Chapter 3

Cost-Effectiveness Analysis

Human health improved dramatically during the last century, yet grave inequities in health persist. To make further progress in health, meet new challenges, and redress inequities, resources must be deployed effectively. This requires knowledge about which interventions actually work, information about how much they cost, and experience with their implementation and delivery (*DCP2,* chapters 14 and 15).

WHY USE COST-EFFECTIVENESS ANALYSIS?

The 1993 edition of *Disease Control Priorities in Developing Countries* (Jamison and others 1993) was among the first efforts to guide choices about public health policies in developing countries by systematically combining information about effective interventions with information about their costs. It was motivated, in part, by a sense that developing countries were neglecting numerous opportunities for improving health and that better allocation of scarce resources could achieve better health outcomes. The publication presented cost-effectiveness analysis as an important tool for identifying these neglected opportunities and redirecting resources to better use.

Cost-effectiveness analysis helps identify neglected opportunities by highlighting interventions that are relatively inexpensive, yet have the potential to reduce the disease burden substantially. For example, each year more than a million young children die from dehydration when they become ill with diarrhea. Oral rehydration therapy (ORT) does not diminish the incidence of diarrhea, but dramatically reduces its severity and the associated mortality rate. The scientific evidence that ORT can save lives was an important step in identifying this as a neglected

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opportunity for improving health. Demonstrating that it could cost only US$2 to US$4 per life year saved helped make the case that this was something public policy should promote, and many countries responded by promoting ORT, saving millions of lives (*DCP2,* chapters 8 and 19).

Cost-effectiveness analysis helps identify ways to redirect resources to achieve more. It demonstrates not only the utility of allocating resources from ineffective to effective interventions, but also the utility of allocating resources from less to more cost-effective interventions. For example, a study by the National Center for Policy Analysis at Harvard University focused on 185 life-saving interventions that take place in the United States each year, costing US$21.4 billion and saving 592,000 life years. The study investigated different ways of allocating these funds and found that the number of life years saved could be doubled if resources were reallocated to more cost-effective interventions (*DCP2,* chapter 2, box 3).

DCP2 tells a similar story. It identifies dozens of interventions for a wide range of diseases and risk factors that are costly relative to the health gain they provide. These include hospital-based interventions, such as surgery for recurrent stroke, and community-based interventions for schizophrenia and bipolar disorder. Other interventions that are not particularly cost-effective include treating latent TB infections with isoniazid and regulations aimed at reducing alcohol abuse. If a country were to reallocate funds and efforts from these kinds of interventions and instead apply them to relatively more cost-effective interventions, substantially more people would be able to live longer and healthier lives. If reallocating funds from less cost-effective interventions is not feasible or appropriate, perhaps future increases in spending can be directed toward activities that will yield more health gains.

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Studies of cost-effectiveness have multiplied since 1993, and the techniques have become more widely disseminated. *DCP2* has benefited from this expanding literature and has aimed for consistent comparisons across diseases and interventions. For example, wherever possible, the cost-effectiveness analyses in *DCP2* have used the same price units, health indicators, and definitions of included costs (box 3.1). This chapter introduces the basic concepts and methods of cost-effectiveness analysis, considers some of its limitations, and explains how it has been and can be put to use. The chapter also considers some of the other contextual factors that must complement cost-effectiveness analysis in the decision-making process if policy makers are to make the best use of the findings provided in *DCP2*.

Box 3.1 A Consistent Basis for Calculating Cost-Effectiveness in DCP2

Units for Cost-Effectiveness Ratios

The editors of *DCP2* asked the authors of the individual chapters to adopt a common method of cost-effectiveness analysis and to use consistent parameters. Authors were instructed to calculate cost-effectiveness in terms of U.S. dollars per DALY, where DALYs were calculated using disability weights provided by WHO and a 3 percent discount rate.

No Differentiation by Age

Unlike some studies, the editors of *DCP2* chose not to apply different weights by age. So, for example, the effect of saving an infant life counts for more than saving the life of an older person because of the difference in expected years of life, but not as the result of valuing a year of life saved at one age as higher or lower than a year of life saved at another age.

Basis for Calculating Years of Life

The calculations of expected years of life were based on regional average life expectancies at each age. This has the effect of reducing the cost-effectiveness of interventions in regions with lower life expectancy; however, within any region, this allows for a more realistic comparison of interventions that affect children and those that affect adults.

