First Principles of Cost-Effectiveness Analysis in Health

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COST-EFFECTIVENESS ANALYSIS (CEA) is a technique for identifying the most effective use of limited resources. Originally developed in the military realm, CEA has come to be applied to many areas of social policy, including health care. Although the economics and medical literature contain a number of reviews of the technique (1–4), its principles deserve wider understanding as consumers, providers, and regulators increasingly participate in the shaping of health care policy. This paper is a nontechnical discussion of the principles of cost-effectiveness analysis applied to health, in particular, preventive health programs: these

principles are illustrated with examples, and the strengths and weaknesses of this approach are discussed.

Principles

Cost-effectiveness analysis is a way of summarizing the health benefits and resources used by health programs so that policy makers can choose among them. It summarizes all program costs into one number, all program benefits (the effectiveness) into a second number, and it prescribes rules for making decisions based on the relation between the two. The method is particularly useful in the analysis of preventive health programs, because it provides a mechanism for comparing efforts addressed to different diseases and populations (5). Cost-effectiveness analysis requires fewer troublesome steps than its close relative, cost-benefit analysis, because CEA does not attempt to assign monetary values to health outcomes or benefits. Rather, CEA expresses health benefits in simpler, more descriptive terms, such as years of life gained. Details of cost-effectiveness analysis vary among practitioners and circumstances, and some problems still have not been resolved satisfactorily.

The version we describe is a straightforward one applicable to a broad array of health programs.

An alternative, widely used formulation (2) is that CEA is a method to determine which program accomplishes a given objective at minimum cost. This alternative definition can be derived from the more general formulation for cost-effectiveness analysis: that is, the analysis of tradeoffs between monetary and nonmonetary (in this case health) effects.

The five major steps in our formulation of cost-effectiveness analysis are summarized in the chart.

Step 1. Define the program to be analyzed: its focus, processes, and limits. Seemingly minor differences in the definition of the program, such as targeting it to high-risk persons, can have major impacts on costs and effects. For these reasons, a precise definition of the program is critical.

A given problem may be amenable to a variety of approaches. Cost-effectiveness analysis can be used creatively, in conjunction with health expertise, to formulate innovative programs. One might use cost-effectiveness analysis first to compare markedly different programs, such as immunization or treatment, as a means for preventing deaths from influenza. If immunizations are identified as the best general approach, CEA can then be used to refine variants of an immunization campaign and to tailor its design to the specific situation. Refinements involve such issues as the ages of the vaccinees and the means of delivery. The program to be analyzed can then be described by answering the six questions generally covered in the lead

to a newspaper article: who, what, when, where, why, and how.

Step 2. Compute the net monetary cost for prevention and treatment of illness under the proposed program compared with the cost of the status quo. Generally, costs are computed from a societal perspective, that is, the value of all societal resources used in the program are counted as costs, regardless of who pays for them. It is often convenient to compute costs on a per participant basis.

There are four parts to step 2. The first is to compute the gross costs in each year of the program's operation. For example, if the program includes screening, the gross costs are those of screening, followup of positive results, and treatment of persons who might otherwise have gone untreated if their cases had not been found. The timing of each expenditure relative to the beginning of the program is noted.

The second part in computing net costs is to calculate the monetary savings attributable to the program, sometimes called direct benefits. These savings are the costs of avoided treatment that otherwise would have been obtained. Note that this step involves calculating the demand, rather than the need that is obviated. It would be inappropriate to count as monetary savings the avoidance of costs of needed services which are not now provided, so-called unmet need. The effects of services that obviate unmet need will be included as health benefits under step 3.

The third component in computing net costs is discounting to present value. Discounting is a procedure economists use to relate costs and savings occurring

Steps in Cost-Effectiveness Analysis

1. DEFINE THE PROGRAM
- Develop alternative approaches to problem.
- Define precisely programs to be analyzed (who, what, where, why, when, and how).

2. COMPUTE NET COSTS
- Compute gross program costs.
- Compute monetary savings.
- Discount costs and savings to present value.
- Compute net costs (gross costs less savings).

