Chapter **2**

Intervention Cost-Effectiveness: Overview of Main Messages

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Deeper understanding of the role of human health as a critical component of economic development has stimulated interest in improving the efficiency with which the modest health resources available in low- and middle-income countries (LMICs) are spent. In recent years, exponential growth in the number of economic evaluations of health interventions, spurred in part by the first edition of this volume (Jamison and others 1993), has created a wider knowledge base for evaluating the costs and benefits of interventions to enable better targeting of financial resources in the health sector (box 2.1). Although efficient spending on health has always been a desirable goal, it is particularly critical in the face of recent threats, such as HIV/AIDS and drug-resistant bacteria, as well as the problems presented by increasing prevalence of chronic diseases, such as diabetes and cardiovascular disease (CVD), that threaten to roll back the significant health gains achieved in the past two decades. This book is an opportunity to assess anew the costs associated with and the health gains attainable from specific interventions and thereby better inform the allocation of new health funding.

Drawing from the collective knowledge and analytical work of the many experts who have contributed to this volume, this chapter provides a broader perspective on the relative efficiency and effect on health of a number of interventions than is possible in a single, condition-specific chapter.[1] The objective is to provide information on the cost-effectiveness estimates for 319 interventions covering nearly every disease condition considered in the volume, and the resulting avertable burden

of disease.[2] This chapter provides broad conclusions on the economic efficiency of using these interventions to improve health.

PRIORITY SETTING

Information on the costs of purchasing health in conjunction with regional or national realities regarding disease priorities, private willingness to pay for health, and public budget constraints can be used to identify widely prevalent investments that are not cost-effective (shaded in figure 2.1) and highly cost-effective opportunities to improve health that policy makers are currently neglecting. Throughout the chapter, "not cost-effective" describes an intervention that has a relatively high ratio of costs to effectiveness. The information provided also may be helpful in identifying interventions that are not cost-effective and are rarely used and cost-effective interventions that are justifiably widely used (unshaded in figure 2.1). The broad objective of this exercise is to help improve global population health by improving understanding of the implications of investing in different interventions. Some of the interventions considered are widely prevalent, whereas others are less well known. Although some interventions are personal, others are population-based (see annex 2.A for definitions). They encompass the spectrum of disease conditions covered in this book but are by no means exhaustive of the universe of possible interventions.

Use of Cost-Effectiveness to Set Policy: The Directly Observed Treatment Strategy

Nearly 2 million people die from tuberculosis (TB) each year, 98 percent of whom live in developing countries and most of whom are 15 to 49 years old. Meanwhile, anti-TB medicines are 95 percent effective in curing TB, even in low-income countries, and cost as little as US$10 for a six-month course of treatment or directly observed therapy short course (DOTS). The TB chapter of the first edition of this book (Murray, Styblo, and Rouillon 1993) and studies by Joesoef, Remington, and Jiptoherijanto (1989) and Kamolratanakul and others (1993) describe treatment of smear-positive TB with short-course chemotherapy as an extremely cost-effective intervention for TB.

Since 1980, the World Health Organization (WHO) has collaborated closely with many countries in East Asia and the Pacific to introduce short-course chemotherapy and then the DOTS strategy to achieve global targets, with a cure rate of 85 percent and a case-detection rate of 70 percent. In 1990, 10 countries were using short-course chemotherapy. In 1993, as a result of growing TB prevalence rates, WHO's declaration of a global emergency,

and studies showing DOTS' cost-effectiveness, the DOTS strategy was established worldwide as the most effective response to TB. By 1995, DOTS had expanded to 73 countries, and by 2003, it had reached more than 180 countries worldwide (WHO 2004).

As of 1999, DOTS has been implemented with the collaboration of WHO in 13 provinces of China and has achieved a cure rate of 90 percent. The population in East Asia and the Pacific with access to DOTS increased from 44 percent in 1995 to 57 percent in 1997, with the proportion of registered TB patients who are enrolled in a DOTS program also increasing, from 30 percent in 1995 to 46 percent in 1997 (WHO 1999). The progress is mainly attributable to high-prevalence countries in the region, which include Cambodia, China, and the Philippines.

By 2002, national TB programs reported that 69 percent of the world's population lived in countries or parts of countries with DOTS coverage. DOTS programs treated a total of 13.3 million TB patients and 6.8 million smear-positive patients between 1995 and 2002.
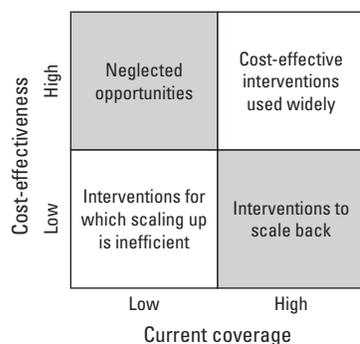
Source: Authors.

Figure 2.1 Efficiency of Interventions

Cost-Effectiveness

The specific measure of cost-benefit analysis adopted in this volume is cost-effectiveness. Effectiveness is measured in natural units (deaths averted and years of life saved) and in disability-adjusted life years (DALYs), a composite measure that combines years lived with disability and years lost to premature death in a single metric (see chapter 15 for an explanation of how DALYs are calculated). Nevertheless, dollars per DALY averted can at best be only one consideration in the allocation of resources to different diseases and interventions. This

chapter also focuses on the total burden of disease avertable by expanding population coverage of an intervention. The delivery of many interventions, including those that are relatively cost-effective, may require a certain degree of institutional and organizational capacity on the part of a health system, and countries will have to pay attention to this important consideration.[3] These factors, in combination with other considerations such as equity, social justice, medical suitability, and epidemiological appropriateness, should guide where money may be spent most effectively (Cookson and Dolan 1999, 2000).

Cost-effectiveness ratios can be used to set health priorities in two ways. One approach is to use a cutoff level of cost-effectiveness beyond which interventions are no longer used. This cutoff can vary from place to place depending on the availability of health resources, the disease burden, and the local preferences for health spending. The World Bank has described health interventions that cost less than US$100 per year of life saved as highly cost-effective for poor countries, but this benchmark is arbitrary, as chapter 15 makes clear by noting the interaction with income, budget levels, and the disease burden (Jamison and others 1993).

An alternative approach to using cost-effectiveness data to set intervention priorities is to interpret the cost-effectiveness ratio as the "price" of equivalent units of health using different interventions (box 2.2 explains this approach). Reinterpreted

Box 2.2

A Framework for Using Cost-Effectiveness Information to Set Health Priorities

A frequent, often justified, criticism of cost-effectiveness analyses is that they address only one of many criteria that could be used to evaluate health interventions. Epidemiological, medical, political, ethical, and cultural factors often also play important roles in the decision to allocate resources to a specific health condition or intervention; however, determining how one might weigh cost-effectiveness ratios alongside these other considerations when setting priorities for spending is difficult. Musgrove (1999) shows how to take some of these connections into account, including circumstances in which cost-effectiveness is an adequate criterion by itself. One approach is for the policy maker to think of cost-effectiveness ratios as the relative "price" of purchasing a unit of health (a DALY, for instance) using different interventions. These costs, along with the budget constraint, can help determine the optimal allocation of resources among a given set of interventions.

Consider, for instance, a policy maker in a country in Sub-Saharan Africa facing the choice between treating Parkinson's disease and expanding malaria treatment programs while constrained by a fixed budget allocated by the ministry of finance. The cost per DALY averted of treating Parkinson's disease using carbidopa is vastly greater than that for the malaria control program. A simplistic interpretation of the cost-effectiveness information would be to expand the malaria treatment program to the maximum extent possible before turning to the treatment of Parkinson's disease. This solution could be desirable in some situations, particularly if the budget is large enough to deal fully with the malaria problem and still allow for some treatment of Parkinson's. Emphasizing as complete coverage as possible of a particular problem may be especially appropriate in an epidemic situation, in which turning to another disease first can mean the epidemic will be worse in the future. Devoting some resources to each problem instead of concentrating on either may be more sensible when neither presents the threat of a growing epidemic.

Asking policy makers to make a binary choice between two sets of interventions on the basis of cost-effectiveness ratios alone may be unrealistic and misleading. Rather, policy makers should first determine their willingness to trade off health improvements in children (malaria) versus the elderly (Parkinson's). Policy makers may want to avert at least some burden from Parkinson's even if these cases are relatively expensive to treat for each unit of health gained because of such considerations as the target age group, the

socioeconomic status of target populations (including the extent to which they can obtain treatment from their own resources), and the ministry of health's ability to deliver the program effectively. After the tradeoffs have been made and can be represented by an indifference curve (see the figure and explanation), the cost-effectiveness information is useful in determining how much of the policy makers' fixed budget should be allocated to each intervention— that is, at what coverage of one problem should they start devoting resources to the other? The indifference curve represents health planners' willingness to trade off between investment in antimalarial drugs and treatment for Parkinson's based on all the relevant factors and independent of the budget constraint.
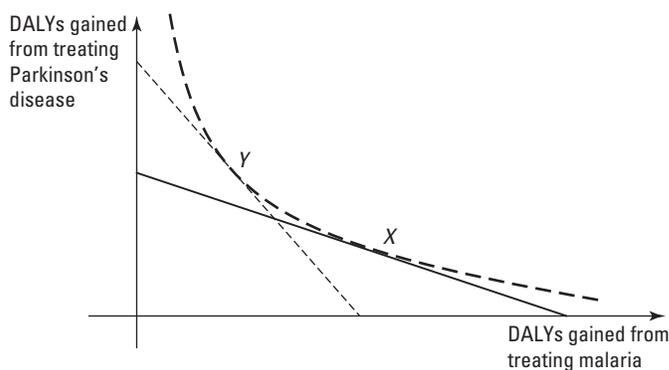
The solid line represents the budget, and its slope is the ratio of the cost-effectiveness ratios of the two interventions. The dashed line represents an alternative scenario in which the cost-effectiveness of treating Parkinson's is better (more DALYs can be gained) than the ratio represented by the solid line. The axes show how many DALYs can be gained from each treatment, so a large number of DALYs corresponds to a low "price" of health or cost per DALY. The figure shows the simple case, in which these prices are constant for either budget line—that is, expanding either program does not raise the unit cost—although this case is unlikely when part of the population is difficult to reach, is harder to treat, or has more severe disease, in which case the rise in unit cost means that an intervention becomes relatively less cost-effective, giving a further reason to start devoting resources to an alternative intervention.