Currency Units

The main alternatives for measuring costs are to convert all currencies into a widely accepted currency such as U.S. dollars using market exchange rates or to convert them into international dollars by using a conversion factor based on purchasing power parity. The principal advantage of using international dollars is that they adjust for the real difference in purchasing power between one currency and another. However, *DCP2* elected to use U.S. dollars because they are more consistent with other cost estimates that are familiar to policy makers, and because available purchasing power indexes are based on aggregating a full spectrum of prices, and may therefore be misleading if used to analyze a specific sector with its own composition of tradable and nontradable goods. International dollars are harder to understand and do not correspond to financial feasibility as reflected in budgets.

Costs

DCP2 counts the costs of producing an intervention but not the costs of consuming it on the part of patients and their families. Indirect costs are often not monetary, especially the costs of people's time, and are hard to estimate consistently. When such costs are high, they make interventions appear not to be cost-effective, but the problem may lie with where facilities are sited and how they are staffed and operated rather than with the interventions they offer.

Source: Adapted from *DCP2,* chapter 15.

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WHAT IS COST-EFFECTIVENESS ANALYSIS?

Cost-effectiveness analysis is a method for assessing the gains in health relative to the costs of different health interventions. It is not the only criterion for deciding how to allocate resources, but it is an important one, because it directly relates the financial and scientific implications of different interventions. The basic calculation involves dividing the cost of an intervention in monetary units by the expected health gain measured in natural units such as number of lives saved. For example, using volunteer paramedics and trained lay people as first responders to accidents costs about US$128 per life saved in South Asia and US$283 in the Middle East and North Africa, whereas using a community-based ambulance costs about US$1,100 and US$3,500 per life saved in the same two regions, respectively. By measuring cost-effectiveness in terms of lives saved, all lives are treated equally regardless of whether the person is an infant who might live another 80 years or a middle-aged person who can expect only another 40 years of life.

Some studies calculate cost-effectiveness using years of life lost as the natural unit for measuring the effect of interventions (box 3.2). This measure treats each additional year of life gained from an intervention as equal. It sums the number of years of life that would be saved by an intervention. Hence an intervention that saved an infant's life (for example, preventing dehydration from diarrhea) would count more than one aimed at saving an older person's life (for instance, preventing recurrence of a stroke).

Because the future is uncertain, common (but not universal) practice is to discount both health gains and costs in distant years. *DCP2* uses a discount rate of 3 percent per year, which has the effect of making 80 years of life expectancy at birth worth about 30 discounted years. With discounting, saving an infant's life still gains more years than saving that of a middle-aged person, but the difference shrinks considerably. Interventions that incur costs now but provide gains only years later look less cost-effective under discounting than when gains accrue immediately, but interventions whose costs and health benefits follow the same time pattern are all affected equally and their relative cost-effectiveness is unchanged.

Nevertheless, averting death or prolonging life is not the only goal of health interventions. Investigators have proposed other measures to differentiate between a year of life in perfect health and a year of life with some health impairment. One of the more commonly used measures

Box 3.2 Some Technical Terms Used by DCP2

Cost-effectiveness ratio: The cost of an intervention divided by the resulting change in health status. The choice of currency units for measuring costs and the health units for measuring impact may vary. Wherever possible, *DCP2* reports U.S. dollars per DALY.

Average cost-effectiveness: The total cost of addressing a particular health problem using a particular intervention divided by the total health gain.

Incremental cost-effectiveness: The additional cost of extending a particular intervention divided by the additional health gain that would result.

DALY: A unit for measuring the amount of health lost because of a particular disease or injury. It is calculated as the present value of the future years of disability-free life that are lost as the result of the premature deaths or cases of disability occurring in a particular year.

Discount rate: A rate that is used to convert future costs and benefits into equivalent present values. For example, at a 3 percent discount rate, a cost of US$1 next year would be equivalent to US$0.97 today and a cost of US$1 in 10 years time would be equivalent to US$0.74 today.

Intervention: An activity using human, physical, and financial resources in a deliberate attempt to improve health by reducing the risk, duration, or severity of a health problem (Jamison 2002, table 2).

Quality-adjusted life year: A unit for measuring the health gain of an intervention calculated as the number of years of life saved and adjusted for quality.

