Cost-Effectiveness and Cost-Benefit Analyses for Public Health Programs

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COST EFFECTIVENESS and cost benefit are subjects which, to those who are not professional economists, evoke a somewhat less than overwhelming response. They are, however, ingredients frequently mentioned in the recipes for planning-programing-budgeting systems and, if only for this reason, it becomes desirable to have a speaking acquaintance with these subjects.

Most persons who undertake a survey of the literature in this field quickly find the terms "cost effectiveness" and "cost benefit" used more or less interchangeably. Some writers, however, appear to make a firm distinction between the two terms, often without defining the difference.

I will attempt to differentiate between those expressions in this paper, although there is some lack of uniformity in the definition of terms even among economists.

In cost-benefit analysis, the monetary cost of a program is normally compared with its expected benefits, and normally these benefits are expressed in dollars. I use the word "normally" to indicate that there are exceptions. Costs, benefits, or both might be expressed in nondollar terms. An example of this is a comparison of different types of training programs for health service personnel. In such an example, "benefits" could be shown in number of persons trained, and "costs" could be shown in number of trainers needed, perhaps under different approaches. If training manpower is limited, the number of trainers could be more important than their salaries.

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In a cost-benefit analysis of alternate programs, we compare the expected benefits to determine which is the best investment. Because of the frequent emphasis on the most effective use of money when given a choice of possible programs, both costs and benefits are usually expressed in dollars to permit ready comparison. For the same reason benefit divided by cost, the benefit-cost ratio, is often useful in making comparisons.

Cost-effectiveness analysis differs from cost-benefit analysis in that costs are calculated and alternate ways are compared for achieving a specific set of results. Our objective is not just how to use funds most wisely; it also includes the constraint that a specified output must be achieved. Very often, this output is not expressed in dollars.

If we were told to determine the best program for training 1,000 nurses in a given time (to use the previous example of training) we could obtain costs of various training programs and make comparisons, and the study could be classified as one of cost effectiveness.

Cost-benefit studies expedite comparisons among several programs with differing objectives, whereas cost effectiveness generally refers to a comparison of different ways of reaching the same objective. In both cost-effectiveness and cost-benefit studies, we are frequently troubled because we have no satisfactory unit of measurement common to the benefits from various health programs.

Such indices as "years of gain in life expectancy" have been proposed as a useful yardstick to measure benefits. Some studies attempt to translate time into monetary terms by computing expected income loss because of premature death or disability.

Until we discover a universal unit for quantifying the value of health, ways to measure benefits will continue to hamper comparisons among alternate health programs. Perhaps of more importance, this lack complicates comparing benefits among health and nonhealth activities competing for limited funds.

Examples of Both Analyses

I will give some examples of these analyses, starting with a hypothetical benefit-cost ratio computation on a trivial scale. Assume that a pill X, which is on the market, will assure the user a day of good health and $20 for working that day. To make matters even more simple, also assume that without taking pill X the user will not be able to work and therefore will not earn the $20. If pill X costs $5, the benefit-cost ratio in dollars is 20 divided by 5 or 4.

Now before rushing out to buy pill X, we might also examine all other alternatives and discover that there are other similar pills with different probabilities of success or a different period of effectiveness. We might compute the ratios of all the alternatives, compare them, and from this information select what appears to be the best choice in terms of benefit-cost ratio.

As cost-benefit studies are used in health program planning, they often concern comparisons among different programs, each vying for financial support. It may be necessary to decide if an admittedly desirable program must be completely scrapped simply because other programs are more deserving of limited funds.

Unfortunately, we must often make these decisions with incomplete information. Still worse, there may be well-recognized factors affecting the analysis which are deliberately ignored, either because we do not know how to deal with them in a quantitative sense or because we believe their effect is too small to justify laborious computation, or a little of each.