When the price of buying a unit of health to treat Parkinson's is relatively high in terms of cost per DALY averted, the relatively flat (solid) budget line applies, and the optimal balance of investment in the two interventions is at

point *X*. If the cost of buying a unit of health to treat Parkinson's is relatively low, then the steeper (dashed) budget line applies and the relative allocation of resources is represented by point *Y*. Therefore, policy makers would allocate relatively more resources to treating Parkinson's when the price of buying a unit of health through this intervention is relatively low, and they would allocate fewer resources when the price of health obtained through this intervention is relatively high. The figure shows the general likely shape of an indifference curve, but one possibility is

that policy makers' willingness to trade off between buying health from the two approaches is just a straight line, in which case they would want to invest the maximum amount possible in the lower-cost intervention (malaria) before turning to the higher-cost intervention (Parkinson's). The role of the cost-effectiveness information is to make policy makers aware of differences in the price of improving health using different interventions. Interventions with a high price should, all else being equal, be used less, whereas those with a low price should be used to a greater extent.

this way, there is no one-dimensional economic criterion that interventions must attain to be declared economically fit, and cost-effectiveness plays the more useful function of informing tradeoffs that policy makers are forced to make when investing in a portfolio of health interventions.

Target Audiences

The general notion of efficiency in how resources, both public and private, are spent on improving health is of interest not only to severely resource-constrained countries that each year spend only a few public dollars on health for each individual, but also to relatively wealthier nations with many competing priorities for public and private resources. The primary audiences for cost-effectiveness information are ministries of health and finance and policy makers in other branches of government in LMICs, both to help reallocate existing outlays in the health sector and to allocate new monies efficiently. Other audiences include aid agencies, international development lending institutions, nongovernmental organizations, and private health care providers.

Priority Setting in the Private Sector

The use of the efficiency criterion in priority setting should not be limited to public resources. A large proportion of health care in developing countries is paid for out of pocket, and greater clarity on interventions that are efficient from an economic perspective is no less urgent when the payer is private: inefficient private spending on health care in developing countries is wasteful as well. Much of this inefficiency may be attributed to significant differences in knowledge—termed *information*

asymmetries—between profit-making providers and patients. Private providers may encourage unnecessary procedures and excessively invasive procedures that, in some instances, can be more dangerous than no treatment at all. Governments have a role to play in lowering these information asymmetries, partly by providing information to populations, for instance, on the importance of childhood vaccinations. Moreover, even if government expenditures are not directly influenced by the lack of efficiency in privately delivered health care, they are affected by the inefficiency of private health systems if private patients seek public emergency care or require other state assistance. In their role as large purchasers of health care, governments—even in largely privately financed health care systems, such as in the United States—exercise enormous influence over the choices of drugs used and interventions provided and can play an important role in promoting policies to facilitate greater efficiency in health care systems.

The costs and efficacy of interventions may vary greatly, even within a single geographical region, depending on local health system capacity, cultural context, disease epidemiology, and a host of other factors. Greater efficiency in how countries spend their health care resources can have a tremendous effect on the health of their populations. Box 2.3 discusses gains from improved priority setting found in the lifesaving study by Harvard University (Tengs 1997; Tengs and others 1995).

METHODOLOGY

This chapter compares the cost-effectiveness of interventions that cover a broad spectrum of health conditions prevalent in developing countries. All results are presented in U.S. dollars discounted to the year 2001 using a 3 percent annual discount

The Harvard Lifesaving Study

A study by Harvard University in the United States showed potential gains of life years saved by choosing interventions on the basis of their cost-effectiveness. The study's authors assessed more than 500 types of lifesaving interventions, defined as any behavioral or technological strategy that reduces the probability of premature death among a specified target population. The study focused on 185 interventions and the extent to which each intervention was currently being implemented, without taking its cost-effectiveness into account.

The authors estimated that the selected 185 interventions would cost US$21.4 billion per year and would save

592,000 life years. The same amount of money could have saved another 636,000 life years had funds been redirected from less to more cost-effective interventions. Following an assessment of varying factors regarding interventions—those that affect the most people and are the most effective, least cost, and most cost-effective—the study reports that if the goal is to save the most life years, cost-effectiveness is a useful approach that will result in the most efficient allocation of resources. The study indicates that choosing the most cost-effective interventions could double the life years saved.

Sources: Tengs 1997; Tengs and others 1995.

rate. Chapter 15 summarizes the general guidelines governing the analysis leading to the results reported for all LMICs.

Regional Variations

Where possible and appropriate, intervention cost-effectiveness ratios and other information have been disaggregated by World Bank region. In discussing the estimates, this chapter focuses on differences in the costs of interventions rather than on differences in their effectiveness in specific regional settings, although both contribute to differences in cost-effectiveness estimates across regions. Cost-effectiveness estimates also differ among regions because of variations in underlying mortality, age structure, disease prevalence, and efficiency with which interventions are implemented. The analyses take all but the last of these considerations into account.

Interregional cost differences are attributable to differences in the local costs of goods and services that are not easily tradable. For components that are tradable, such as patented drugs and specialized medical equipment typically imported from industrial nations, the analyses assume uniform international costs for all LMICs, usually adjusted for local transportation and distribution costs. By using a single composite set of resource costs for each region, the analyses mask intraregional differences in the costs of nontradable goods, such as physician time or hospitals, but this methodology is appropriate because results are presented only at the level of the region.[4] Interventions may differ in cost-effectiveness because they are targeted more appropriately to some age groups rather than others, and important gender differences may also exist in cost-

effectiveness for some conditions, but data to estimate such differences are lacking.

Caveats

The findings in this chapter are subject to a number of caveats. First, despite efforts to ensure the consistency of cost-effectiveness numbers across chapters, the approaches taken in arriving at these numbers vary significantly. Although some chapters rely on cost-effectiveness numbers drawn from the literature, other chapters have analyzed these numbers afresh using the standardized resource costs described elsewhere. Table 2.1 contains definitions of indicators used to assess the

Table 2.1 Quality of Cost-Effectiveness Evidence for Interventions

Level	Source of cost-effectiveness evidence
1	Literature review of one cost-effectiveness study in one country
2	Literature review of several cost-effectiveness studies for multiple countries
3	Literature review of several cost-effectiveness studies for a single intervention in a single region
4	Original economic analysis by authors following the volume editors' guidelines in one country
5	Original economic analysis by authors following the volume editors' guidelines in one region

Source: Authors.
Note: Standard region-specific age structures and underlying mortality rates were used to calculate DALYs. Nontradable inputs were converted into U.S. dollars at the market exchange rate. The costs of tradable inputs were assumed to be internationally consistent, as were the costs associated with surgical treatments.

quality of evidence on which the cost-effectiveness estimates are based. The tables in annex 2.B and annex 2.C indicate the quality of evidence associated with each intervention.

Second, almost without exception, the cost-effectiveness numbers do not vary with the scale at which the intervention is undertaken, and this is probably not the case in reality (Birch and Donaldson 1987; Johns and Torres 2005). Some interventions, such as vaccination programs, have large setup costs but marginal costs of extending coverage that decline at least initially. Other interventions, such as educational campaigns for condom use, may be easy to target to urban populations, but the marginal costs of expanding such interventions to relatively inaccessible populations increase with coverage. Therefore, many of the cost-effectiveness ratios presented here are useful only for modest increments in coverage, and separate analyses may have to be conducted to determine their applicability to program start-ups and larger-scale intervention changes.

Third, the cost-effectiveness numbers presented apply to countries whose institutional and technical capacity in relation to health is close to the average for the region. This evaluation is restricted to what countries could do more (or less) of, and clearly a more ambitious analysis would also cover what countries could do better. This issue is discussed in detail in chapters 3 and 70.

Finally, the estimates are based on the best available data, which in many cases are somewhat weak. Statistically derived confidence bounds for the cost-effectiveness estimates are not provided, and in most cases, uncertainty analysis has not been carried out. Readers are encouraged to pay attention to the order of magnitude of each estimate rather than to the specific number presented.