Years of life lost: A measure of the impact of an adverse health event, generally calculated by subtracting the age at which death occurs from life expectancy at that age.

that addresses this issue is the disability-adjusted life year. A DALY measures not only the additional years of life gained by an intervention but also the improved health that people enjoy as a consequence. It assigns a value of 1 to a single year lived in perfect health. Any health impairment or disability is assigned a disability weight that describes the magnitude of the impairment, with a larger weight if the impairment is severe and a smaller one if the disability is modest. The value of a year lived with a disability then gets a value of 1 minus the disability weight, which measures the remaining degree of health. Researchers have assigned disability weights to various chronic conditions, pain, disability, and loss of bodily functions using a variety of methods, including international surveys that ask individuals to compare the quality of life under different health conditions. *DCP2* relied on disability weights calculated by

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WHO's disease burden studies, sometimes using these to estimate disability from conditions that WHO had not explicitly considered.

DALYs are useful for policy makers because they are a more comprehensive measure of population health than merely counting deaths and because they allow comparisons among a wide range of health interventions. Some health interventions are aimed directly at reducing mortality, but many are aimed at reducing the severity of illness and improving the quality of life. With DALYs, these different interventions can be compared against a common standard. For example, a cost-effectiveness analysis that measured health gain by the number of averted deaths would find little value in preventing onchocerciasis, but measuring health gain in DALYs assigns a high value to preserving people's vision because the disability weight of blindness is large.

One of the advantages of using cost-effectiveness ratios is that they avoid some ethical dilemmas and analytical difficulties that arise when attempting cost-benefit analyses. Applying the alternative analytical technique of cost-benefit analysis requires assigning a monetary value to each year of life. By foregoing this step, cost-effectiveness analysis draws attention exclusively to health benefits, which are not monetized. When an intervention leads to health savings, the costs should be subtracted from intervention costs when compared to health outcomes. Many health interventions yield benefits beyond the immediate improvement of health status. For example, healthier parents will be able to provide better care for their children, healthier workers will be more productive in the workplace, and healthier families may avoid falling into poverty. Some health interventions can induce virtuous cycles. For instance, preventing the death of a parent may mean that a family has more income to provide nourishment for growing children. Other health interventions provide important ancillary benefits that are valued independently. For example, the cost-effectiveness of water and sanitation services in reducing gastrointestinal diseases is low, but piped water and sanitation services are valued in and of themselves as a convenience and an environmental improvement.

The values people place on nonhealth benefits are quite high as demonstrated by their willingness to pay for such services, but cost-effectiveness will not measure additional nonhealth-related benefits. Therefore comparing interventions according to cost-effectiveness criteria must be done with a clear understanding that it compares interventions only in terms of their efficiency at improving health, and

if nonhealth benefits are going to be introduced into a debate, then they should be considered for all the interventions under discussion and not for a select few.

Cost-effectiveness analysis also requires comparable units for measuring costs. For domestic studies, the cost units in domestic currency will have a clear meaning. In the absence of unit prices of the inputs into interventions, for comparison across countries, *DCP2* authors were provided costs for each World Bank region in a widely used currency, usually U.S. dollars. The main question involves whether to use market foreign exchange rates to convert domestic currency costs and compare them to the value of imported and importable inputs expressed in dollars, or whether to use a different conversion factor based on studies of the relative purchasing power of the domestic currency. Because market exchange rates are easier to understand and correspond better to actual financial constraints, *DCP2* has used such rates for such conversions.

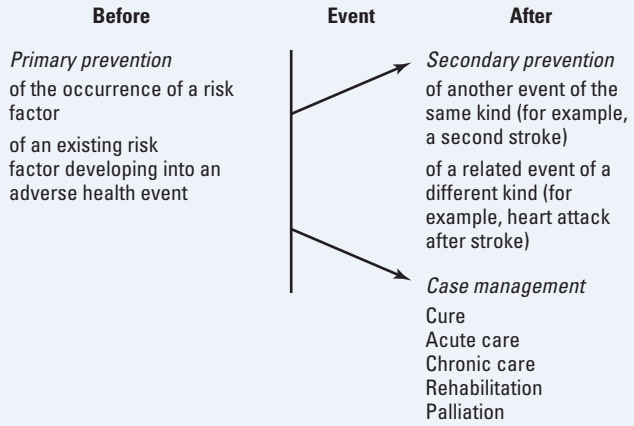
Cost estimates are affected by prices and prices can vary considerably between, and even within, countries. The authors of *DCP2* were unable to collect unit prices of the inputs into interventions in every country, so instead they were provided with average unit prices in each of six developing regions: East Asia and the Pacific, Europe and Central Asia, Latin America and the Caribbean, the Middle East and North Africa, South Asia, and Sub-Saharan Africa (previously published analyses, however, sometimes used WHO regional groupings). In the most complete analyses, the authors multiplied these regional unit prices by the estimated quantities of inputs required for each intervention and then divided by the estimated health effect to derive the cost-effectiveness ratios. In cases where the authors could not find disaggregated information on inputs but some cost-effectiveness measures were reported, they made extrapolations. In some cases, input ratios were available for one region and the authors extrapolated these to other regions (see, for example, *DCP2,* chapter 30).