Returning to the pill example, suppose that in our search of alternatives we find a pill Y for $4 which will give the same return (a day of good health) as pill X. We will consider the relative virtues of pills X and Y in determining a ratio of effectiveness to cost, and we might further assume that the user does not necessarily want to work. He values a day of good health just because it gives him some time free from disease or discomfort. To him it is only a day to be used as he chooses—working, playing, or just sleeping.

On a cost-effectiveness scale, the ratio with pill X is 1 to 5 or 0.2 and with pill Y, 1 to 4 or 0.25. The units are now days of good health per dollar and again pill Y is the winner, but now it is no longer clear if either pill is a good choice. The decision rests on someone's judgment as to whether or not the return is worth the cost.

According to my earlier distinction, the output now is specified as days of good health, and we seek a pill which will achieve this result most economically. In using this changed approach, a decision maker has the responsibility of imposing his judgment, whereas before he could claim his decision had some economic justification.

A benefit-cost dollar ratio gave him a magic number to work with because presumably any project with a ratio of 1 or larger could at least pay its own way, and anything with a ratio of less than 1 was a loser. This somewhat flippant description of cost-benefit analysis should not, however, be construed to minimize its real value. Much serious and valuable work is going on right now, using cost-benefit studies to assist authorities to reach decisions.

In 1966, Mr. Gardner, former Secretary of the Department of Health, Education, and Welfare, appointed study groups to make a series of health program analyses and to investigate the costs and benefits of certain health programs. In making their studies, the analysts (*1*) used purely economic costs and benefits, although they pointed out that "For the purposes of estimating benefits among diseases, it is recognized that economic loss or even death do not completely state the damage and harm caused by disease. Pain and the impact on family relationships are among the more obvious additional items. We do not know how to bring such items into this kind of analysis as yet. . . ."

Despite some shortcomings, these analyses can be highly useful. But before examining some actual analyses, I want to discuss briefly some pitfalls to avoid in making these studies.

Avoiding Errors in Using the Analyses

Comparing total rather than only marginal costs is an error that is difficult to avoid. What should be analyzed is the effect of change from the present situation, both in new benefits and new costs. For example, suppose we have an investment of $10 in a device which produces 50 units an hour and we learn of the invention of two improvements which will increase this machine's efficiency. Item A, an adapter costing $5, allows the device to produce 60 instead of 50 units per hour. Item B, costing $7, can increase the output to 65 units per hour. Assuming that we are going to buy one of the new adapters and that we will not consider operating costs, market conditions, or final equipment disposition, which adapter would be the best choice from a cost-effectiveness standpoint?

Wrong. The total cost, if we buy item A, will be the original $10 plus the added $5, or $15, and the total resultant output is 60 units per hour. Dividing output by cost gives us a ratio of 60 to 15 or 4. The total cost, using item B, will be the original $10 plus $7, or $17 with a resultant output of 65, or a ratio of 65 to 17 or 3.8. The conclusion using this misleading analysis is that item A is preferred because it seems to give the largest ratio of effectiveness to cost.

Right. The marginal or added cost for item A is $5, and the added output is 10 units per hour for a ratio of 10 to 5 or 2.0. The marginal cost using item B is $7 and the added output is 15, giving a ratio of 15 to 7 or 2.1. Our conclusion using this correct procedure is that item B is preferred because of its greater marginal ratio.

The point is that the level of expenditure made in the past, whether good, bad, or indifferent, won't affect the decision on items A and B, so the analysis should be limited to the effect of change only.

Another frequent problem is caused by trying to find a policy which simultaneously gives the greatest benefit and the least cost. Cost analysis studies may seek a policy which will realize the greatest benefit at a given cost, or a given benefit at the least cost, but not both at the same time. This fact can be seen very easily by comparing some hypothetical alternatives. Suppose we could spend $1 and gain $3 for the ratio of $3 to $1 or 3. Compare that with the expenditure of $100 for a benefit of $500 for a ratio of 5. The second choice certainly seems best and maybe it is—if we have the $100. If we don't, it is immaterial what the ratios are. The larger benefit is obtainable only with a larger cost.