ASSESSING THE EVIDENCE ON THE COST-EFFECTIVENESS OF INTERVENTIONS

Figures 2.2 and 2.3 display results gathered from other chapters on cost-effectiveness ratios. In some cases, interventions are grouped on the basis of their similarity and whether they were personal interventions or population-based interventions. For instance, all population-based programs to prevent HIV transmission via contaminated blood and needles were grouped as a single intervention. Note that the cost-effectiveness ranges should not be interpreted as statistical confidence intervals but rather as a range of "best estimates" of cost-effectiveness incorporating variation across interventions included in the cluster. Ranges for the cost-effectiveness ratios are also attributable to variations in the epidemiological settings in which these interventions were evaluated. For example, a population-based primary intervention in an area of low prevalence is likely to be less cost-effective than the same intervention in a region of high prevalence. Figure 2.2 reflects sets of interventions dealing with high-burden diseases, and figure 2.3 deals with relatively low-burden diseases.
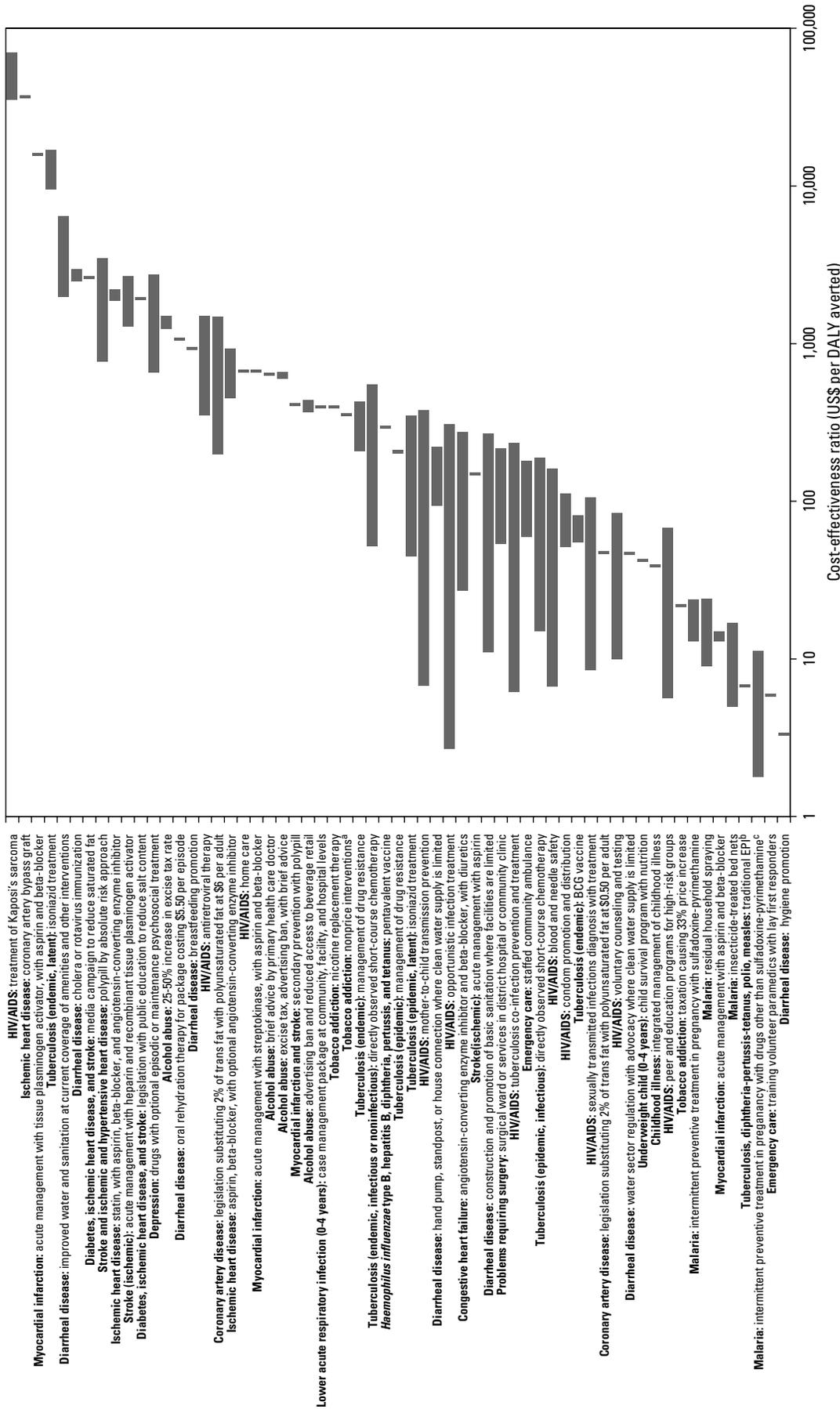
Within each figure, intervention clusters are displayed in the order of increasing cost-effectiveness. Additional information on the setting, objective, and target population of each intervention cluster for which cost-effectiveness has been calculated is provided in annex 2.B. The tables in annex 2.B also provide information on the quality of the evidence on which the data presented are based. Furthermore, the annex tables present information on potentially avertable deaths and DALYs if the coverage of these interventions were expanded by a further 20 percentage points of the relevant population (scaling up from 62 percent means reaching 82 percent, not 74 percent, of the pertinent population). Care should be taken not to confuse this information with the current burden of the underlying disease, on which basis interventions were divided into high-burden and low-burden diseases (figures 2.2 and 2.3, respectively).[5] For example, a cost-effective treatment for CVD has only limited scope for increased scale of intervention in countries with a low burden of this disease. At the same time, in many parts of Asia and Sub-Saharan Africa, even though HIV treatment is not a highly cost-effective intervention, it deserves attention because of its sizable potential for lowering the disease burden.

The tables in annex 2.C summarize information on intervention clusters for which cost-effectiveness was evaluated with a metric other than DALYs. For these interventions too, details of setting, objective, target population, and quality of the evidence have been provided. Given the difficulty in comparing these intervention clusters with those evaluated using DALYs, they are excluded from figures 2.2–2.5.

Observations about specific interventions follow. Ranges of cost-effectiveness estimates shown reflect geographical variations across regions.

Prevention and Control of Tuberculosis

The treatment of all forms of active tuberculosis (TB) using the directly observed treatment strategy based on short-course chemotherapy is among the most cost-effective of all interventions available to improve health in LMICs (US$5 to US$35 per DALY averted except in Europe and Central Asia) (box 2.1). The bacillus Calmette-Guérin (BCG) vaccination for children is also cost-effective (US$40 to US$170 per DALY averted), but its main effect is to reduce the burden of severe TB in children (TB meningitis and miliary TB). Because BCG has relatively little effect on the huge burden of pulmonary TB in adults—which constitutes the major cause of ill health resulting from *Mycobacterium tuberculosis*—development of a new vaccine that targets adults is highly desirable. The treatment of latent TB in patients uninfected with HIV is relatively cost-ineffective (US$4,000 to US$25,000 per DALY averted), but it is more cost-effective for groups of patients who are coinfected with TB

HIV/AIDS: treatment of Kaposi's sarcoma
Ischemic heart disease: coronary artery bypass graft
Myocardial infarction: acute management with tissue plasminogen activator, with aspirin and beta-blocker
Tuberculosis (endemic, latent): isoniazid treatment
Diarrheal disease: improved water and sanitation at current coverage of amenities and other interventions
Diarrheal disease: cholera or rotavirus immunization
Diabetes, ischemic heart disease, and stroke: media campaign to reduce saturated fat
Stroke and ischemic heart disease: polypill by absolute risk approach
Ischemic heart disease: statin, with aspirin, beta-blocker, and angiotensin-converting enzyme inhibitor
Diabetes, ischemic heart disease, and stroke: acute management with heparin and recombinant tissue plasminogen activator
Depression: drugs with optional episodic or maintenance psychosocial treatment
Alcohol abuse: 25–50% increase in excise tax rate
Diarrheal disease: oral rehydration therapy for package costing $5.50 per episode
HIV/AIDS: antiretroviral therapy
Diarrheal disease: breastfeeding promotion
Coronary artery disease: legislation substituting 2% of trans fat with polyunsaturated fat at $6 per adult
Ischemic heart disease: aspirin, beta-blocker, with optional angiotensin-converting enzyme inhibitor
HIV/AIDS: home care
Myocardial infarction: acute management with aspirin and beta-blocker
Alcohol abuse: brief advice by primary health care doctor
Alcohol abuse: excise tax, advertising ban, with brief advice
Myocardial infarction and stroke: secondary prevention with polypill
Alcohol abuse: advertising ban and reduced access to beverage retail
Lower acute respiratory infection (0–4 years): case management package at community, facility, and hospital levels
Tobacco addiction: nicotine replacement therapy
Tobacco addiction: nonprice interventions[a]
Tuberculosis (endemic, infectious or noninfectious): directly observed short-course chemotherapy
Tuberculosis (epidemic): management of drug resistance
Haemophilus influenzae type B, hepatitis B, diphtheria, pertussis, and tetanus: pentavalent vaccine
Tuberculosis (epidemic): management of drug resistance
Tuberculosis (epidemic, latent): isoniazid treatment
HIV/AIDS: mother-to-child transmission prevention
Tuberculosis (endemic): management of drug resistance
HIV/AIDS: opportunistic infection treatment
Diarrheal disease: hand pump, standpost, or house connection where clean water supply is limited
Congestive heart failure: angiotensin-converting enzyme inhibitor and beta-blocker, with diuretics
Stroke(ischemic): acute management with aspirin
Diarrheal disease: construction and promotion of basic sanitation where facilities are limited
Problems requiring surgery: surgical ward or services in district hospital or community clinic
HIV/AIDS: tuberculosis co-infection prevention and treatment
Emergency care: staffed community ambulance
Tuberculosis (epidemic, infectious): directly observed short-course chemotherapy
HIV/AIDS: blood and needle safety
HIV/AIDS: condom promotion and distribution
Tuberculosis (endemic): BCG vaccine
HIV/AIDS: sexually transmitted infections diagnosis with treatment
Coronary artery disease: legislation substituting 2% of trans fat with polyunsaturated fat at $0.50 per adult
HIV/AIDS: voluntary counseling and testing
Diarrheal disease: water sector regulation with advocacy where clean water supply is limited
Underweight child (0–4 years): child survival program with nutrition
Childhood illness: integrated management of childhood illness
HIV/AIDS: peer and education programs for high-risk groups
Tobacco addiction: taxation causing 33% price increase
Malaria: intermittent preventive treatment in pregnancy with sulfadoxine-pyrimethamine
Malaria: residual household spraying
Myocardial infarction: acute management with aspirin and beta-blocker
Malaria: insecticide-treated bed nets
Tuberculosis, diphtheria-pertussis-tetanus, polio, measles: traditional EPI[b]
Malaria: intermittent preventive treatment in pregnancy with drugs other than sulfadoxine-pyrimethamine[c]
Emergency care: training volunteer paramedics with lay first responders
Diarrheal disease: hygiene promotion

Cost-effectiveness ratio (US$ per DALY averted)

Source: Authors.

SSA = Sub-Saharan Africa.

Note: Diseases were considered high burden for LMICs if their total avertable burden was greater than 35 million DALYs. Bars represent the range in point estimates of cost-effectiveness ratios for specific interventions included in each intervention cluster and do not represent variation across regions or statistical confidence intervals. Point estimates for LMICs were obtained directly from the relevant chapters, calculated as the midpoint of range estimates reported in the chapters, or calculated from a population-weighted average of the region-specific estimates reported in the chapters. For details of these intervention clusters, including the specific interventions covered in each, see annex tables 2.B.1 and 2.B.2. Only interventions with cost-effectiveness reported in terms of DALYs are included in this figure. For interventions with cost-effectiveness reported in other units, see annex tables 2.C.1 and 2.C.2.

a. Nonprice interventions for tobacco addiction include advertising bans, smoking restrictions, supply reduction, and information dissemination.

b. EPI = Expanded Program on Immunization.

c. Chloroquine as first-line drug, artemisinin combination therapy as second-line drug and sulfadoxine-pyrimethamine as first- or second-line drug.