3. COMPUTE NET HEALTH EFFECTS (in terms of additional years of healthy life)
- Add
  —Additional years with full health,
  —Additional years of disease,
  —Improvement in health (no extension of life),
  —Negative effects (inconveniences and morbidity).
- Modify by time preference factors.

4. APPLY DECISION RULES
- Identify case based on signs of net costs and net effects.
- Apply rule for appropriate case.

5. PERFORM SENSITIVITY ANALYSIS
- Vary uncertain parameters and recompute costs and health effects.
- Examine effects on decision.

at different times to a common basis. The principle is that future costs are less expensive than present costs because (a) most people would accept less money to receive it sooner and (b) a smaller amount of money can be invested by society and allowed to grow at a compound rate of interest (analogous to the growth of a savings account) to yield the amount of money required for future costs. This rate of interest is called the discount rate. For example, suppose that one cost of a program is an expenditure of $1,000, but the expenditure will not be made for 5 years. Suppose the discount rate is 5 percent per year. The $1,000 is then discounted to about $780. In other words, $780 put aside and allowed to grow at 5 percent will become $1,000 in 5 years. The principle of discounting also applies to savings achieved by the health program.

The discount rate, usually in the range of 5 to 15 percent, depends on the cost of obtaining money for the institution for which the analysis is being conducted (for example, society as a whole, an employer, or a health provider). Because there may be uncertainty or disagreement about the rate, the analysis is sometimes repeated using alternative discount rates. The discount rate used should reflect opportunity costs and the rate of time preference for money. Uncertainty and "market imperfections" (especially divergences caused by income taxes between the social productivity of investment and private return) complicate the determination of the appropriate discount rate. Despite a vast economic literature—see for example Meyer (6) —this issue is still not entirely resolved.

Net costs are calculated in the fourth part of this step by subtracting savings from gross costs—both in present-value terms. Net costs can be positive, negative, or zero.

Step 3. Compute the health effects or benefits. Cost-benefit analysis requires that benefits be expressed in monetary terms, but cost-effectiveness analysis permits the use of any commensurate measure of benefits. Lives saved, complications averted, or cases of illness prevented are examples of possible benefit units. A more general and sometimes preferable measure is the additional healthy year of life, also known as the quality-adjusted life year, or QALY (7). Function years and well years are similar concepts (8). Additional years of healthy life are the algebraic difference between the number of healthy years a program recipient expects to live because of the existence of the program being evaluated and the number of healthy years he would have expected had there been no program. Estimation of these numbers must rely heavily on epidemiologic findings, expert opinion, controlled trials and, when available, randomized trials.

Health effects must be calculated from the same perspective (for example, societal or governmental) and basis (total, or per participant) as costs. The change in years of healthy life resulting from a program may be expressed as the sum of four types of health effects.

The first and most valued type of effect is additional years of healthy survival. If, for example, a preventive program postpones death by 1 year during which perfect health is maintained, then the effect is 1 additional healthy year of life.

The second type of effect is also a postponement of death, but during this extension of life, perfect health is not maintained. The proposed program in this instance is said to achieve "additional years of disease." Suppose that, for example, preventive care extends the life of a recipient by 1 year, but during it the recipient is restricted to home. Presumably, the recipient does not value that year as highly as a year of perfect health. The CEA should reflect this valuation. A year restricted to home might, for example, be valued at 80 percent of complete health. Percentages such as these are value judgments that should reflect the preferences of affected persons. Although assessment of these preferences is difficult, progress in determining such values has been made through interviews with patients (9), through forced-choice questionnaires with professionals (7), and through interviews with consumers (8,10).

The third type of effect is an improvement in health without affecting survival. For example, one's symptoms or the restrictions of being homebound might be relieved. The benefit, in these cases, is the difference between the value of a year at lower life quality and the value of the year at the improved level of health.

The fourth type of effect is negative; the adverse effect arises because some health programs are inconvenient or have some associated morbidity, or restrict activities. Examples of preventive measures with negative effects are requirements that a staunch Bostonian move to Phoenix, Ariz., for asthma relief, that a person visit his physician weekly, or that he discontinue his favorite foods or activities. Presumably, a year with these restrictions is preferred to the alternatives of premature death or sickness, but it may not be valued as highly as a year of full activity without these restrictions. The negative effect is the difference between the value of a year without restrictions and the value of a year with restrictions. The negative effect might, for example, be 5 percent of a year.