Now assume that for $100 we could get a $300 benefit, again with a benefit-cost ratio of 3. We see that there is no preferred choice between this ratio and the previous one of $3 to $1, yet anyone can see by simple inspection that, despite what the ratios say, a profit of $200 is better than one of $2. To avoid this difficulty, some economists prefer not to use a ratio, but instead to compute marginal benefit minus marginal cost.

The fact that investments in the public sector tend to come in large chunks causes another type of problem in cost-benefit analysis. Only on paper is it possible to build half a water purification plant, and in reality most projects require large discrete expenditures. Sometimes particular combinations of projects, if they are possible under the total budget, are especially efficient but may get overlooked. To illustrate, suppose we have $100 to invest, with the following alternatives:

A brings a return of $600 for a cost of $60—the benefit-cost ratio is 600 to 60 or 10.

B brings a return of $500 for a cost of $40—the benefit-cost ratio is 500 to 40 or 12.5.

C brings a return of $1,000 for a cost of $70—the benefit-cost ratio is 1,000 to 70 or 14.3.

Using these ratios, C looks to be the preferred choice, because it has the highest ratio. But closer inspection shows that a combination of A and B with a combined ratio of 600 plus 500 over 60 plus 40, equaling 11 is pretty good too.

Combining A and B brings a return of $1,100 whereas C only returned $1,000. True, with C there was some money left over, but even if we count this in, we end up with only $1,000 plus $30 or $1,030 as compared with $1,100.

The difficulty, of course, is that in so readily taking the best individual bargain we reduced our budget to a point where we could no longer take advantage of any other opportunities. Cost-benefit analysis didn't really fall down on the job, because C is the best way to spend $70.

Are we to use our money (really the public's money) to find the best bargain? Or are we supposed to use it to get the greatest return? Unfortunately, we have seen that these two aren't necessarily the same. There is a need for a clear-cut statement of objectives as a prerequisite of any meaningful cost-benefit or cost-effectiveness analysis.

Another part of these analyses that cannot be overlooked is that of discounting, a procedure that is used extensively in dealing with future costs or benefits. The purpose of discounting is to convert the economic implications of actions taking place later to their equivalent value now. To do this, we use interest tables and a discount rate that supposedly represents the value of money over time. Just as by using interest tables we can find how much $1 invested today will be worth at some time in the future, so we can do the reverse and find out how much a dollar needed some years from now is worth today. For example, the present value of a dollar to be used 1 year from now is about 91 cents, if money is worth 10 percent interest.

It is important to know what interest rate to use. At first thought, this seems apparent, but further thought indicates that it is not so simple. The rate should represent what the money is worth if it were available for other uses. Now the difficulty is one of worth to whom and for what other uses. If we are limiting our thinking to government, you might say that money is worth what the government pays to borrow it, say interest that is paid on E bonds. Others think it should measure the cost of using private capital in the form of taxes to the government, private capital that might have been used elsewhere; therefore, the rate ought to be the going market rate of interest or more.

Another interesting fact about the time preference for money is that it tends to vary inversely with the life expectancy. In other words, younger persons seem willing to wait for a future payoff but, as you might expect, the older we get, the more interested we are in quick results if we are to use them.

Fairly small variations in the discount rate can often lead to big differences in the cost-benefit ratio. To illustrate this, consider an activity costing $100 a year. Assume that by the end of the year the $100 has been spent, and the resultant benefit is equivalent to $105. Without doing any discounting (zero percent), the net benefit in dollars is 105 − 100 or 5.

If a discount rate of 5 percent were used, the net program benefit in dollars would be zero, because at this rate of return, the $100 could have given a $105 benefit even without the activity. If a 10 percent discount rate were used, however, there would be an apparent $5 loss for this activity because the money it cost might have been used otherwise to obtain $110 in benefit instead of only $105.