Figure 2.2 Cost-Effectiveness of Interventions Related to High-Burden Diseases in LMICs

Figure 2.3 Cost-Effectiveness of Interventions Related to Low-Burden Diseases in LMICs
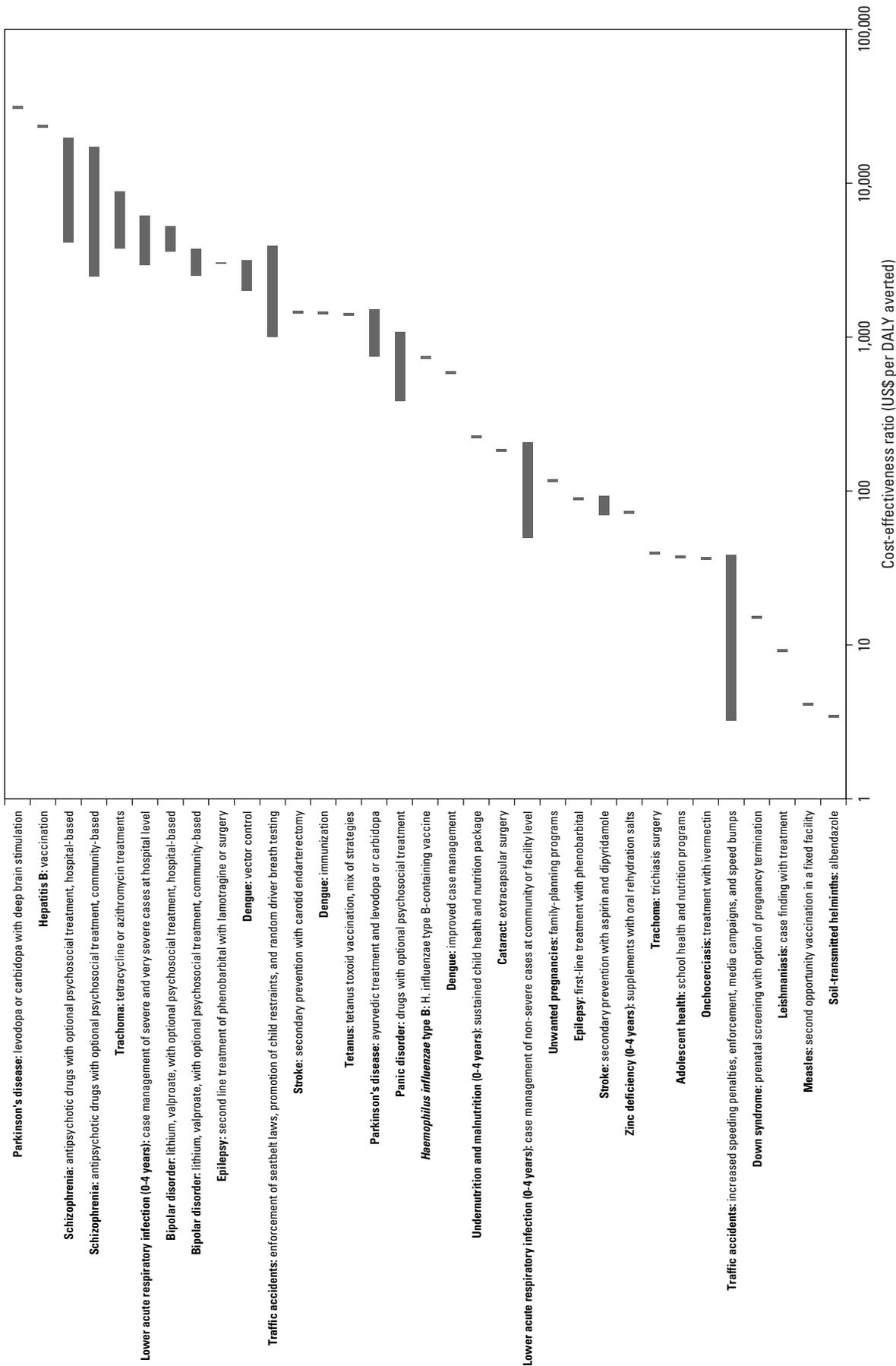
Source: Authors.

Note: Diseases were considered low burden for LMICs if their total avertable burden was less than 35 million DALYs. Bars represent the range in point estimates of cost-effectiveness ratios for specific interventions included in each intervention cluster and do not represent variation across regions or statistical confidence intervals. Point estimates for LMICs were obtained directly from the relevant chapters, calculated as the midpoint of range estimates reported in the chapters, or calculated from a population-weighted average of the region-specific estimates reported in the chapters. For details of these intervention clusters, including the specific interventions covered in each, see annex tables 2.B.1 and 2.B.2. Only interventions with cost-effectiveness reported in terms of DALYs are included in this figure. For interventions with cost-effectiveness reported in other units, see annex tables 2.C.1 and 2.C.2.

and HIV. In the context of TB control, antiretroviral therapy for HIV/AIDS is likely to be useful in extending the lives of patients successfully treated for TB.

Multidrug-resistant TB is much more expensive to treat than drug-susceptible TB—2 to 10 times the cost of standard first-line regimens for drug-susceptible TB—and this is one reason why priority should be given to preventing its emergence and spread. The management of drug resistance through the use of a standardized regimen that includes second-line drugs costs roughly US$70 to US$450 per DALY averted. Individualized treatment regimens for multidrug-resistant TB—that is, with drug combinations adjusted to the resistance pattern of each patient—are more costly but usually yield higher cure rates. Individualized treatment is harder to implement on a large scale but may not be less cost-effective than standardized treatment with regimens that include second-line drugs. The set of interventions needed to manage drug-resistant TB and TB associated with HIV requires higher levels of investment than the basic directly observed treatment strategy, but its cost is still typically less than US$1 for each day of healthy life gained. Thus, a strong economic argument exists for integrating such interventions into an enhanced strategy for TB control.

Prevention and Treatment of HIV/AIDS

Despite the scale and relentless progression of the HIV/AIDS epidemic, important strides have been made in developing cost-effective interventions for both prevention and treatment.

Prevention. Although remarkably little rigorous evaluation has been conducted, population-based programs to prevent HIV/AIDS appear to be highly cost-effective approaches in countries with high HIV/AIDS prevalence where the epidemic is generalized. These programs include voluntary testing and counseling (US$14 to US$261 per DALY averted); peer-based programs to educate high-risk groups, including sex workers and injecting drug users (US$1 to US$74 per DALY averted); and social marketing, promotion, and distribution of condoms (US$19 to US$205 per DALY averted). Programs to improve blood and needle safety, while highly cost-effective (US$4 to US$51 per DALY averted), are limited in terms of the burden of disease they can avert.

Prevention of mother-to-child transmission using a single dose of nevirapine in generalized epidemic settings (US$6 to US$12 per DALY averted) stands out for its combination of well-documented high cost-effectiveness and significant avertable infections and deaths. Treatment of sexually transmitted infections to lower the risk of HIV transmission, although less well proven, also appears to be highly cost-effective (US$16 to US$105 per DALY averted).

Treatment. For care of people living with HIV/AIDS, treatment of most infectious opportunistic infections is cost-effective (US$10 to US$500 per DALY averted), with treatment becoming significantly more cost-effective for patients who also have access to antiretroviral treatment. Few studies evaluate the cost-effectiveness of providing antiretroviral treatment, and even these are limited to clinical trial settings and are not directly applicable to the resource-poor settings in which antiretroviral treatment is being expanded. Economic evaluation of the cost-effectiveness of antiretroviral treatments based only on health outcomes for the treated patient is incomplete because of the large nonhealth impacts of HIV/AIDS and the effect of treatment on prevention of HIV transmission.

The cost-effectiveness of antiretroviral treatments is highly variable across settings as a function of drug prices and adherence rates. In low-cost settings with high adherence rates, antiretroviral treatment is moderately cost-effective (US$350 to US$500 per DALY averted); however, it can be a significantly poor value for resources spent in low-adherence settings if drug resistance is allowed to emerge and proliferate. Little is known about how to achieve necessary adherence levels (80 to 90 percent) at large scale at an affordable cost in low-income settings. To this end, research on effective, low-cost interventions to achieve long-term adherence to antiretroviral treatments (using support groups and other complementary interventions) in resource-poor settings is an urgent priority.

Childhood Illnesses and Mortality among Children under Five

Neonatal mortality rates and mortality rates for children under five can be reduced by large margins, at an affordable cost, by using interventions proven effective in low-income settings. Improvements are likely to come from increasing the coverage of preventive measures, such as breastfeeding, and from expanding the scope of existing childhood vaccines beyond the traditional six antigens in areas where existing coverage is relatively high and where new antigens address diseases of significant burden, particularly pneumococcal vaccines. Curative interventions—including case management of acute respiratory infections, malaria, and diarrhea—hold promise for lowering the 6 million preventable deaths each year in this age group.

Neonatal Mortality. An estimated 4 million deaths occur during the first 28 days of life, accounting for 38 percent of all deaths of children under five. Causes include infections (36 percent, including neonatal sepsis, pneumonia, diarrhea, and tetanus), preterm birth (27 percent), and asphyxia (23 percent). Intensive care is not required to save most of these babies. Developed countries and some low-income countries—for instance, Sri Lanka—have achieved neonatal mortality rates of 15 per 1,000 without intensive care, which is less than a third of current neonatal mortality rates in Sub-Saharan Africa.