To conduct a cost-effectiveness analysis, researchers also need to specify the health intervention in some detail. A health intervention is a deliberate activity that aims to improve someone's health by reducing the risk, the duration, or the severity of a health problem. Such interventions can be defined relative to adverse health events, such as being involved in an accident, contracting an infection, or suffering from a malignant tumor. Primary prevention seeks to avert an adverse health

event, while secondary prevention aims to keep an adverse health event from recurring or causing a related problem once it has occurred. Following an adverse health event, interventions can also fall into several categories of case management, including cures, acute care, chronic care, rehabilitation, and palliation (box 3.3).

Box 3.3 Intervention Categories with Examples

The figure illustrates how interventions are related to a health event. The definitions of these categories are given below.



Population-based interventions all aim at primary prevention (as defined below), are directed to entire populations or large subgroups, and fall into three categories:

- Promoting personal behavior change (diet, exercise, smoking, sexual activity)
- Control of environment hazards (air and water pollution, disease vectors)
- Medical interventions (immunization, mass chemoprophylaxis, large-scale screening, and referral)

Personal interventions are directed to individuals, and can be intended for the following:

- Primary prevention—to reduce the level of one or more risk factors, to reduce the probability of initial occurrence of disease (medication for hypertension to prevent stroke, or heart attack), or to reduce the likelihood of disease when the risk factor is already present (prophylaxis for sickle-cell anemia).
- Secondary prevention following the occurrence of disease—to prevent another event of the same kind (medication to reduce the likelihood of a second coronary event) or to reduce the risk of a different but related event (medication to reduce the likelihood of a first heart attack after stroke).
- Cure—to remove the cause of a condition and restore function to the status quo ante (surgery for appendicitis).

- Acute management—to provide short-term activity to decrease the severity of acute events or the level of established risk factors, to minimize their long-term impacts (thrombolytic medication following heart attack, angioplasty to reduce stenosis in coronary arteries).
- Chronic management—to provide continued activity to decrease the severity of chronic conditions or prevent deterioration (medication for unipolar depression, insulin for diabetes). Chronic management can include some secondary prevention.
- Rehabilitation—to provide full or partial restoration of physical, psychological, or social function that has been damaged by a previous disease or condition (therapy following musculoskeletal injury, counseling for psychological problems).
- Palliation—to reduce pain and suffering from a condition for which no cure or rehabilitation is currently available (analgesics for headache, opiates for terminal cancer).

Source: DCP2, chapter 15, box 15.1.

Characterizing an intervention fully also requires defining the level of care at which it is delivered; the particular supplies and processes involved; and the types of health care workers and any associated services required, such as laboratory tests. The more detailed and accurate the analysis, the more readily investigators can assess whether it is similar to or diverges from how that intervention is characterized in other contexts. For example, health interventions might be provided by a less specialized facility or involve more visits in one country than another.

The scope of the costs included will also affect the cost-effectiveness analysis. Researchers may choose a narrow definition of costs and focus exclusively on the direct variable costs of providing a service; that is, they may only include the costs of additional materials and staff that are required and exclude costs associated with the use of existing infrastructure or installed capacity. In other cases researchers may use wider definitions of costs by apportioning some share of the fixed costs of facilities and administration to the costs of the service. The *DCP2* authors were asked to follow the latter approach.

In some studies, researchers include other costs, such as the value of the time patients and family members spend in obtaining a service or the cost of transportation to reach facilities. When more costs are included, the cost per unit of health gain will be higher and the intervention will appear to be less cost-effective. If the interventions that are being compared have similar characteristics, such as all being offered at a similar facility, then including these other costs will not alter the ranking of interventions, but comparisons across interventions that are dissimilar could yield different results if the ratios are otherwise close.

"An ethical problem is involved if poor people's time is valued only on the basis of their low wages or incomes."

To be consistent, *DCP2* chapters use only direct costs, because estimates of these other costs are both difficult to obtain and rarely consistent across studies. An ethical problem is also involved if poor people's time is valued only on the basis of their low wages or incomes.