Why all this fuss over a technical detail? Because discounting is particularly important when a long timespan is covered, as often happens with health programs in which some benefits accrue only many years after the outlay (*2*).

With so many difficulties to consider, are the results worth all the effort? Wildavsky, a nationally recognized cost-benefit analyst, says cost-benefit studies are shot through with political and social value choices and surrounded by uncertainties and difficulties of calculation (*3*).

But he also says that the method has great utility by telling decision makers what they will be giving up if they follow alternative plans. He admits that the cost-benefit formula does not always jibe with political realities—it omits political costs and benefits—and we can expect it to be twisted out of shape from time to time. Yet, he sees the method as being of great importance in getting rid of the worst projects and asserts that avoiding the worst when one can't get the best is no small accomplishment.

Example of a Cost-Benefit Study

Now that we have discussed some pros and cons of these methods, let's examine some actual studies made by professionals.

I will summarize briefly part of a cost-benefit analysis done in late 1966 (*4*). In this study, several ways of preventing motor vehicle acci-

Table 1. Present program costs and estimated losses in thousands of dollars, before discounting

Year	Present program costs	Total losses	Losses from injury			Mortality losses
			Total	Direct costs	Indirect costs	
Total	$16,600	$32,700,000	$7,800,000	$4,300,000	$3,400,000	$24,900,000
1968	3,200	6,200,000				
1969	3,300	6,300,000				
↓	↓	↓	↓	↓	↓	↓

dents were compared. Of all the alternatives, the list was narrowed down to nine that were considered both feasible and realistic. Of these nine possibilities, I have picked one for discussion. The goal of this program was to prevent motor vehicle injuries by improving driver training. This is how the analysts proceeded.

Step 1. A baseline was established from which to measure change. Remember that the increment of change is the essential ingredient in cost-benefit analysis. The baseline used was the present level of program activities, costs, fatalities, and injuries, which are listed in tabular form. Since some activities and some level of accidents will necessarily take place in the future even with no program change, it was also necessary to project what the future would hold even if nothing different were done.

It was assumed that the present level of effort would remain relatively constant through 1972. The number of fatalities and injuries was also projected through 1972, based on existing trends. Population projections were obtained from the census, mortality and injury data were obtained from the national health survey and other sources, and trend lines were plotted on graph paper.

Step 2. A common denominator was determined by converting fatalities and injuries into dollar costs. To do this, lost earnings as a result of premature death were determined. The cost of days lost from work as a result of injury and a number of other costs, such as those from days of hospitalization and physician visits, were also computed. Almost all these data were nonexistent and had to be developed from other records. Table 1, although incomplete, shows the general procedure used to calculate program costs and losses, assuming present levels.

Table 2. Added program costs in thousands of dollars and reduction in injuries and fatalities

Added program costs		Reductions	
Actual	Discounted	Number of injuries	Number of fatalities
$825,000	$750,550	665,300	8,515

I have presented the table primarily because the derivation of the information is important for analysts. Direct costs include hospital care, physician's services, nursing home care, drugs, and medical supplies. Indirect costs include loss of earnings by those whose injuries kept them from working. Mortality costs include the expected lifetime earnings (before conversion to present value by discounting) for the projected fatalities in each year, based on life expectancy tables. It was assumed that unemployment would average 4 percent and that earnings would be the same as in 1964.

It may be of interest to know how the study group handled housewives' services. Losses for housewives who were expected to be incapacitated because of motor vehicle accidents were based on the wages earned by domestic servants. After adjustment for wage supplements, a housewife's salary was estimated to be $2,767 annually, using 1964 data.

Step 3. The alternative, a program to improve driver education and training, was fully described.

Step 4. The change in status if this alternative were in effect was calculated (table 2).

Step 5. The costs and benefits were computed and the final ratio obtained (table 3).