Adding a set of community-based interventions—including promoting healthy behaviors, such as breastfeeding, and providing extra care of moderately small babies at home through cleanliness, warmth, and exclusive breastfeeding, plus community-based management of acute respiratory infections—to the standard maternal and child health package is likely to be highly effective. The cost of a year of life saved using this approach could be as low as US$100 to US$257 in India (US$221 to US$568 per DALY averted) and US$100 to US$270 in Sub-Saharan Africa (US$183 to US$493 per DALY averted). Use of these approaches is feasible now in most countries. Adding a clinical package that includes essential newborn care (warmth, cleanliness, and immediate breastfeeding); neonatal resuscitation; facility-based care of small newborns; and emergency care of ill newborns to the maternal and child health package has been shown to be highly cost-effective in India (US$11 to US$265 per year of life saved, or US$24 to US$585 per DALY averted) and Sub-Saharan Africa (US$25 to US$360 per year of life saved, or US$46 to US$657 per DALY averted); however, clinical care will require significant initial investment to raise coverage.

Basic resuscitation of newborns using a self-inflating bag that is available for as little as US$5 in LMICs can save lives at low cost in areas where a midwife is available. Providing two tetanus toxoid immunizations costing less than US$0.20 each to all pregnant women would avert more than 250,000 deaths at low cost and is eminently achievable. Improving maternal and child health services delivered through a combination of family- and community-level care, outreach, and clinical care will improve the survival of newborns and children and reduce stillbirths and maternal deaths.

Vaccinations. Childhood vaccinations, long recognized as among the most cost-effective uses of limited health resources in low-income countries, prevented more than 3 million deaths in 2001. National immunization programs traditionally have included vaccines against TB, diphtheria, tetanus, pertussis, poliomyelitis, and measles at a cost per fully immunized child of US$13 to US$24, depending on coverage levels and type of delivery strategy. The total cost in developing countries for national programs in 2001 ranged from US$717 million to US$1.4 billion, with an estimated cost per death averted ranging by region from under US$275 (under US$10 per DALY averted) in Sub-Saharan Africa and South Asia to US$1,754 (US$20 per DALY averted) in Europe and Central Asia.

The cost-effectiveness of scaling up immunization coverage with the traditional Expanded Program on Immunization (EPI) vaccines is highly dependent on the underlying prevalence of illness, starting coverage levels and trajectories, and mix of delivery strategies (whether facility-based strategies, campaigns, or mobile and outreach modalities). The cost per death averted varies by region, from US$162 in Africa to more than US$1,600 in Eastern Europe. Cost-effectiveness ratios are less than US$20 per DALY averted in all regions other than Europe and Central Asia. The cost-effectiveness of the tetanus toxoid vaccine also varies widely by region from under US$400 per death averted and under US$14 per DALY averted in Sub-Saharan Africa and South Asia to more than US$190,000 per death averted and more than US$15,000 per DALY averted in Europe and Central Asia.

Adding additional antigens to national programs has been successfully accomplished in many countries. Expanding the vaccination schedule to include a second opportunity for measles through either routine or campaign-based approaches costs between US$23 and US$228 per death averted and under US$4 per DALY averted in regions other than Europe and Central Asia. Other new vaccines are less cost-effective because of their high unit costs per dose, but they may be worthwhile, especially in regions of high disease prevalence. For instance, the pentavalent vaccine (diphtheria, pertussis, tetanus, hepatitis B, and *Haemophilus influenzae* type B) was estimated to have a cost per death averted ranging from US$1,433 to greater than US$40,000 and cost-effectiveness of US$42 per DALY averted in Sub-Saharan Africa and greater than US$245 per DALY averted in other regions. The cost of adding a yellow fever vaccine ranges from US$834 per death averted and US$26 per DALY averted in Sub-Saharan Africa to US$2,810 per death averted and US$39 per DALY averted in Latin America and the Caribbean.

Because certain regions and countries contain the largest burden of disease, such as measles in India and Nigeria, targeting scarce public health resources to those geographic areas could potentially yield high returns to investment. Although immunization may have relatively low incremental cost-effective ratios, the total budget requirements for maintaining or increasing coverage rates, as well as for introducing new vaccines, can account for a large share of government health budgets.

The cost-effectiveness ratios of vaccination interventions presented here are based on estimates of their current costs and effectiveness; but they could change substantially with changing costs and the development of new interventions. For instance, multivalent pneumococcal conjugate vaccines have shown the potential to reduce the incidence of invasive pneumococcal disease while lowering the need for antibiotic use and the likelihood of drug resistance. The current price of these vaccines makes them expensive to most people in the developing world. However, with future price decreases, these vaccines could be adopted widely and could markedly lower the impact of the most common causes of morbidity and mortality in children under five (excluding the neonatal period). Moreover, new vaccines being developed could be included in the EPI schedule, including vaccines that protect against rotavirus, malaria, human papilloma virus associated with cervical

cancer, HIV/AIDS, and dengue. With future demonstrations of reasonable cost-effectiveness, these vaccines could become a component of the set of attractive interventions.

Acute Respiratory Infections. Even though vaccination strategies can be cost-effective in lowering the disease burden related to acute respiratory infections, case management may also be an efficient use of financial resources, although more demanding of health system capacity. Moreover, community case management and case management at a health care facility may be of comparable cost-effectiveness. In fact, treating nonsevere pneumonia at health care facilities using a combination of oral antimicrobials and acetaminophen (US$24 to US$424 per DALY averted) is more cost-effective than a similar treatment administered at home by a health care worker (US$139 to US$733 per DALY averted). Treating severe pneumonia in a hospital facility is more expensive (US$1,486 to US$14,719 per DALY averted).

Diarrheal Disease. Among interventions against diarrheal disease during the first year of life, breastfeeding promotion programs (US$527 to US$2,001 per DALY averted), measles immunization (US$257 to US$4,565 per DALY averted), and oral rehydration therapy (US$132 to US$2,570 per DALY averted) are relatively cost-effective compared with rotavirus immunizations (US$1,402 to US$8,357 per DALY averted) and cholera immunizations (US$1,658 to US$8,274 per DALY averted). The cost-effectiveness of oral rehydration therapy is extremely sensitive to the cost of the package. The cost-effectiveness of this intervention can be as low as US$132 per DALY averted for an assumed cost per child of US$0.70. An important reason for the relatively unfavorable cost-effectiveness ratios for diarrheal disease is that significant reductions in mortality from this condition have already been achieved and further gains are likely to be more expensive.

Further improvements in water and sanitation (US$1,118 to US$14,901 per DALY averted from diarrheal disease) are generally less cost-effective in regions where access to these amenities is adequate and other interventions against diarrheal disease exist. However, in areas with little access to water and sanitation facilities, improving access can be highly cost-effective (US$94 per DALY averted for installation of hand pumps and US$270 per DALY averted for provision and promotion of basic sanitation facilities).

Inherited Disorders of Hemoglobin. Inherited hemoglobin disorders, including sickle cell anemia and the thalassemias, affect roughly 500,000 babies born each year and cause early death for many of them. Prenatal screening for sickle cell disease, which is expensive, can be replaced by much cheaper newborn screening. Antibiotic prophylaxis is moderately cost-effective at preventing death in the first few years (US$8,000 to US$12,000 per death averted, or US$300 to US$400 per DALY averted). Expensive interventions, such as bone marrow transplantation or repeated transfusions, are seldom needed. At US$10,000 or more per DALY averted, treatment for transfusion-dependent thalassemias is expensive and probably unaffordable to all but the rich in LMICs. A feasible strategy to deal with the thalassemias is to screen couples to determine their risk of having an affected child, followed by prenatal testing—a relatively expensive proposition—of couples at high risk. Information is then available to parents to help them determine whether to terminate the pregnancy. Such strategies appear to have worked in Cyprus, Greece, and Italy, all countries that formerly had a high incidence of thalassemias.

Ongoing Challenges: Malaria and Other Tropical Diseases

Despite health researchers' relative neglect of diseases predominantly found in the tropics, interventions to control—and in some cases even eliminate—these diseases rank among the most cost-effective of all available options.

Malaria. In countries where malaria is prevalent, both prevention and effective treatment of this disease are highly cost-effective and can result in large health gains. Prevention tools include insecticide-treated bednets (US$5 to US$17 per DALY averted) and indoor residual spraying where DDT, malathion, deltamethrin, or lambda-cyhalothrin is applied to surfaces inside homes as a spray or deposit for prolonged action (US$9 to US$24 per DALY averted for Sub-Saharan Africa).

Intermittent preventive treatment of malaria during pregnancy using sulfadoxine-pyrimethamine is a highly cost-effective intervention (US$13 to US$24 per DALY averted) to decrease neonatal mortality and reduce severe maternal anemia. Changing first-line treatment for malaria from chloroquine, a drug that is ineffective in many parts of the world, to artemisinin-based combinations offers the advantage of faster cures and potential reductions in transmission, with cost-effectiveness ratios of less than US$150 per DALY averted. Changing to sulfadoxine-pyrimethamine may be slightly more cost-effective initially because of the lower cost of this drug relative to artemisinin-based combinations; however, this advantage is likely to be eroded quickly because of the rapid expected growth of parasite resistance.

Lymphatic Filariasis, Onchocerciasis, and Chagas Disease. Annual mass drug administration to treat the entire population at risk for a period long enough to interrupt transmission is a cost-effective approach for eliminating lymphatic filariasis in areas of high prevalence (US$4 to US$8 per DALY averted). An alternative approach is to fortify salt with diethylcarbamazine (US$1 to US$3 per DALY averted) and to use ivermectin in

countries where onchocerciasis is coendemic. Onchocerciasis control programs have been highly successful in West Africa: investigators have estimated the cost-effectiveness of community-directed ivermectin treatment programs at roughly US$6 per DALY averted when the drug has been provided free of charge. The cost of vector control to prevent—and perhaps eliminate—Chagas disease has been estimated at US$260 per DALY averted.

Leishmaniasis and African Trypanosomiasis. Feasible intervention opportunities exist even for tropical diseases for which control measures are relatively less effective. Improved case management and immunization (currently undergoing clinical trials) for dengue (US$587 to US$1,440 per DALY averted) are relatively cost-effective compared with environmental vector control (more than US$2,000 per DALY averted). Leishmaniasis treatment is also extremely cost-effective (US$315 per death averted and US$9 per DALY averted), as is treating African trypanosomiasis patients in the second stage of the disease using melarsoprol or eflornithine (US$10 to US$20 per DALY averted).