HOW RELIABLE IS COST-EFFECTIVENESS ANALYSIS?

Though the basic cost-effectiveness calculation appears to be simple, choices about units of measurement, definitions of interventions, scope of costs, and prices to be included not only will alter the numerical results but also will affect the interpretation of the cost-effectiveness ratio. In many cases the differences are so large that refining the underlying analyses is unnecessary. For instance, no amount of refinement will make coronary artery bypass grafting (>US$25,000 per DALY averted) more cost-effective than using new antimalarial drugs where resistance to older ones has developed (US$8 to US$20 per DALY averted) or taxing tobacco products (US$3 to US$50 per DALY averted) (table 3.1). For this reason, readers of *DCP2* are encouraged to pay attention to different orders of magnitude, distinguishing extremely or moderately cost-effective interventions from those interventions that are not cost-effective.

When cost-effectiveness ratios are within a similar range, policy decisions become more difficult. In such situations, closer scrutiny of the cost-effectiveness ratios may be warranted to improve confidence that the measures are close. This would entail verifying whether the units of measurement, the definition of interventions, and the scope of costs that are included were similar.

Note also that the quality of the evidence available to assess cost-effectiveness varies, especially given the wide range of interventions being looked at. *DCP2* notes that the best evidence comes from studies with randomized controls or systematic overviews and that the next best available evidence comes from nonrandomized studies that were nevertheless able to use rigorous statistical methods. The weakest evidence comes from limited case studies or surveys of expert opinion. However, a lack of evidence does not mean that an intervention is not cost-effective. It simply means that researchers do not know how cost-effective the intervention is. Nor does it mean that readers should ignore the cost-effectiveness numbers. Rather, readers should be cautious, should not rely heavily on point estimates, and should pay attention to orders of magnitude and quality of evidence.

Table 3.1 The Amount of Health US$1 Million Will Buy

Service or Intervention	Cost per DALY (US$)	DALYs averted per US$1 million spent
Reducing Under-Five Mortality		
1. Improved care of children under 28 days old (including resuscitation of newborns)	10–400	2,500–100,000
2.1 Expansion of immunization coverage with standard child vaccines	2–20	50,000–500,000
2.2 Adding vaccines against additional diseases to the standard child immunization program (particularly against haemophilus influenza and hepatitis B)	40–250	4,000–24,000
3. Switching to the use of combination drugs (ACTs) against malaria where there is resistance to current inexpensive and highly effective drugs (Sub-Saharan Africa)	8–20	50,000–125,000
Preventing and Treating HIV/AIDS		
4. Prevention of mother-to-child transmission (ARV–nevirapine–prophylaxis of the mother; breast-feeding substitutes)	50–200	5,000–20,000
5. STI treatment to interrupt HIV transmission	10–100	10,000–100,000
6.1 ARV treatment achieving high adherence for a large percentage of patients	350–500	2,000–3,000
6.2 ARV treatment that achieves high adherence for a small percentage of patients		because of very limited gains by individual patients and the potential for adverse changes in population behavior, there is the possibility that more life years would be lost than saved
Preventing and Treating Noncommunicable Disease		
7. Taxation of tobacco products	3–50	20,000–330,000
8.1 Treatment of acute myocardial infarction (AMI) or heart attacks with an inexpensive set of drugs	10–25	40,000–100,000
8.2 Treatment of AMI with inexpensive drugs plus streptokinase (costs and DALYs for this are in addition to what would have occurred with inexpensive drugs only)	600–750	1,300–1,600
9. Lifelong treatment of heart attack and stroke survivors with a daily "polypill" combining 4 or 5 off-patent preventive medications.	700–1,000	1,000–1,400
10.1 CABG or bypass surgery in specific identifiable high risk cases, such as disease of the left main coronary artery (incremental to 9)	>25,000	<40
10.2 Bypass surgery for less severe coronary artery disease (incremental to 9)	very high	very small

(Continued on the following page.)