Programs with only one type of effect (for example, averting deaths in a narrow age range) are relatively straightforward to evaluate; changes in that effect are compared to costs. More problematic are programs with

diverse effects: perhaps extending some lives at perfect health, extending others at impaired health, enhancing the quality of health of other lives without extending them, and having negative effects on still other lives. To measure all these effects by a common metric is a formidable task. While the QALY holds promise of being an appropriate common unit, the practical difficulties of converting various impacts on health into QALY terms should not be underestimated. A more concrete measure of effects, such as cases of cancer prevented, should be used whenever it is common to all programs being compared.

All health effects should be subject to a discount factor, based on the society's time preferences. Generally, people prefer their health benefits sooner rather than later (9). Suppose, for example, that one preventive measure promised 5 additional healthy years and those 5 years were to be the next 5 years. Another preventive program promised 5 additional healthy years that would not start for 20 years. We would probably prefer the program that provided us with the benefits sooner. This observation implies that benefits should be discounted, though not necessarily at the same rate as costs. Many analysts, for example Weinstein and Stason (4,11), add the further assumption that society's tradeoff between money and marginal health effects remains constant over time. This assumption achieves the convenient result that benefits are discounted at the same rate as costs.

The present values of the four types of effects can be summed to give a measure of present net effects. These net effects will be in units of years of healthy life.

Step 4. Apply a decision rule based on the net costs and net health effects. The rule must be selected from among the four cases, as described in table 1.

In the first case, the net costs and net effects are both positive; that is, there are true benefits but also real costs. In other words, the health of recipients is judged to be better with the proposed program than it would have been without the program, but the program uses resources. In these situations a cost-effectiveness ratio is calculated by dividing the cost by the improvement in years of healthy life. The result is a measure of efficiency, expressed as dollars per year of healthy life. The lower this number, the more efficient is the program, in the sense that it can produce years of healthy life at relatively low cost for a year. If funds are limited, then they should be spent first on the more efficient programs; that is, on those activities that would produce years of healthy life more cheaply.

The second case is that the net costs are negative or zero and the effects are positive. The proposed program improves (or at least does not impair) health, and it reduces costs as well. This kind of program is obviously desirable. Health programs fall into the case 2 situation if they are inexpensive, highly effective, and prevent illness for which expensive treatment would be sought. Provision of sanitary water, immunization against common diseases, fluoridation of community water supplies to reduce dental caries, or antibiotic treatment of streptococcal sore throat are possible illustrations.

The third case arises when the net effects are negative and the net costs are positive. In other words, the morbidity and inconvenience associated with the preventive program more than offset the health benefits that it produces. Such programs cost money while worsening health. Unless compelling factors excluded from the CEA indicate otherwise, such programs should not be implemented.

In the fourth case, the net effects are negative, but net costs are also negative. A program in this category restrains cost but may sacrifice health. Closing a health facility is a case 4 situation. To measure efficiency in cost containment, a cost-effectiveness ratio like that in the case 1 instances should be calculated. A program that entails no sacrifice in health (an infinite ratio) is best. Otherwise, the decision rule should be to select the program with the largest ratio. The selected program achieves the greatest savings per unit sacrifice in health. Programs that save resources but result in worse health should not be excluded automatically; by shifting those resources to more effective

Table 1. Decision rules in cost-effectiveness analysis

Net effects	Net costs positive	Net costs zero or negative
Positive	CASE 1. Cost-effectiveness = net costs ÷ net health effects. Select most efficient programs for improving health (lowest ratios).	CASE 2. Program economically valuable. Should generally be implemented.
Zero or negative . . .	CASE 3. Program benefits offset by morbidity and inconvenience. Program generally should not be implemented.	CASE 4. Cost effectiveness = net costs ÷ net health effects. Select most efficient programs for containing costs (highest ratios).

programs, overall improvements in health could be realized for the same total level of expenditure.