Helminthic Infections. Helminthic infections, although not a major contributor to deaths in tropical regions, have a significant effect on health, growth and physical fitness, school attendance, worker productivity, and earning potential. Mass school-based treatment of soil-transmitted helminths (*Ascaris*, *Trichuris*, and hookworm) using albendazole costs US$2 to US$9 per DALY averted. Although the cost of treating schistosomiasis with praziquantel is significantly greater (US$336 to US$692 per DALY averted), a combination of albendazole and praziquantel is extremely cost-effective (US$8 to US$19 per DALY averted).

Maternal and Neonatal Health

Given the hugely disproportionate burden of maternal and neonatal deaths in LMICs, identifying affordable, easy-to-implement interventions to prevent these deaths is a priority. Evidence from South Asia and Sub-Saharan Africa suggests that improved primary-level coverage with a package of interventions is extremely cost-effective (US$3,337 to US$6,129 per death averted and US$92 to US$148 per DALY averted). Improvements in the quality of prenatal and delivery care are of similar cost-effectiveness (US$2,729 to US$5,107 per death averted and US$82 to US$142 per DALY averted). An important finding is that improving the quality of care and expanding coverage are of comparable cost-effectiveness.

Improving Nutrition

The direct and indirect effects of undernutrition and micronutrient deficiencies account for a significant propor-

tion of the overall burden of disease in LMICs. For the most part, interventions to provide micronutrient supplementation can prevent malnutrition in children at a fairly low cost. They include breastfeeding support programs (US$3 to US$11 per DALY averted and US$100 to US$300 per death averted) and growth monitoring and counseling (US$8 to US$11 per DALY averted). Specific micronutrient supplementation programs can be implemented either by distributing capsules or by fortifying sugar, salt, water, or other essentials. In addressing vitamin A deficiencies, capsule distribution (US$6 to US$12 per DALY averted) is more cost-effective than sugar fortification (US$33 to US$35 per DALY averted), especially in countries where the prevalence of vitamin A deficiency is low. However, fortification of salt, sugar, and cereal in the case of iron deficiency and fortification of water and salt in the case of iodine deficiency is less expensive than distributing supplements for mild deficiency, though pregnant women and severely anemic or iodine-deficient people may still require supplementation. Overall cost-effectiveness is US$66 to US$70 per DALY averted for iron fortification programs and US$34 to US$36 per DALY averted for iodine fortification programs.

Cancer Prevention and Treatment

Screening for breast cancer using clinical breast examination (CBE) is estimated to be cost-effective at US$552 per life year saved for biennial screening of women from age 40 to 60. This efficacy of CBE is related to the large percentage of tumors with a poor prognosis observed in developing countries. In this setting, CBE is estimated to be more cost-effective than mammography: mammograms every two years result in 10 percent more life years saved than annual CBE, but the cost is more than 100 percent greater. As with any screening program, cost-effectiveness is greater with higher underlying prevalence of disease.

In general, cancer prevention, when feasible, is far more cost-effective than treatment. The cost-effectiveness of initial treatment is between US$1,300 and US$6,200 per year of life saved for the more treatable cancers of the cervix, breast, oral cavity, colon, and rectum and between US$53,000 and US$163,000 per year of life saved for the less treatable cancers of the liver, lung, stomach, and esophagus. Postmastectomy radiation might be more cost-effective in developing countries, where the cost of radiation treatment can be relatively low compared to developed countries. Palliative care for terminally ill cancer patients can be a challenge in resource-constrained settings, where opioid drugs, a cost-effective option, may be in short supply. Studies from developed countries indicate that more advanced treatments to relieve pain and side effects of chemotherapy may be cost-effective under certain conditions.

Mental and Neurological Disorders

Mental disorders are a heterogeneous group of conditions with considerable variation in both the cost of the interventions and the burden reduction associated with such interventions. Interventions to treat depression, bipolar disorder, and schizophrenia rank among the least cost-effective of interventions considered in this volume. However, the potentially significant benefits to family members and to society as a whole are not captured by the DALY methodology and should be balanced against the relatively high cost of improving health of people with these disorders. For many disorders, drug treatment has been shown to be effective, especially when combined with psychosocial treatment that includes cognitive-behavioral approaches to managing symptoms and improving adherence to medications, group therapy, and family interventions.

Schizophrenia and Bipolar Disorder. Drug treatment accompanied by psychosocial treatment delivered through a community-based service was found to be the most cost-effective approach for severe mental disorders such as schizophrenia and bipolar disorder. Newer antipsychotic and mood-stabilizing drugs have recently become less expensive; even so, they are less cost-effective than drugs that have been available for many years. For example, family psychoeducation was much more cost-effective with haloperidol (US$1,743 to US$4,847 per DALY averted) compared with a newer antipsychotic drug (risperidone) in treating schizophrenia (US$10,232 to US$14,481 per DALY averted). For bipolar affective disorder, the combination of family psychoeducation with the older medication lithium (US$1,587 to US$4,928 per DALY averted) is more cost-effective than the combination of family psychoeducation with the newer sodium valproate (US$2,765 to US$5,908 per DALY averted).

Depression and Panic Disorder. Treating the more common depressive and anxiety disorders was more cost-effective than treating the more severe disorders; the interventions were less expensive, and the reduction in disability was greater. For depression, drug therapy with tricyclic antidepressants (imipramine or amitriptyline) costs US$478 to US$1,288 per DALY averted. Managing depression as a chronic illness with case management to reduce relapses did not greatly decrease the cost-effectiveness (US$749 to US$1,760 per DALY averted). Using newer medications with fewer side effects and potentially greater compliance (an advantage if medications need to be taken long term)—for example, a generic selective serotonin reuptake inhibitor (SSRI) such as fluoxetine—increased the cost somewhat (US$1,229 to US$2,459 per DALY averted). Finally, the treatment of panic disorder using tricyclic antidepressants (US$305 to US$619 per DALY averted) and SSRIs (US$567 to US$865 per DALY averted) was

more cost-effective than when combined with psychosocial treatment. Psychosocial treatment without drug treatment was of comparable cost-effectiveness (US$338 to US$927 per DALY averted).

The use of tricyclic antidepressants was more cost-effective than benzodiazepines, which are still commonly prescribed for anxiety disorders and produce dependence in many patients. Overall, the cost-effectiveness of a package of mental health interventions that addressed all four sets of disorders is between US$1,429 and US$2,902 per DALY averted, depending on the region.

Parkinson's Disease and Epilepsy. Ayurvedic treatment, a form of traditional medicine used in India, is relatively cost-effective in treating Parkinson's disease (US$750 per DALY averted). Less cost-effective interventions include a combination of levodopa and carbidopa (US$1,500 per DALY averted), which are used to treat the debilitating symptoms and delay the progress of the disease, and deep-brain stimulation (US$31,000 per DALY averted).

Cost-effective options for treating epilepsy are available, especially the use of phenobarbital to help control seizures (US$89 per DALY averted), but few eligible patients receive treatment. More expensive options, such as lamotrigine or surgery, are significantly less cost-effective than phenobarbital for first-line treatment; however, they are cost-effective for the small proportion of epilepsy patients who do not respond to phenobarbital.

Multipronged Strategy to Prevent and Treat CVD

CVD, including ischemic heart disease, congestive heart failure, and stroke, is the single most important cause of death worldwide; interventions to treat CVD are likely to account for increasingly greater proportions of health care expenditures in developing countries.

Population-Based Primary Prevention. Interventions to modify lifestyles can effectively lower the risk of coronary artery disease and stroke without expensive health infrastructure. They include lowering the fat composition of the diet, limiting sodium intake, avoiding tobacco use, and engaging in regular physical activity. The costs and the effectiveness of these approaches vary widely with the socioeconomic and cultural context in which they are contemplated.

Replacing dietary trans fat from partial hydrogenation with polyunsaturated fat is likely to be extremely effective in populations in South Asia, where the intake of trans fat is high. If such replacement is done during manufacture at a relatively low cost rather than through changes in individual behavior, a cost-effectiveness ratio of US$25 to US$73 per DALY averted can be attained. Replacing saturated fat with monounsaturated

fat in manufactured foods accompanied by a public education campaign is relatively expensive in the base case (US$1,865 to US$4,012 per DALY averted), although the cost per DALY averted is highly sensitive to both the relative risk reduction in CVD events as well as the cost per individual. Reducing salt in manufactured foods through a combination of legislation and education campaigns is also relatively expensive in the base case (US$1,325 to US$3,056 per DALY averted), but could be much more cost-effective in high-density populations with a high salt intake. Little evidence is available on the cost-effectiveness of programs to encourage exercise and other behavior changes by individuals.

Personal Interventions. Prevention strategies targeted at individuals at high risk for CVD—measured as a combination of nonoptimal blood pressure and cholesterol, lifestyle, and genetic risk factors—can be effective, especially when implemented in tandem with population-based measures. A previous cardiovascular event is a reliable predictor of a second event. The cost-effectiveness of primary prevention of CVD may vary greatly depending on the underlying risk factors, the age of the patient, and the cost of medications.

Single-pill combinations of blood pressure–lowering medications, statins, and aspirin offer the potential dual benefit of being highly effective at lowering the risk of CVD and facilitating patient compliance with the ongoing drug regimen. A hypothetical multidrug regimen that includes generic aspirin, a beta-blocker, a thiazide diuretic, an angiotensin-converting enzyme (ACE) inhibitor, and a statin may be implemented at a cost-effectiveness ratio of US$721 to US$1,065 per DALY averted compared with a baseline of no treatment in a population with an underlying 10-year CVD risk of 35 percent. The use of the multidrug regimen for prevention in patients with a lower underlying CVD risk improves health benefits, but costs increase more than proportionately.

Acute Management of CVD. The cost of treating acute myocardial infarction using aspirin and beta-blockers is less than US$25 per DALY averted in all regions. Relatively more expensive interventions that offer marginally greater effectiveness include the use of thrombolytics such as streptokinase (US$630 to US$730 per DALY averted) and tissue plasminogen activator (US$16,000 per DALY averted).