Table 3.1 (*Continued*)

Service or Intervention	Cost per DALY (US$)	DALYs averted per US$1 million spent
Other		
11. Detection and treatment of cervical cancer	15–50	20,000–60,000
12. Operation of a basic surgical ward at the district hospital level focusing on trauma, high risk pregnancy, and other common surgically-treatable conditions	70–250	4,000–15,000

Sources: DCP2, Chapter 1, table 1.3.
Note: DALYs averted per US$1 million spent on an intervention will vary enormously from country to country and in light of many other factors. This table aims only to provide a very *rough* sense of how much health can be bought with different interventions and to show that there is huge variation in the amount of different health interventions (or that the same intervention applied in different ways) can provide for the same amount of money.
ACT = artemisinin combination therapy
AMI = acute myocardial infarction
ARV = antiretroviral
CABG = coronary artery bypass graft
STI = sexually transmitted infection

WHAT ARE APPROPRIATE TASKS FOR COST-EFFECTIVENESS ANALYSIS?

"Cost-effectiveness analysis . . . provides information about the costs of improving health by means of a particular intervention."

Cost-effectiveness analysis can offer no help for many important policy-making tasks. It essentially provides information about the costs of improving health by means of a particular intervention. As with any investment decision, the price of something is an important, but not the only, consideration. For example, the cost of building a school—like the cost of building a clinic—will vary depending on its size and location and the materials used. Those choices will affect the cost of schooling per student, which may affect the number of children who can attend and perhaps the quality of their learning. However, without information about price, decision makers cannot see the trade-offs involved in addressing other concerns.

Thus the question becomes how policy makers, health program administrators, researchers, and others can make the best use of cost-effectiveness analysis. Three types of comparisons become immensely easier with cost-effectiveness analysis:

- comparisons of different interventions for the same disease
- comparisons of different interventions for reaching specific segments of a population
- comparisons of different interventions for different diseases.

Using the cost-effectiveness ratio is most straightforward when comparing interventions that address the same disease or risk factor and differ only in the mode of delivery. In this case, cheaper interventions generally result in greater health gains. For example, addressing vitamin A deficiency by means of capsule distribution has a similar impact on health as fortifying sugar; however, capsule distribution costs about US$6 to US$12 per DALY averted, whereas sugar fortification costs about US$33 to US$35 per DALY averted. Another way of looking at this is to note that for the same cost, capsule distribution could reach three to five times more people than fortified sugar (*DCP2*, Chapter 28). This is a clear indication that more health gain is possible by spending resources on capsule distribution.

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However, even in this simple example, decision makers might need to take other factors into account, in particular, that different interventions may reach different people. The cost-effectiveness analysis treats all health gains equally, whereas in public policy, distribution issues are also important. For example, capsule distribution might only reach people who attend health centers, while sugar fortification would only reach people who buy sugar. Depending on the characteristics and behaviors of the population with vitamin A deficiency, fortification might, in practice, be both more effective and more equitable. Fortification would still be costlier per DALY, so decision makers would have to decide whether the additional cost of achieving the more equitable outcome is affordable relative to other uses of the same funds.

Cost-effectiveness analysis is also useful when comparing interventions that address different diseases or risk factors. Scarce resources will generate more health improvements when they are applied to interventions that are more cost-effective. If the cost-effectiveness analysis uses number of deaths averted as its measure of health gain, then allocating resources to more cost-effective interventions will avert the most deaths. For example, spending US$1 million on expanding the traditional vaccination schedule for children to include a second opportunity for measles immunization would avert between 800 and 66,000 deaths, depending largely on the prevalence of measles. In contrast, spending the same amount of money to expand the schedule to include Hib vaccine would avert between 10 and 800 deaths and including yellow fever vaccine would avert between 300 and 900 deaths.

". . . spending US$1 million . . . to include a second opportunity for measles immunization would avert between 800 and 66,000 deaths, . . ."

If instead the analysis uses DALYs as the measure of health gain, then allocating resources to the most cost-effective interventions will maximize years of healthy life. For instance, US$1 million spent on

nevirapine and breastfeeding substitutes to prevent HIV-infected mothers from transmitting HIV to their children would yield a gain of 5,000 to 20,000 DALYs, whereas the same amount of money spent to expand immunization coverage with standard children's vaccines would yield a gain of between 50,000 and 500,000 DALYs.

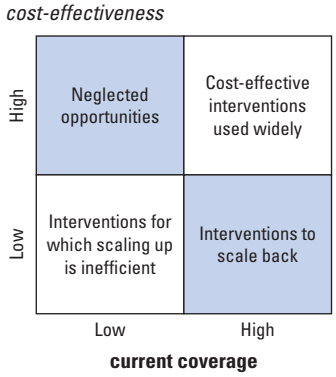
Thus cost-effectiveness should not be the exclusive basis for making health-related public policy decisions and should be complemented with information about distributional consequences. For public policy makers, these two kinds of information establish the trade-offs inherent in allocating funds to different interventions.

