How Do We Measure Costs and Benefits for Health and Safety Interventions? An Introduction to the Methodologies

What Unit of Measurement Should Be Used?

The first decision that health-policy analysts must make when measuring the costs and benefits of health and safety intervention is the unit of measurement to use. In conventional cost-benefit analyses, such as those that use willingness-to-pay or cost-of-illness estimates, both the costs and benefits of policy are measured in dollars. This means that for health policy analyses, health outcomes must be translated into dollar amounts.

Conventional cost-benefit analysis $\Rightarrow$
Dollar benefits minus dollar costs (1)

Analysis based on a money scale has three major advantages. First, such analysis provides a complete ranking of programs, including programs with diverse outcomes. The diverse outcomes are comparable and therefore can be ranked because costs and benefits are measured in a common unit, i.e., dollars. For example, the costs and benefits of a kidney dialysis machine can be compared with those of a nutrition program. Second, a money scale provides an evaluation of the desirability of each program. For example, if the net benefits (benefits minus costs) of the kidney machine and the nutrition program were negative (regardless of the ranking), neither would be worth the cost. A program is worth the price only if dollar benefits exceed dollar costs. Third, money is already commonly used to rank choices and convey value. It allows us to compare values and make trade-offs among all goods, whether produced in the public or private sector. We can compare the relative value of various public health programs and compare public health programs with alternative ways individuals might spend their money, like consumer goods. We can easily compare the value of programs with the value of goods and labor services that have to be used up carrying out the program.

In spite of money's advantages as a unit of analysis, analysts or policymakers may be uncomfortable with assigning dollar values when benefits are human health and safety. They may not like the idea of assigning a finite value to life and health, and they may not like the idea of using a unit of account that is itself distributed unevenly throughout the population.

Cost-effectiveness analysis is an approach that uses dollars to measure costs. However, it avoids assigning a dollar value to health benefits. Instead, benefits are left in physical terms, namely a count of the adverse health outcomes averted.

Cost-effectiveness analysis $\Rightarrow$ (2)

$$\frac{\textit{Dollar costs}}{\textit{Adverse outcomes averted}}$$

Cost-effectiveness analysis makes programs with identical types of health outcomes comparable and shows which program yields the greatest health benefit per dollar. Cost-effectiveness cannot be used to compare programs with different health outcomes because costs and benefits are measured in different units of account. The costs and benefits of a kidney machine cannot be compared with those of a nutrition program. Despite this restriction, cost-effectiveness analysis has been applied to a wide variety of health interventions. For example, Tengs et al. (1995) calculated the cost effectiveness of over 500 interventions with respect to lives saved. Cost-effectiveness estimates do not, by themselves, indicate whether any policy intervention offers positive net benefits. For example, though cost-effectiveness analysis may be able to rank a kidney dialysis machine and a nutrition program with respect to lives saved, it will not indicate whether either is worth the price.

Another approach to comparing costs and benefits uses a count of health outcomes for both costs and benefits. Health policy analysts have long recognized that many policies designed to lower particular public health risks unintentionally raise other risks (see Lave (1981) for a discussion of risk-risk analysis). For example, treating drinking water with chlorine reduces the incidence of several diseases. But exposure to chlorine raises the risk of cancer. The example indicates risk-risk analysis may yield a count of

desired health outcomes measured in different units than the undesired health outcomes caused by undertaking a health or safety program. Here, benefits would be denominated as numbers of a variety of infectious disease cases. Costs would be a count of induced cancers. With multiple programs, ranking will often not be a straightforward exercise. Calculating net benefits cannot avoid making value judgments about the relative merit of avoiding different types of illnesses.

It is possible to count health outcomes for both program benefits and costs, while maintaining the same unit of account for benefits and costs. A trade-off exists between privately purchased health-risk reductions and publicly purchased health-risk reductions. With any fall in disposable income, individuals lose some of their ability to privately purchase reductions in risk. Thus, because new regulatory compliance costs or taxes required to finance new safety programs reduce individual disposable incomes, they reduce the ability of individuals to protect themselves from health risks. As a result, adverse health outcomes occur. An analyst who knows how the costs of a government program are distributed could forecast the number of adverse health outcomes induced by the program. Lutter and Morrall (1994) argue that analysts can compare a count of the fatalities averted by public sector programs with a count of the fatalities induced by regulatory costs. They call such a comparison health-health analysis.

Health-health analysis $\Rightarrow$

Lives saved minus lives lost (3)

A primary disadvantage of health-health analysis is that it confines the tally of costs to mortality risks. A primary advantage of health-health analysis is that costs and benefits are measured in a common unit: lives. As with conventional cost-benefit analysis, net benefits can be calculated. For example, suppose program A is expected to save 18 lives and program B is expected to save 10 lives. If the two programs cost the same dollar amount, program A is ranked higher in cost-effectiveness. However, health-health analysis yields more information than cost-effectiveness. It can determine that neither is worth the cost of 20 lives (negative net benefits for both programs).