Step 5. The final step in a cost-effectiveness analysis is to perform a sensitivity analysis. Many of the procedures required to estimate costs and benefits require estimates of data and preferences that are not known with certainty. For example, it is not possible to predict exactly the future discount rate. Opinions can differ about the value of a year with impaired health relative to a year of perfect health. Finally, medical experts are uncertain about the value of various preventive measures, and their professional assessments are constantly updated with new research.

The sensitivity analysis is the process of deliberately varying these uncertain factors to examine their effect on the decision rule. If the final decision is not affected by making different assumptions about these uncertain quantities—by choosing high and low estimates, for example—then one can be relatively confident of the decision. If, on the other hand, the decision would be drastically altered by different estimates, then one should be considerably more cautious in making recommendations. Furthermore, one should, if possible, try to investigate further the precise values of these parameters before proceeding. One should also be alert to ways to gain more information about the uncertain issues.

Applications

One hypothetical and two actual applications of cost-effectiveness analysis are presented as illustrations.

Hypothetical inoculation program. A hypothetical influenza inoculation program is being contemplated by a department of public health.

Step 1. Define the program. Vaccinations would be administered to 100,000 persons aged 65 and older over the next year by public health nurses in existing clinics and health centers.

Step 2. Compute net costs. On the basis of similar programs elsewhere, it is estimated that vaccinations cost $3 apiece (medications, marginal labor costs, and so forth). The inoculations are expected to prevent 1,000 cases of influenza this year and to result in 50 adverse reactions requiring treatment. The average cost of treatment for influenza is $50, and for the adverse reactions, it is $300. The discount rate for converting money and health effects to present value is 5 percent. Net costs for this program are calculated as follows:

Inoculations (100,000 × $3)	$300,000
Treatment of reactions (50 × $300)	+15,000
Gross program costs	$315,000
Savings due to people not getting influenza (1,000 × $50)	−50,000
Net program costs	$265,000

Because all costs would occur in the first year, discounting is not necessary.

Step 3. Compute net health effects. It is estimated that 10 people will not die of influenza this year as a result of this program. They will live for 8 (all healthy) years. Persons who avoid influenza as a result of the program experience an increase in the quality of their life of .04 of a healthy year. (They would have felt miserable with the illness, but it would not have lasted long.) The 50 persons suffering adverse reactions have their life quality lowered by .09 for the next year. Thus, the three health effects are prolonging 10 lives, enhancing the quality of 1,000 lives by preventing influenza, and impairing 50 lives through adverse reactions. A life prolonged by 8 healthy years is present valued not as 8 years but as 6.79 years, because the worth of all years after the first must be discounted. (The second year is valued as being worth $1 \div 1.05 = .952$ of the first year and so on.) The other effects are first-year effects and need not be discounted. The net health effects are calculated as follows:

Type of effect	Healthy years
Additional healthy years (10 × 6.79)	67.9
Health improvement for those spared the morbidity of influenza (1,000 × .04)	+40.0
Gross health effects	107.9
Negative effects of adverse reactions (50 × .09)	−4.5
Net health effects	103.4

Step 4. Apply decision rules. This is a case 1 situation: definite health gains are achieved, but at net positive costs. Dividing net costs by net health gains, we obtain the cost-effectiveness ratio: $265,000 ÷ 103.4 healthy years = $2,563 per healthy year.

This ratio should help decision makers to determine whether to implement the inoculation program. If alternative programs extend lives at costs of less than $2,563 per life year, they should be given funding preference over the inoculation program. If alternative programs cost more than $2,563 per life year extended, the inoculation program should be preferred.

Step 5. Perform sensitivity analysis. All parameters for the analysis that are subject to doubt may be varied

to discover the impacts on the results. Suppose that some experts think that only 800 cases of influenza would be prevented by the inoculations. Such a supposition would reduce net savings by $10,000 (200 × $50), thus increasing net costs by that amount. Net health effects would be reduced by 8 (200 × .04) healthy years. The cost-effectiveness ratio is now: $275,000 ÷ 95.4 healthy years = $2,883 per healthy year.

