the cost of the new treatment or test but also the costs of concomitant therapy, the costs of treating any complications, and the costs of subsequent events. For instance, a new treatment for unstable angina might increase bleeding but reduce the need for coronary revascularization and shorten hospital stay, and a fair evaluation would include all of these costs. The time horizon for the economic evaluation needs to be long enough to document all the costs resulting from a particular intervention because subsequent clinical complications may be decreased or increased by a treatment or test. Angioplasty patients, for example, may need treatment for restenosis, and a fair economic evaluation must count these later costs.

We have found it helpful to distinguish between the costs of the new intervention itself and the costs of other care. Thus, a new drug may cost $1000 per patient, but if complications and adverse effects were reduced to the extent that it saves an average of $800 per patient, the net cost of this intervention is therefore $200, not $1000. Some therapies may pay for themselves with immediate savings, whereas others may have high early costs but later cost savings. It is therefore important that an economic evaluation be of sufficient scope to account for all relevant costs, including those of early and late adverse events.

A more technical issue is the precise method used to measure costs. The most common approach is to enumerate major resources used in care of the patient (eg, drugs, tests, procedures, hospital days) and to assign a cost weight to each resource. The cost weights may be taken from an official price list, such as the standards used in Australia. In the United States, because the Centers for Medicare and Medicaid Services (CMS) is the dominant payer for medical care, Medicare reimbursements often are used as national cost standards. For physician costs, the Medicare Physician Fee Schedule has the dual attractiveness of widespread use and derivation based on careful analysis of resource use. For hospital costs, Medicare’s Diagnosis-Related Groups (DRG)-based reimbursement schedule is widely used but is less attractive as a national cost standard because it has only a crude relationship to resource use for individual patients. Private insurance databases could be used instead of Medicare, but these data are not as readily available and share the same DRG-based crude relationship to resource use. An alternative method of measuring hospital costs in the US is to obtain patient-specific medical billing data (UB-92 forms) and convert the raw hospital charges to costs with the use of the conversion ratios published in each hospital’s annual Medicare Cost Report, which is available to the public. Yet another method is to use the marginal and average costs from a hospital’s electronic microcosting system. This approach, which in principle is the most accurate, is limited because a significant number of US hospitals do not have such systems installed, and those that do may regard their cost data as too sensitive for release outside the institution.
A graphical representation of the relationship between investing extra resources in health care and the resulting incremental health benefits produced. At point A, we are spending little money and generating large health benefits. At point C, we are spending large amounts of money and generating ever-shrinking benefits ("flat of the curve" medicine). Point B represents an idealized separation point between economically attractive (to the left of point B) and economically unattractive (to the right of point B) therapies.

**Benchmarks in Economic Analysis**

There is no absolute standard that can be applied to judge how much society is willing to pay for medical care. In a general sense, wealthier countries should be willing to pay more for such care than poorer countries. Despite these difficulties, certain conventions for cost-effectiveness have gained general acceptance. In the United States, a cost-effectiveness ratio of <$50 000 per QALY is generally regarded as economically attractive, in part because it approximates the cost of providing chronic hemodialysis to patients with renal failure, a cost that is borne by the public through the Medicare program. Conversely, a cost-effectiveness ratio of >$100 000 per QALY is generally regarded as economically unattractive. The range between $50 000 and $100 000 per QALY added is the gray zone in which there is no consensus on whether a treatment is economically acceptable.

These benchmarks can be conceptualized by graphing the relationship between added resources and health outcomes (Figure). The first few dollars of care are spent on the cheapest and most effective interventions. For example, aspirin given to a patient with an acute myocardial infarction provides large survival benefits at a small cost. With a few more dollars available, one would purchase the next best therapies for improving health care, which cost a bit more or deliver a bit less benefit (or both). Streptokinase for acute anterior ST-elevation myocardial infarction is an example of a somewhat more expensive therapy that delivers substantial additional benefit. Giving patients with acute myocardial infarction tissue plasminogen activator instead of streptokinase would cost much more money and produce a smaller increment of benefit. This relationship between resources applied and benefits received applies to most conditions. Initially, we are spending very little but generating large benefits (Figure, point A). Subsequently, we are spending significant amounts of money and producing ever-shrinking benefits (Figure, point C), a phenomenon economists refer to as diminishing marginal returns. Patients would like to move up this curve as far as possible, so as to obtain every possible treatment benefit. The economic perspective, however, is that medicine should operate somewhere on the shoulder of the cost-versus-benefit curve, not on the flat of the curve, because those last few dollars would produce more benefit if spent elsewhere. The acceptable cost-effectiveness ratio corresponds to the optimal slope of the cost-versus-outcome curve (Figure, point B).