It is interesting to note that analyses of costs and benefits that are denominated in lives convey a different type of information than those denominated in dollars. The choice of a unit of account reveals which costs and benefits are most important. For example, suppose a health program was estimated to cost $1 million and yield benefits of $5 million. With a benefit-cost ratio of five, the project appears like a good return on Federal expenditures, all else equal. A similar risk-risk ratio is likely to generate less enthusiasm. In discussing the actuarial evidence on the benefits of passenger-side airbags, Graham and Segui-Gomez (1997) state that a 5:1 ratio of deaths averted to deaths induced is unacceptable

> Overall, the best estimates are that for every five lives saved by front-right passenger airbags, a life (usually a child) is lost. We are aware of no precedent in the history of preventive medicine where a mandatory measure was sustained with such a poor ratio of lifesaving benefit to fatal risk.

That a 5:1 ratio of benefits to costs derived from conventional benefit-cost analysis would be viewed differently from a 5:1 ratio of benefits to costs derived from a risk-risk analysis shows that the unit of account does matter. A decisionmaker can rely on an efficiency argument to justify a program with positive dollar net benefits, even if program beneficiaries are different from those who bear the cost. The Graham and Segui-Gomez statement suggests that some are unwilling to make choices when lives are the unit of account. Efficiency arguments could be invoked just as they are when dollars are the unit of account. But calculating net benefits in lives makes distributional consequences obvious. It requires arguing that a life lost in one group can be offset one-for-one by a life saved in another group. The Graham and Segui-Gomez statement indicates that children's lives cannot be exchanged with adult lives, at least not at a rate near one-for-one.

Table 1 classifies the various cost-benefit approaches by unit of account. The choice of a unit of account reveals the philosophical underpinnings of the approach as well as the usefulness of the approach. Approaches that use the same unit of account for costs and benefits (willingness-to-pay, cost-of-illness, health-health analysis) are the most useful for ranking. When money is the common unit of account (willingness-to-pay and cost-of-illness), the approach has the added benefit of indicating social desirability.

Approaches that monetize benefits and costs are built on the philosophical stance that, like other commodities, health and life can be valued in economic terms for comparison with other goods that people value. Using health-health analysis, finding positively valued net benefits may be less significant than with conventional cost-benefit analysis. However, finding that a program yields a net loss of life may be powerful evidence that its costs exceed its benefits.

What Should Be Counted as a Cost?

Having chosen a unit of account, the second decision that health-policy analysts must make when measuring the costs and benefits of health and safety intervention is to determine what should be counted as a cost. Economists think of costs as consequences of choices. Without choice, there is no sense in which costs exist. Alchian (1968) defined cost of an event as the highest valued opportunity necessarily forsaken. That is, an individual incurs a cost only when forced to choose between alternative goods or courses of action. Where goods are not scarce (more than what everyone might want) or where alternatives do not exist, choices have no cost. This notion of cost is exactly how Buchanan (1987) describes opportunity cost:

> *Opportunity cost is the evaluation placed on the most highly valued of the rejected alternatives or opportunities*. It is that value that is given up or sacrificed in order to secure the higher value that selection of the chosen object embodies.

Three observations germane to the differences among approaches to valuing life and health flow from his definition of cost. First, someone must be choosing. The various approaches to comparing costs and benefits imply different choicemakers with different goals and objectives, and the analyst must, at least implicitly, determine who is choosing. Is the choicemaker a central planner intent on maximizing net national product or an individual maximizing utility?

Second, the fact that different approaches implicitly postulate different choicemakers with different goals and objectives, means that each approach will value benefits and costs uniquely. Each will tally a different set of costs and benefits as each approach tallies what its implicit choicemaker believes he or she will gain or lose.

Third, costs differ from damages. This distinction is what makes willingness-to-pay differ from other valuation approaches. Consider the example of an environmental hazard that poses a small risk of cancer to many people. Everyone might be willing to pay a small amount to reduce a small probability of contracting cancer in the distant future. The dollar value of the realized damages that actually accrue to individuals will be much different from the opportunity costs of reducing the risk. Years after the risk was mitigated, most will receive nothing. As the probability of cancer without mitigation was known to be small, most would not have contracted cancer from exposure to that particular carcinogen, mitigated or otherwise. A few will benefit enormously by avoiding a cancer. A few will pay for mitigation and get cancer anyway, unless the risk was eliminated. What individuals are willing to pay to reduce such risks may therefore bear little resemblance to the actual damages they might experience. On the other hand, when the choicemaker is a net-national-product-maximizing central planner, such as with cost-of-illness and some forms of cost-effectiveness analysis, actual damages sustained may be a good guide to program benefits. In cases where damages occur on a regular and recurring basis, costs and benefits may be precisely specified (although still difficult to measure).

Table 1—Characteristics of methods for comparing costs and benefits

		Costs	
		Monetized	Count of health outcomes
Benefits	Monetized	Conventional cost-benefit analysis (COI and WTP)	
	Count of health outcomes	Cost-effectiveness analysis	Risk-risk analysis or health-health analysis

The different notions of cost and the various ways in which health and safety benefits and costs can be measured are the subject of the following sections. Each approach defines costs and benefits differently. Each approach is sufficiently different so that the choice of approach will influence the guidance given to policymakers.