HOW CAN POLICY MAKERS USE COST-EFFECTIVENESS ANALYSIS?

To provide good policy guidance, cost-effectiveness must be complemented with essential information about the larger context, in particular, the prevailing burden of diseases, the existing coverage of health interventions, and the overall capacity of the health system.

An essential contextual factor in using information on the cost-effectiveness of any intervention is the burden caused by a disease. Some interventions may be highly cost-effective but affect only a small number of people or provide a small improvement in health (figure 3.1). For example, leishmaniasis treatment is relatively cost-effective, but is only applicable to a relatively small number of cases. By contrast, antimalarials and insecticide-treated bednets are cost-effective measures that, in certain countries, would avert a large burden of disease. If possible,

Figure 3.1 Efficiency of Interventions



Source: DCP2, chapter 2, p. 34.

countries would finance all measures that would improve health, but as every country faces a tight budget or constrained capacity to deliver services, the avertable burden of disease is an essential piece of information that policy makers require when choosing between otherwise similarly cost-effective interventions.

Health interventions that are preventive will generally be more cost-effective in places where the burden of the targeted disease or risk factor is high and, consequently, where the intervention will avert more cases. Yet current prevalence is not always a good indicator of whether an intervention will be cost-effective, particularly in places where effective public health programs are responsible for the low rate of prevalence. For example, the prevalence of diphtheria, tetanus, pertussis, and measles is generally low in countries with effective vaccination programs, yet the cost-effectiveness of the vaccination program, which is needed to avoid a resurgence of these illnesses, is still quite high.

Prevalence also has a large effect on the cost-effectiveness of screening for illnesses and, indirectly, on the cost-effectiveness of a package to address a certain ailment. For example, screening and treatment for helicobacter, a bacterial risk factor for stomach cancer, is not cost-effective in the United States, but is cost-effective in Colombia, because the prevalence of stomach cancer is higher in Colombia and many of the costs of treatment are lower (*DCP2,* chapter 29).

The cost-effectiveness of screening for cancers and many other illnesses depends on the costs of identifying cases, on how many people do not follow up with treatment, and on the direct costs of treatment. Of course, if no treatment is available, screening is pointless. Testing for anemia among people with AIDS is cost-effective among those treated with zidovudine not only because screening is relatively cheap (less than US$0.02 per anemia test) but also because anemia occurs in 10 percent of these patients. When costs are higher or the likelihood of encountering conditions is small, screening may not be cost-effective.

Cost-effectiveness is also sensitive to the probabilities of transmission. For example, universal blood screening for HIV is costly, yet it is also cost-effective, even in countries with a low prevalence of HIV/AIDS, because receiving contaminated blood has such a high probability of leading to infection—almost 100 percent.

An appropriate time horizon is also imperative in assessing the weight of a disease burden and the value of an intervention for several reasons. One is that the gains from the intervention may accrue only in

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" . . . universal blood screening for HIV is costly, yet it is also cost-effective, even in countries with a low prevalence of HIV/AIDS . . ."

the long term, so the intervention appears to be effective with a long horizon but not a short one. The discount rate matters greatly to this comparison because it makes the distant future less valuable. Another reason is that the intervention may have to be repeated for several years to assure the potential health gains. This is the case for ORT, which may need to be given many times over several years to prevent diarrheal disease deaths among young children, and for penicillin prophylaxis, to prevent deaths from infection in children with sickle cell disease (*DCP2*, chapters 19 and 34). Finally, an intervention may have substantial start-up costs that must be amortized over some period. *DCP2* uses 10 years as the standard in such cases.

The coverage of existing interventions is another crucial contextual factor in making use of cost-effectiveness analysis. When policy makers decide how to allocate resources, they can compare interventions that are relatively more or less cost-effective in light of the current supply of services. For example, some interventions may be extremely cost-effective but have low coverage. These are neglected opportunities that policy makers should look at more closely. Barring other contravening factors, these are likely to be interventions that would have a large effect on health for relatively little cost.