In Part II of this series (to be published next week), we will use the framework of economic evaluation to assess recent work on therapeutics in cardiovascular medicine.

**Appendix**

**Glossary of Terms Commonly Used in Medical Economics Literature**

- **Cost-benefit analysis (CBA):** a form of economic-efficiency analysis in which both the costs and outcomes (health benefits) are valued in monetary terms. In medicine, cost-effectiveness analysis is much more widely used.
- **Cost-effectiveness analysis (CEA):** a form of economic-efficiency analysis in which costs are valued in monetary terms and health benefits are valued in natural units. CEA is always incremental, comparing some new healthcare technology or strategy of interest with a relevant alternative.
- **Cost-effectiveness ratio:** the ratio of incremental costs to incremental health benefits that are produced in a cost-effectiveness analysis. It can also be thought of as the cost to produce 1 extra unit of health benefit (eg, dollars) to save 1 extra life-year (with given therapy in a defined cohort). Although cost-effectiveness ratios are often presented as point estimates, both the numerator and denominator have a variability that either can be assessed directly by use of statistical measures, such as confidence intervals and bootstrap analyses, or approximated with the use of sensitivity analyses.
- **Cost-utility analysis (CUA):** a variant of cost-effectiveness analysis in which the health benefits are expressed in a scale that incorporates both longevity and patient preferences (utilities) for the health states produced. Dollars per QALY added is the most common form of cost-utility ratio in the medical literature.
- **Cost-identification analysis (cost analysis):** a type of economic analysis that enumerates the relevant resources and associated costs of a given healthcare technology or strategy but does not assess health benefits. As with all economic analyses, the results apply to a particular cohort or population in a particular context.
- **Cost-to-charge ratios:** correction factors contained in the annual report each US hospital produces for the Centers for Medicare and Medicaid Services (CMS). With these correction factors, an economic analyst can convert hospital charges to average hospital costs.
- **Decision analysis models:** a set of tools and methods for examining clinical decision problems (eg, test versus don’t test, treat versus don’t treat) in an explicit structured format. The decision tree is created by the analyst to reflect all relevant decisions and possible outcomes. In this context, cost can be included as one of the outcomes examined. Often, decision models incorporate data from a variety of sources, some robust (eg, large clinical trials), and some less so (eg, expert opinions). Weaknesses in the data are explored with the use of sensitivity analyses.
- **Discounting:** a technique of converting the value of future costs and future health benefits to their present value. Because individuals have a time preference (ie, they prefer to get benefits now, pay costs later), discounting is required to convert benefits and costs to a common time frame, which is typically the present (eg, 2002). The current convention is to use a discount rate of 3% with sensitivity analyses exploring rates from 6% to 5%.
- **Dominance:** a therapy or strategy is said to dominate another if it is both more effective and less expensive.
EuroQol: a widely used generic quality-of-life measure with associated preference (utility) weights. Developed by a consortium in Western Europe, the EuroQol is a short instrument that assesses 5 health status domains: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each domain has 3 possible levels: no problem, some problems, and major problems. There are a total of 243 possible health states that can be defined by the EuroQol (reflecting all possible combinations of the 5 component domains). Preference (utility) weights have been derived for the EuroQol in Europe by use of the time trade-off method.

Economic-efficiency analysis: A basic axiom of economics is that resources (eg, healthcare personnel time, healthcare facilities, and equipment) are limited, and therefore, decision-makers and policymakers must choose how best to invest those scarce resources to produce the most benefit. Economic-efficiency analysis brings together both the costs and health consequences of potential new investments in an integrated framework. The most commonly used forms in medicine are cost-effectiveness analysis and cost-utility analysis.

Incremental cost: the cost of moving a cohort of patients from one therapy or care strategy (eg, usual care) to another (eg, new therapy).