Would this change affect decisions about the program? The first decision considered—whether or not to implement the inoculation program alone—might be affected. If decision makers conclude that they can afford to save lives and to enhance health at a cost of $2,700 per healthy year and that they cannot afford to pay more than this, then the decision is altered. Under the original analysis, the program would be implemented; under the revised analysis it would not be. The sensitivity analysis indicates to the decision makers how much uncertainty resides in the analysis that guides their actions.

Stool guaiac test. Neuhauser and Lewicki (12) analyzed the stool guaiac test in screening for colon cancer. The decisions in this application of CEA are both the basic desirability of the test and the optimal number of retests per patient. The cost-effectiveness approach may be used to address both issues. To reduce the chance of missing a case, the test can be repeated, but there are followup costs for all positive tests, both true and false positives. As shown in table 2, the cost per additional case identified mounts rapidly with test replications. The first screening test is highly cost effective: it gains an additional year of life for only $294. Further tests gain additional life years at progressively increasing costs. The additional benefit from six tests compared to five is so slight that the cost per additional case discovered, and the cost per year of life gained due to the sixth test, are in the millions of dollars. Pursuing such a screening program to the last degree of perfection is inefficient. Cost-effectiveness analysis indicates that resources might better be spent elsewhere, perhaps by more outreach and screening of high-risk persons.

Mobile coronary care units. A mobile coronary care unit is an emergency vehicle with equipment and trained personnel for monitoring the victims and providing emergency treatment for heart attacks. It is intended to reduce mortality prior to hospitalization, the period when half of the heart attack deaths occur. Zeckhauser and Shepard (13) performed a preliminary analysis under the optimistic assumptions that these mobile units cut prehospital deaths in half and

that the additional survivors have a prognosis comparable to past heart attack survivors (table 3). Discounting costs at the rate of 5 percent, they estimated the cost per 30-year-old male of having a mobile coronary care unit available for the rest of his life. The present-valued cost over the subject's remaining lifetime for the unit and staffing it is $49. The cost of treating heart attacks that the recipient would not otherwise have lived to suffer is $52, and the cost of other medical treatment arising from greater longevity is $29. The total is $130 per person.

As an initial indication of health effects, the authors calculated the impact of the mobile coronary care unit on life expectancy at age 30. They used data from the literature, subjective estimates for some parameters, and computer simulation. The gain in life expec-

Table 2. Incremental cases of cancer detected and marginal cost per year of life saved by successive stool guaiac tests in a population of 10,000

Number of tests	Incremental cases detected	Cost per year of life saved
1	65.9469	$ 294
2	5.4856	1,373
3	0.4580	12,288
4	0.0382	117,384
5	0.0032	1,181,174
6	0.0003	11,776,803

SOURCE: Reference 12.

Table 3. Computation of cost effectiveness (per male from age 30 years) of having a mobile coronary care unit in the area

Estimated lifetime cost or effect	Unit
Costs (dollars) [1]	
Unit and staffing	$ 49
Treatment of heart attacks	$ 52
Other medical treatment	$ 29
Total costs	$130
Health effects (QALYs) [2]	
Years before heart attack	0
Years with heart attack (.015 × 80 percent)	.012
Subsequent years (.057 × 95 percent)	.054
Total effects	.066
Cost effectiveness	
Cost effectiveness = $130 ÷ .066 QALY = $1,970 per QALY	

[1] Present value. [2] QALY = quality adjusted life year. SOURCE: Reference 13.

tancy estimated by these procedures was a third of a year, or 4 months. This measure was then refined to reflect two facts: (*a*) that these additional years are likely to be added far in the future, mostly between ages 55 and 80; and (*b*) that some of these additional years will be ones with impaired health due to heart attack.

In calculating the equivalent number of healthy years added by the mobile coronary care unit, certain assumptions about health quality were necessary. A year of life in which a heart attack occurs was assigned a value of only 80 percent that of a year in full health. The value was reduced to this level because the victim is hospitalized for several weeks, is homebound for several more weeks, and may be unable to work or to carry out normal activities for several months after the infarction. Second and later years after the attack were valued at 95 percent of the value of a year at full health. This value reflects the inability of some survivors, due to anxiety or to some residual disability, to resume full activities. Applying these quality-adjustment factors and a discount factor of 5 percent per year, the authors estimated net benefits to be .066 years—or only 24 days—per person. The final estimate of the cost-effectiveness of the mobile coronary unit is $130 divided by .066 years. This works out to be about $2,000 per perfectly healthy, present-valued year gained. Assuming that this ratio is correct, it indicates that the mobile coronary unit is a relatively efficient way of prolonging life.