DCP2 mostly reports cost-effectiveness ratios as if they were independent of the level and scale of interventions, yet the incremental cost-effectiveness of most interventions will also vary with the level of service coverage. The cost of reaching the first 1 percent of a population may be quite high when the fixed costs of purchasing equipment, training staff, and setting up management systems are taken into consideration and may yield relatively few health gains. As coverage increases, however, the average cost may fall and health improvements may increase, resulting in a substantial improvement in the cost-effectiveness of reaching an additional group, for example, extending from 50 percent coverage to 51 percent coverage. Once coverage is high, reaching the remaining, and often marginalized, segments of the population may again be quite costly without a correspondingly large health gain, and consequently cost-effectiveness will worsen. Consider the experience of eradicating smallpox. At a certain point in the campaign, large parts of the world were free of smallpox and eradication became contingent on identifying the last few redoubts of the virus and responding massively and quickly to quarantine those infected and vaccinate everyone else in those areas. Today the polio campaign faces a similar challenge: reaching and vaccinating a few children in

rural parts of India and Sudan is much costlier than treating many more in urban areas, but elimination of the disease can justify those high costs. A similar process is at play with the provision of basic health care in that it is generally less costly per person in areas with dense rather than sparse populations.

In addition to disease prevalence and existing coverage, policy makers need to take other local factors into consideration. *DCP2* provides estimates based on regional averages of unit prices,[1] but local prices and the availability of inputs may vary substantially from regional averages. Therefore a first consideration is whether a particular country's prices are near to or diverge sharply from the regional average. A second consideration is whether prices of key inputs have changed since the original analysis. One of the most dramatic changes since the earlier edition of *Disease Control Priorities in Developing Countries* (Jamison and others 1993) has been the fall in prices of antiretroviral drugs. Consequently, antiretroviral therapy is substantially more cost-effective today than it was a decade ago. Further reductions in the costs of diagnostic testing and alternative forms of delivery may increase the cost-effectiveness of antiretroviral therapy even further in the near future.

Finally, the cost-effectiveness of most health interventions also depends on how well the health system functions (*DCP2,* chapter 3). Most *DCP2* chapter authors calculate cost-effectiveness ratios based on the assumption that a functioning health system is available to deliver the intervention; however, this is an assumption whose validity varies greatly across countries. If a country has a particularly weak health system, then interventions that rely heavily on medical professionals, complex treatments, or sophisticated information systems will not be as cost-effective in practice as they would be in countries with stronger health systems.

The experience of introducing IMCI (*DCP2,* chapter 63) demonstrates the extent to which health system functioning can influence the cost-effectiveness of health interventions. Experiences in several districts in Brazil and Tanzania show that the IMCI package of interventions not only improves children's health outcomes but can actually be cost saving by reducing improper care and excessive use of medications. However, in most low- and middle-income countries the IMCI

[1] When price data were only available from a few countries in a region, *DCP2* authors tried to select a price that was most likely to be representative of that region, even if it was not a calculated average.

package has encountered difficulties in implementation and failed to realize its promise of cost-effectiveness because of high rotation and attrition of trained staff, inadequate supplies, and insufficient funds.

SUMMARY FOR USING COST-EFFECTIVENESS ANALYSIS PROPERLY

Applying resources effectively means spending money on things that influence health, and this requires scientific knowledge about risk factors, diseases, biochemistry, social behavior, and so on, but this scientific knowledge alone does not determine which interventions will have the most impact. To determine the best allocation of public funds, policy makers need information about relative costs to determine what combination of interventions can yield the greatest improvements in health. Cost-effectiveness analysis is the tool for weighing different costs and health outcomes when policy makers have to make resource allocation decisions. It does this by giving policy makers the "price" of achieving health improvements through different kinds of interventions, and thereby helps them make decisions that get the most out of their financial resources.

Ultimately, knowing which interventions work and at what cost has to be tempered by knowledge of institutions and implementation. Only when scientific and practical knowledge are combined can policy makers identify the interventions that will have the most impact in practice. Thus the cost-effectiveness analyses presented in *DCP2* and in this book provide an important contribution to broader debates about public policy decisions pertaining to health.

DCP2 compiles the best available evidence about the cost-effectiveness of different interventions. To use these numbers properly, readers should

- consider the cost-effectiveness ratios reported for their regions as a first approximation and rank the interventions in broad categories
- assess whether the calculated ratios would differ substantially in their countries because prices, demographics, epidemiology, or service coverage differ significantly from the regional average
- consider whether the cost-effective interventions would address major sources of the disease burden in their countries

- determine whether the cost-effective interventions would be feasible given existing institutions and experiences with implementation in their countries
- evaluate the cost-effective interventions in terms of how they would distribute health improvements and whether this would be equitable in their countries.

At the conclusion of such a review of the international evidence, countries will be able to achieve better health for their people because they can explicitly assess the costs and consequences of different courses of action.