Induced costs and savings: costs and cost savings that occur as a consequence of some medical intervention or strategy. They are distinct from the cost of the intervention itself. For example, restenosis would be an induced cost of percutaneous coronary intervention.

League table: a table presenting selected medical therapies and strategies ranked by their incremental cost-effectiveness or cost-utility ratios. A number of important objections have been raised about the uncritical use of these tables.

Life-year: an epidemiological construct describing the survival of 1 patient (or subject) for 1 year.

Marginal cost: the cost of producing 1 extra unit of health care. The term also refers to the cost of moving a single patient from one care strategy to another.

Microcosting: the most comprehensive form of cost analysis. It starts with an exhaustive identification and quantification of resource inputs consumed by the healthcare strategy under study. Detailed cost weights are developed for each resource identified. Total cost is calculated as the sum of the number of each type of resource consumed multiplied by its unit price.

Productivity costs: the costs incurred because of the time lost from employment for pay because of illness or disability. The concept has been expanded to time lost from leisure activities and to work without pay. Productivity costs are sometimes referred to as indirect costs, although this latter term also has a distinct accounting meaning.

Sensitivity analysis: one of the principal methods used to assess the impact of uncertainty on an economic analysis. Typically used in conjunction with a decision model or similar analytic framework, it involves varying key model parameters through a plausible range of values and observing the effect on the model results. Parameters may be varied one at a time, holding all others in their starting position, or 2 or more may be varied simultaneously.

Short Form (SF) 36: a widely used quality-of-life instrument originally developed by researchers at the Rand Corporation. The SF-36 is generic, rather than disease specific, and it is a health profile, meaning that it assesses quality of life across the major domains relevant to health care. The SF-36 has 8 distinct domain components: physical function, role function (physical), role function (emotional), general health, bodily pain, social function, psychological well-being, and vitality. Each component is scored from 0 (worst) to 100 (best). In addition, summary physical and mental scores can be created. At present, there is no method of using SF-36 scores to calculate QALYs.

Societal perspective: the broadest perspective used in economic analysis. It includes all relevant costs and health outcomes irrespective of who bears the costs and who gains the benefits.

Standard gamble: the method preferred by economists for measuring patient utilities because of its relationship to underlying theory. In this method, the patient (rater) is asked to choose between 2 alternatives. Alternative 1 is typically stated as having the patient remain in his or her current state of health until death (x years). Alternative 2 is a gamble with 2 possible outcomes: The patient may be returned to excellent health for the remainder of his or her life (x years), or he/she may die immediately. The probabilities of the outcomes in alternative 2 are varied until a point is reached at which the patient is indifferent between alternatives 1 and 2. For example, a patient may be indifferent between living 3 more years in advanced heart failure and a gamble with a 20% chance of resuming excellent health for 3 years and an 80% chance of dying immediately. Thus, the utility weight of the patient’s chronic heart failure state is 0.20.

Time trade-off: a utility assessment method that was developed as a simpler alternative to the standard gamble and that yields similar utility values. In this method, the patient is asked to choose between living the remainder of his or her life in his or her current state of health versus living a shorter time in excellent health. The duration of the time in excellent health is varied until the patient is indifferent between the 2 alternatives.

Utility: the relative desirability of a particular health outcome or health state, assessed as the preference of a rater (typically a patient or a member of the general public) for that outcome relative to defined alternatives (eg, death, excellent health). Utility can be assessed directly by techniques such as the standard gamble and the time trade-off. It can be assessed indirectly with the use of health (quality-of-life) indexes that have preassigned utility weights (eg, EuroQol).

References

Key Words: cost-benefit analysis ■ cardiovascular diseases ■ financing
Medical Economics and the Assessment of Value in Cardiovascular Medicine: Part I
Daniel B. Mark and Mark A. Hlatky

Circulation. 2002;106:516-520
doi: 10.1161/01.CIR.0000021407.93752.7B
Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2002 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the
World Wide Web at:
http://circ.ahajournals.org/content/106/4/516

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published
in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial
Office. Once the online version of the published article for which permission is being requested is located,
click Request Permissions in the middle column of the Web page under Services. Further information about
this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/