Some of the major assumptions in this example were as follows: First, calculations were based on an assumption that improved methods of basic driver training, education, and retraining could reduce the number of deaths and injuries from motor vehicle accidents by 20 percent annually after the program has been in operation for 5 years.

Second, during the first 5 years an average reduction of 10 percent was expected. If this estimate is in error, and the actual death and injury reduction proves to be only 5 to 6 percent during these first years, the benefit-cost ratio becomes less than one. How sure was the study group of their estimate? They stated, "There is little doubt that some improvements are possible with better training and education, but how much remains a big question. Furthermore, methods to evaluate this program are crude and consist mainly in instituting the program and then either observing changes in accident rates with time or in comparing other comparable populations who don't have the program."

Our conclusion might be that this program appears to be worthwhile, but certainly we should not be overconfident that it will effectively reduce deaths and injuries. If a budget cut became necessary, this program might be one of the first to go because of its relatively low rank.

Example of a Cost-Effectiveness Study

My next example is a September 1967 report for the Bureau of the Budget, utilizing the cost-effectiveness approach (*5*). This study on the treatment of kidney disease was undertaken by a group of physicians, statisticians, and economists who specifically noted that they felt that a cost-benefit analysis was inappropriate partly because of the difficulty of putting a value on human life.

The study compares the effectiveness and cost of two alternate ways of prolonging the life of persons otherwise doomed to an early death because of end-stage kidney disease. New technological capabilities and the obvious consequences of no action (death) make this investigation unusual.

Two possible means of prolonging the life of persons suffering from end-stage uremia are a kidney transplant or the use of dialysis equipment, generally known as the artificial kidney. Both techniques can be used in various combinations, such as repeated transplants followed by dialysis.

Effectiveness is measured in a straightforward comparison of the number of years of life expected to be added, on the average, through transplantation or dialysis. This comparison originally assumed that a gain in years of life by one mode of treatment is the same in quality as that from another treatment method. The study group, however, could not accept this because the volume of evidence suggested a difference in the value of the added time.

A patient dependent on mechanical dialysis equipment must limit his actions to some extent—a geographic limitation, for example—because he must be able to get to the equipment when it is needed. Also, certain restrictions in diet must be followed by persons using the artificial kidney, restrictions that do not affect those with a transplant.

Although the committee did not go so far as to suggest that their weighting factor was the result of rigorous analysis, they did accept a factor of 1.25 to weight the value of a year of life gained after transplantation more heavily than that gained by hemodialysis. They stated that this factor was for illustrative purposes but even so it seems extremely significant that a committee of this status publicly went on record as accepting the difficult premise that life under some conditions could be 25 percent more valuable than under other conditions.

The philosophical point to be emphasized is that this in no way implies that some people's lives are more important than others. This fact is not the issue here, and it would be unfair to imply this. However, the concept of different values of time, because of the various uses to which time can be put, is an important and controversial one to many researchers.

On the cost side of the ledger, the computations were made more complex because the cost of failures as well as successes must be included on the presumption that all medically suitable patients will be treated.

A further complication of the dialysis alternative is the large difference in cost, depending on whether treatment is done at a center or in the home.

Table 3. Added program costs and savings, in thousands of dollars, and benefit-cost ratio

Costs of added program	Total savings	Morbidity savings			Mortality savings	Benefit-cost ratio
		Total	Direct	Indirect		
$750, 550	$1, 287, 000	$213, 000	$117, 000	$96, 000	$1, 074, 000	1.7

In making the calculations, life tables were constructed to show the life expectancies under each treatment mode. A further example of the committee's need for innovation was that not enough time has elapsed to permit reliable estimates of long-range life expectancies in this new field; estimates must therefore be based on speculation and the best testimony now available.