Nevertheless, a sensitivity analysis indicates that this estimate should be regarded with caution. Although communities have installed mobile coronary care units, in some areas these units alone (without the backup assistance of citizens trained in cardiopulmonary resuscitation) reduce mortality very little (*14*). Whereas the analysis assumed that persons saved by these units would have a prognosis similar to that of other heart attack victims who reach the hospital alive, the prognosis may actually be considerably worse. In the latter instance, the benefits will be smaller.

The present value of the costs could be greater than the $130 per person that was estimated. That estimate assumed that the area being served was sufficiently populous to utilize a mobile coronary care unit fully and that the population was sufficiently dense so that the unit could reach the victim quickly. The cost-effectiveness ratio of $2,000 per healthy year cited previously might therefore be regarded as a best-case (or lower-bound) estimate. The cost effectiveness of mobile coronary care units could be 10 times worse, or $20,000 per additional year of healthy life. It would then be of the same order of magnitude as

estimates made of the cost effectiveness of the treatment of moderate hypertension (*11*).

Strength and Limitations

Comparisons of programs. For purposes of illustration, suppose that the hypothetical, inoculation program were real and that the differences in discounting among the preceding illustrations could be ignored. Suppose that the health department was willing to invest in health programs only if it could buy years of healthy life at less than $5,000 per year. Then it would fund the cancer detection program with two repetitions (at $1,373 per healthy year), the mobile coronary care unit (at $1,970), and the inoculation program (at $2,563). The third stool guaiac test would not be pursued, and the mobile coronary care unit would be deferred if the unfavorable conditions in the sensitivity analysis prevailed.

Alternatively, suppose that the health department faced a budget ceiling, rather than a maximum amount per year. In these circumstances, we would allocate resources to programs in the order of their cost-effectiveness ratios until the budget was exhausted. That is, it would first fund the cancer detection program with two repetitions. It is the most cost effective of all the possible programs. If budget funds were left over, the department would next fund the mobile coronary care unit, the second most cost-effective program. Next in priority would be the inoculation program. If resources permitted, the third or fourth stool guaiac test could be added. This would not be done, however, until all programs with better cost-effectiveness ratios had already been funded. While cost-effectiveness analysis cannot determine the most appropriate total investment in health, it can indicate the best way to allocate a predetermined budget among health programs.

Data limitations. The most salient practical problem in performing cost-effectiveness analysis is the lack of adequate data. Definitive data on the likely health effects of preventive programs are rare, and cost data, too, are often insufficient. While this problem complicates and reduces the precision of cost-effectiveness analysis, it may paradoxically increase the attractiveness of performing this analysis. Many important decisions cannot wait until ideal data are obtained. Compared with alternative processes for decision-making—for instance, cost-benefit analysis or intuition—cost-effectiveness analysis is better able to cope with data problems because CEA avoids the difficult problems of money valuation, and it uses a sensitivity analysis to check on the implications of uncertainty in the data. Cost-effectiveness analysis, moreover, pro-

vides a framework for using the available objective data and the subjective estimates of experts. Representative experts or consumers can be polled and ranges of values could be considered. A weakness of cost-effectiveness analysis, therefore, is that it rarely yields a single, definitive answer. Its partly compensating advantage is that assumptions are made explicitly and their effect on the analytic results is made clear.

Reflecting the values of consumers. A related weakness is the practical difficulty of incorporating consumers' input into an analysis. In theory, the method can incorporate the preferences of any representative consumer in evaluating alternative programs. Valuations of quality of life can be made by past, current, or prospective recipients of a treatment. Because these values are shown explicitly, the resulting analysis can be scrutinized to assure that these preferences, and expert opinions, have been interpreted correctly. With a sensitivity analysis, the opinions of many experts and the values of many consumers can be incorporated. Undoubtedly, however, analysts will need patience and sensitivity to elicit preferences that are expressed in a usable manner, and consumers may require examples and nontechnical explanations before accepting any numerical analysis.