The combination of aspirin and the beta-blocker atenolol has been shown to be highly cost-effective in preventing the recurrence of a vascular event. The incremental cost-effectiveness ratio of sequentially adding an ACE inhibitor such as enalapril (US$660 to US$866 per DALY averted), a statin such as lovastatin (US$1,700 to US$2,000 per DALY averted), and coronary artery bypass graft (more than US$24,000 per DALY averted) to the baseline therapy is greater when hospital facilities are available. In regions with poor access to hospitals,

the combination of aspirin and a beta-blocker is highly cost-effective (US$386 to US$545 per DALY averted). In all regions, treating congestive heart failure using enalapril and the beta-blocker metoprolol is also highly cost-effective (approximately US$200 per DALY averted).

Acute Management and Secondary Prevention of Stroke. The cost of treating acute ischemic stroke using aspirin is US$150 per DALY averted. Relatively cost-ineffective interventions involve the use of a tissue plasminogen activator (US$1,300 per DALY averted) and anticoagulants such as heparin or warfarin (US$2,700 per DALY averted). Aspirin is the lowest-cost option for secondary prevention of stroke (US$3.80 per single percentage point decrease in the risk of a second stroke within two years or US$70 per DALY averted). The combination of the antiplatelet medication dipyridamole and aspirin is equally cost-effective (US$93 per DALY averted). In contrast, carotid endarterectomy is expensive for secondary prevention (US$1,500 per DALY averted).

Strategies for Injury Prevention

Increasing economic development and use of motor vehicles has resulted in increases in traffic-related deaths and injuries; these events account for roughly a third of the burden from all unintentional injuries in LMICs.

Speed bumps appear to be the most cost-effective and cost less than US$5 per DALY averted in all regions if installed at the most dangerous junctions that account for 10 percent of junction deaths. Increased speeding penalties, media coverage, and enforcement of traffic laws are only slightly less cost-effective. Motorcycle helmet legislation (US$467 per DALY averted in Thailand), bicycle helmet legislation (US$107 per DALY averted in China), and improved enforcement of traffic codes through a combination of enforcement and information campaigns (US$5 to US$169 per DALY averted) are relatively more expensive but deserve greater attention, given the growing health burden associated with rising levels of vehicle ownership. Research has demonstrated that seat belts and child restraints are effective in the developed world, and lowering their costs and encouraging their routine use may improve their cost-effectiveness in LMICs.

Key interventions to reduce intentional violence, both self-inflicted (suicides) and interpersonal (homicides and war-related deaths), include changing cultural norms, reducing access to guns, and improving criminal justice and social welfare systems, but these interventions are difficult to evaluate using a cost-effectiveness framework, and a cost-benefit analysis is more appropriate. Studies of interventions targeting interpersonal violence in developed countries show that behavioral, legal, and regulatory interventions cost less than the money they save, in some cases by an order of magnitude. Providing shelters for victims of domestic violence in the United States

has a benefit-cost ratio of 6.8 to 18.4. Implementing a gun registration law in Canada involved a one-time cost of US$70 million, compared with annual health-related costs of US$50 million for firearm-related injuries in that country. Interventions for troubled youths to reduce criminal activity include mentoring (with net benefits ranging from US$231 to US$4,651 per participant), family therapy (US$14,545 to US$60,721), and aggression replacement therapy (US$8,519 to US$34,071).

Policy Interventions to Lower Alcohol and Tobacco Use

The growing prevalence of smoking, especially among women in LMICs, is a serious threat to health. Interventions to reduce tobacco use are noteworthy not just because they are highly cost-effective but also because the burden of deaths and disability that they can avert is large. Tobacco control through tax increases often has dual benefits of increasing tax revenues as well as discouraging smoking initiation and encouraging smokers to quit. The cost-effectiveness of a policy to increase cigarette prices by 33 percent ranges from US$13 to US$195 per DALY averted globally, with a better cost-effectiveness ratio (US$3 to US$42 per DALY averted) in low-income countries. In comparison, nicotine replacement therapy (US$55 to US$751 per DALY averted) and nonprice interventions, including banning advertising, providing health education information, and forbidding smoking in public places, are relatively less cost-effective (US$54 to US$674 per DALY averted) in low-income countries but are still important components of any tobacco control program.

In regions with a relatively high prevalence of high-risk alcohol use—that is, Europe and Central Asia, Latin America and the Caribbean, and Sub-Saharan Africa—tax increases to lower alcohol use are extremely cost-effective (US$105 to US$225 per DALY averted). However, in regions with a lower prevalence of high-risk use—namely, East Asia and the Pacific and South Asia—tax-based policies can be among the least cost-effective interventions (more than US$2,500 per DALY averted). Advertising bans are among the most cost-effective (but least studied) of all interventions to reduce high-risk drinking in all regions (US$134 to US$280 per DALY averted). In East Asia and the Pacific, a comprehensive ban on advertising and reduced access to retail outlets are highly cost-effective interventions (US$123 to US$146 per DALY averted). Random breath testing is one of the least cost-effective interventions to reduce the alcohol-related disease burden (US$973 to US$1,856 per DALY averted). In Sub-Saharan Africa, however, averting the burden of disease associated with drunk driving is an important priority and is addressed effectively through such policies as random breath testing and stricter enforcement of drunk-driving laws (US$531 per DALY averted). Providing high-risk drinkers with brief advice from a physician in primary care settings is of intermediate cost-effectiveness

(US$480 to US$819 per DALY averted) in all regions, but combining this intervention with a tax on alcohol increases cost-effectiveness (US$260 to US$533 per DALY averted) in all regions except Sub-Saharan Africa.

Packaging of Interventions and Services

This section examines the overall cost-effectiveness of a service level, including all conditions addressed as part of a package of services, rather than evaluating individual interventions separately.

Emergency and Hospital Care. The cost per death averted of training lay first responders and volunteer paramedics is between US$130 and US$283 (or US$5 to US$11 per DALY averted) depending on the region. Ambulances outfitted with trained paramedics can avert deaths at a cost of US$1,148 to US$3,479 (US$46 to US$137 per DALY averted) in urban settings and US$3,457 to US$10,449 (US$140 to US$410 per DALY averted) in rural settings. Although the evidence for the cost-effectiveness of district and referral hospitals is very limited, it does indicate that basic hospital care at the district level could be highly cost-effective (US$13 to US$104 per DALY averted).

Surgery. Some types of surgery are highly cost-effective as part of a country's health strategy. These include providing surgical care to injury victims, including those suffering from head trauma and burns; handling obstetric complications, such as obstructed labor or hemorrhage; and undertaking elective surgery to address conditions such as cataracts and otitis media that have a significant impact on the quality of life. In areas of high prevalence, cataract surgery can be extremely cost-effective at roughly US$100 per DALY averted.

Many of these surgical interventions—including improved resuscitation and airway management using relatively simple procedures such as chest tubes and tracheostomy, improved fracture management, and improved management of burns covering less than 30 percent of the body—require only the basic facilities offered by district hospitals. The quality of surgery and the risk of complications vary widely, and adequate health system capacity is an important consideration. For the typical surgical facility located in a district hospital in an LMIC, the average cost per DALY averted for a representative set of surgical procedures is between US$70 and US$230. General surgery at the district hospital is cost-effective relative to other interventions in South Asia and Sub-Saharan Africa because of the relatively low input costs related to infrastructure and the high level of the avertable disease burden. Examples of surgical interventions with poor cost-effectiveness include first-line treatment of epilepsy with surgery, which is useful only to patients who do not respond to drug treatment, and

percutaneous transluminal coronary angioplasty for cardiovascular events.

Integrated Management of Childhood Illnesses. An intervention package consisting of exclusive breast feeding; vitamin A and zinc supplementation; screening for immunization; and case management of pneumonia, malaria, and diarrhea, including oral rehydration therapy, costs approximately US$4.10 per child in Sub-Saharan Africa and is a cost-effective approach (US$38 per DALY averted) to improving the health of children under five when program coverage is 50 percent.

Value of Doing Things Better

Intervention quality is an important determinant of cost-effectiveness, and improving quality can be an efficient way to use resources. Community health status tends to be correlated with the quality of health service facilities, which can be enhanced even in resource-constrained settings. Indeed, resource-poor settings have the greatest potential for improving quality at low cost. In the case of acute respiratory infections, for example, the cost-effectiveness of improving the quality of care by implementing an educational activity for providers ranges from US$132 to US$800 per life saved (US$4 to US$28 per DALY averted) when initial intervention quality is poor and infections are widespread. Quality improvements can cost between US$2,000 and US$5,000 per life saved (US$70 to US$176 per DALY averted) with improved baseline quality, low disease prevalence, or both. Educational interventions to improve the quality of diarrhea treatment can be extremely cost-effective (less than US$18 per DALY averted) depending on these two factors.

Regional Analyses for South Asia and Sub-Saharan Africa

Given the significant health burden borne by countries in South Asia and Sub-Saharan Africa, cost-effectiveness information for interventions related to high-burden health conditions is presented for these two regions. In South Asia (figure 2.4), CVD-related interventions, including tobacco taxes, treatment of acute myocardial infarction with aspirin and beta-blockers, and increasing coverage of the EPI program, rank among the most cost-effective interventions. Treatment of latent TB, coronary artery bypass graft for ischemic heart disease, treatment of depression, and cholera immunization to prevent diarrheal disease rank among the least cost-effective. Vitamin A deficiency, leprosy, and epilepsy are important conditions that impose a relatively lower burden of DALYs on this region, but a number of highly cost-effective interventions to deal with each of these conditions could be scaled up.

In Sub-Saharan Africa (figure 2.5), HIV/AIDS and malaria rank among the highest-burden conditions. Of the 16 most cost-effective interventions addressing high-burden diseases, 8 are associated with these two sources of ill health alone. Other interventions that are both cost-effective and address high-burden diseases include nutritional support (including breast-feeding advice for mothers) for children under the age of four, and increasing coverage of the EPI. Oral rehydration therapy for diarrheal disease can be cost-effective if the cost of the package is relatively low (that is, less than US$1 per child per treatment).