The results from computing effectiveness showed that an average marginal life expectancy of 9.0 years could be expected for a person on dialysis treatment compared with 17.2 years for one in the transplantation group (actually 13.3 added years from a successfully transplanted kidney followed by 3.9 more years on dialysis after eventual failure of the transplant). After adjustment at $13.3 \times 1.25 + 3.9$, an estimate of 20.5 quality-adjusted years of life is obtained—more than twice as much as that for persons under dialysis treatment (table 4).

Adding another column (not in the report) to show the ratio of effectiveness to cost, using years of life gained as the effectiveness measure and costs in $10,000(s), yields the following figures:

Treatment	*Years of life gained* / *Costs in $10,0000*
Dialysis:	
Center	0. 9
Home	2. 4
Transplantation:	
Unadjusted	3. 8
Adjusted for quality	4. 6

These cost-effectiveness computations indicate that, in increasing the average life expectancy of end-stage uremia patients, the transplantation method provides the lowest cost per year of added life expectancy. Fortunately, it also appears to offer the greatest prospect for added length of life.

One early conclusion of the study group was reached, not as a direct result of this cost-effectiveness analysis, but because of the incidental gain in program understanding due to the study process. This conclusion was that there were not enough available kidneys for transplant and that many were lost after transplantation. The group recognized that research directed at organ storage and preservation and at tissue typing ought to be high on the priority list of kidney disease research.

They also saw that even sizable reductions in the cost of equipment were not likely to exert a radical effect on the overall cost of dialysis because costs were largely for personnel at dialysis centers. Therefore, efforts should be concentrated on possible means of minimizing staffing at dialysis centers rather than devoting significant funds to equipment refinements.

The committee concluded that "In terms of cost effectiveness there are advantages in an approach oriented toward transplantation . . . research activities directed at making transplantation more widely applicable and efficacious are likely to yield considerable economic benefits."

Conclusions

We have looked at some examples of cost-benefit and cost-effectiveness analysis, moving from trivial hypothetical instances to some rea-

Table 4. Cost per year, discounted, and years of life gained by two treatments for kidney disease

Treatment	Cost	Years of life gained	Cost per year
Dialysis:			
Center	$104, 000	9	$11, 600
Home	38, 000	9	4, 200
Transportation:			
Unadjusted	44, 500	17	2, 600
Adjusted for quality	44, 500	20. 5	2, 200

Source: Reference 5.

sonably complex examples of real analyses. Despite difficulties with these methods of analysis, they can be useful decision aids, although even their most ardent proponents would probably not suggest that they be decision determinants.

Prest and Turvey (*6*) stated recently that " . . . one can view cost-benefit analysis as anything from an infallible means of reaching the new Utopia to a waste of resources in attempting to measure the unmeasurable."

I think you will be seeing and hearing more about these techniques in the future because they are a crucial element in the planning, programing, and budgeting systems. William Gorham, former Assistant Secretary of HEW (*7*) said, "A major task under PPB will be cost-effectiveness analyses of alternative solutions to particular social problems. The analyses will, at first, be crude. New measurements of effectiveness will have to be devised, experimented with, and refined. New data will have to be collected, both on cost and on effectiveness. 'Educated guesses' will have to be employed, tested, and revised."

Like most methodologies in a state of test and revision, there are bound to be successes and failures as refinements are made in these analyses.

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Training in Suicide Prevention

A regional center to train workers in suicide prevention is being established at Emory University in Atlanta, Ga., under a grant from the National Institute of Mental Health totaling $33,268 for the first year.

The program will offer short term training in suicide prevention for professional and nonprofessional workers in the southeastern area of the United States. It will be flexible to meet the differing needs of communities represented by the trainees.

Training opportunities will be offered for emergency telephone operators, development of techniques for establishing suicide prevention and emergency mental health services, and clinical training for professional personnel.

Nonprofessional workers, including volunteers, can enroll in monthly 2-day training sessions, and professional workers will attend quarterly 3-day seminars.

Instruction will be offered by the department of psychiatry of Emory University in cooperation with the Fulton County Emergency Mental Health Service.