The unquantifiable nature of human values. Some observers allege that cost-effectiveness analysis may interfere with humanistic values. They assert, as a matter of principle, that health should not be quantified. There is merit in this feeling. A society that based all its decisions on cost-effectiveness analysis might be efficient and healthy, but it could otherwise be cold and sterile. Nevertheless, 1978 health care expenditures amounted to $192 billion, and we cannot rely solely on intuition to choose among competing programs. Some systematic procedures are required. With care, we can obtain the benefits of procedures such as cost-effectiveness analysis while minimizing the dangers of dehumanized decisions. One solution is to use cost-effectiveness analysis primarily to establish general guideline for the provision of preventive and curative services. Providers and administrators can view these guidelines as general recommendations, not inviolable laws, in making decisions about individual patients.

Determining most worthwhile uses for limited resources. Lastly, an important strength of CEA should be mentioned. Many persons feel that preventive health services and educational efforts deserve an enhanced role if national health insurance is enacted. Unfortunately, if every preventive program that has been proposed, or even if every program that has some evidence of

effectiveness were undertaken, we would spend much more than the present 9.1 percent of our gross national product on maintaining health. Since society is not prepared to allocate unlimited resources for health, it needs a method for deciding which activities are most worthwhile within ever-present cost constraints. We need to decide how to allocate resources between primary prevention and early detection, or between detection of new cases and followup and more effective treatment of the known ones. Cost-effectiveness analysis can also help us choose between medical and nonmedical approaches to protecting health, such as better emergency medical services versus better highway design. As long as the alternatives under consideration are directed at a common objective, cost-effectiveness analysis can help illuminate the tradeoff.

In summary, cost-effectiveness analysis cannot tell us what health program society should pursue, what preventive programs we should adopt; these answers as Fein wrote, "are up to society" (15). Cost-effectiveness analysis does, however, provide a framework for organizing information about the effectiveness and efficiency of health programs. With these results, consumers and health policy makers can make more enlightened decisions about which programs to adopt.

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SYNOPSIS

SHEPARD, DONALD S. (Center for the Analysis of Health Practices, Harvard School of Public Health), and THOMPSON, MARK S.: *First principles of cost-effectiveness analysis in health. Public Health Reports, Vol. 94, November–December 1979, pp. 535–543.*

Cost-effectiveness analysis (CEA) can help individual medical care providers and health policy makers to determine the most beneficial uses of limited resources. It comprises five steps: (a) defining the scope and target population of the program to be analyzed, (b) computing the net monetary costs of the program, (c) determining the net health effects, (d) applying the appropriate decision rule, and (e) delineating the possible effects of analytic imprecision through sensitivity analysis. Cost-effectiveness analysis is valuable in choosing among alternative programs of preventive and curative health.

Examples show how CEA has been applied to identify the appropriate number of screening tests to be used in detecting colon cancer and to measure the effectiveness of mobile coronary care units in a community in extending lives. The cancer screening example indicates the importance of focusing on the incremental effects of additional expenditures; that is, examining what is achieved by devoting additional resources to retests of each patient. This perspective compares marginal costs to marginal benefits, or effectiveness. It shows that the dollars used for first, second, and third tests per patient are much more cost effective than those spent on subsequent tests.

Another example—an analysis of mobile coronary care units—shows how their effects in extending life, value judgments about the quality of impaired health, and the discounting of future benefits are combined to obtain a cost-effectiveness ratio relating the resources expended to the benefits gained by this program.

Results of CEA may be used in deciding how to allocate funds among programs according to their cost-effectiveness ratios. Important difficulties encountered in cost-effectiveness analyses, as well as in alternative decision-making methods, are insufficient available data concerning costs and values and problems in quantifying and in incorporating the values of health care to consumers and society. Cost-effectiveness analysis responds to these difficulties through the use of sensitivity analysis and by providing an explicit framework for organizing information about program effectiveness and values.