Table 2.2 identifies interventions relevant to South Asia and Sub-Saharan Africa that have been evaluated in this volume and have the greatest potential to reduce the burden of disease in those regions at an affordable price.[6] The table also highlights interventions that address conditions that account for a moderate to high burden of disease but at a relatively high cost.

Personal versus Population-based Interventions

Figure 2.6 displays a histogram of intervention clusters categorized as either population based or personal (see annex 2.A for definitions). A greater number of personal intervention clusters than population-based intervention clusters are categorized as being highly cost-effective. Although this result may be partly an artifact of the way in which we have grouped interventions into clusters, it lends some support to the observation first made in the first edition of *Disease Control Priorities in Developing Countries* (Jamison and others 1993) that personal interventions are not necessarily less cost-effective than population-based interventions. Population-based interventions are cost-effective when effectively targeted to populations in which disease prevalence (or the potential prevalence and subsequent mortality if the interventions are not implemented) is high. For example, primary prevention of acute myocardial infarction using aspirin is not nearly as cost-effective as secondary prevention in patients who have already suffered a stroke or myocardial infarction, because this latter category has, by virtue of the first event, identified itself as being at higher risk than the general population. Similarly, malaria prevention programs will be highly cost-effective in areas where malaria is a serious problem but less so in countries where the burden of this disease is less and people are better served by treatment with an effective antimalarial.

DISCUSSION

Since the publication of the previous edition of this book, the epidemiological and demographic profiles of many LMICs and the range of available health interventions have changed significantly. This edition has the benefit of hindsight in looking back at the variety and affordability of interventions that were evaluated in the previous edition, both to see how the optimal mix of strategies may have changed in the intervening period and to ascertain trends.

Myocardial infarction: acute management with tissue plasminogen activator, with aspirin and beta-blocker
Ischemic heart disease: coronary artery bypass graft
Tuberculosis (endemic, latent): isoniazid treatment
Diarrheal disease: rotavirus or cholera immunization
Diarrheal disease: improved water and sanitation at current coverage of amenities and other interventions
Ischemic heart disease: statin, with aspirin, beta-blocker, and angiotensin-converting enzyme inhibitor
Diabetes, ischemic heart disease, and stroke: media campaign to reduce saturated fat
Stroke and ischemic and hypertensive heart disease: polypill with absolute risk approach
Depression: drugs with optional episodic or maintenance psychosocial treatment
Diabetes, ischemic heart disease, and stroke: legislation with public education to reduce salt content
Diarrheal disease: breastfeeding promotion
Stroke and ischemic and hypertensive heart disease: aspirin, beta-blocker, statin by absolute risk approach[a]
Neonatal mortality: maternal and child health package, with no neonatal care after birth
Neonatal mortality: combined maternal and child health and neonatal packages
Diarrheal disease: oral rehydration therapy for package costing $2.91 per episode
Myocardial infarction: acute management with streptokinase, with aspirin and beta-blocker
Ischemic heart disease: aspirin, beta-blocker, with optional angiotensin-converting enzyme inhibitor
Coronary artery disease: legislation substituting 2% of trans fat with polyunsaturated fat at $6 per adult
***Haemophilus influenzae* type B, hepatitis B, diphtheria, pertussis, and tetanus:** pentavalent vaccine
Tobacco addiction: nicotine replacement therapy
Neonatal mortality: family, community, or clinical neonatal package
Myocardial infarction and stroke: secondary prevention with polypill
Lower acute respiratory infection (0–4 years): case management package at community, facility, and hospital levels[b]
Tobacco addiction: nonprice interventions
Tuberculosis (endemic): management of drug resistance
Maternal conditions: improved quality of care and coverage
Congestive heart failure: angiotensin-converting enzyme inhibitor and beta-blocker, with diuretics
Maternal conditions: improved overall quality of care
Maternal conditions: increased primary care coverage
Problems requiring surgery: surgical ward or services in district hospital or community clinic
Tuberculosis (epidemic, latent): isoniazid treatment
Tuberculosis (epidemic): management of drug resistance
Emergency care: staffed community ambulance
Lower acute respiratory infection (0–4 years): case management of non-severe cases at community or facility level
Tuberculosis (epidemic, infectious): directly observed short-course chemotherapy
Tuberculosis (endemic, infectious or noninfectious): directly observed short-course chemotherapy
Tuberculosis (endemic): BCG vaccine
Coronary artery disease: legislation substituting 2% of trans fat with polyunsaturated fat at $0.50 per adult
Tobacco addiction: taxation causing 33% price increase
Myocardial infarction: acute management with aspirin and beta-blocker
Tuberculosis, diphtheria-pertussis-tetanus, polio, measles: traditional EPI[c]
Emergency care: training volunteer paramedics with lay first responders

Cost-effectiveness ratio (US$ per DALY averted)

1   10   100   1,000   10,000   100,000
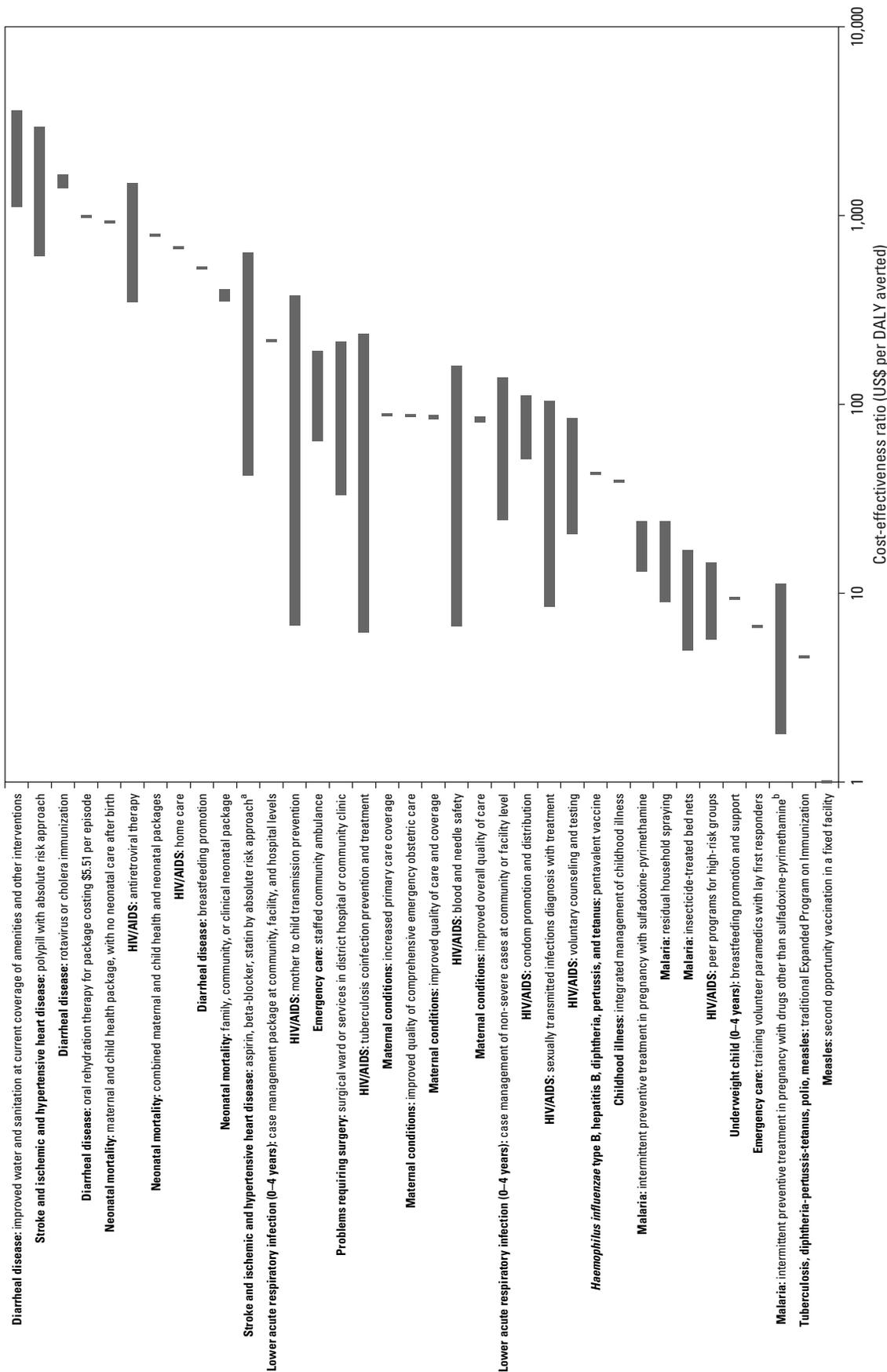
Source: Authors.

Note: Diseases were considered high burden for South Asia if their total avertable burden was greater than 10 million DALYs. Bars represent the range in point estimates of cost-effectiveness ratios for specific interventions included in each intervention cluster and do not represent variation across regions or statistical confidence intervals. Point estimates for LMICs were obtained directly from the relevant chapters, calculated as the midpoint of range estimates reported in the chapters, or calculated from a population-weighted average of the region-specific estimates reported in the chapters. For details of these intervention clusters, including the specific interventions covered in each, see Annex tables 2.B.1 and 2.B.2. Only interventions with cost-effectiveness reported in terms of DALYs are included in this figure. For interventions with cost-effectiveness reported in other units, see annex tables 2.C.1 and 2.C.2.

a. Cost-effectiveness range of aspirin, beta-blockers, and statin to prevent stroke and ischemic and hypertensive heart disease is incremental to salt reduction legislation and health education.

b. Nonprice interventions for tobacco addiction include advertising bans, smoking restrictions, supply reduction, and information dissemination.

c. EPI = Expanded Program on Immunization.

Figure 2.4 Cost-Effectiveness of Interventions Related to High-Burden Diseases in South Asia

Figure 2.5 Cost-Effectiveness of Interventions Related to High-Burden Diseases in Sub-Saharan Africa
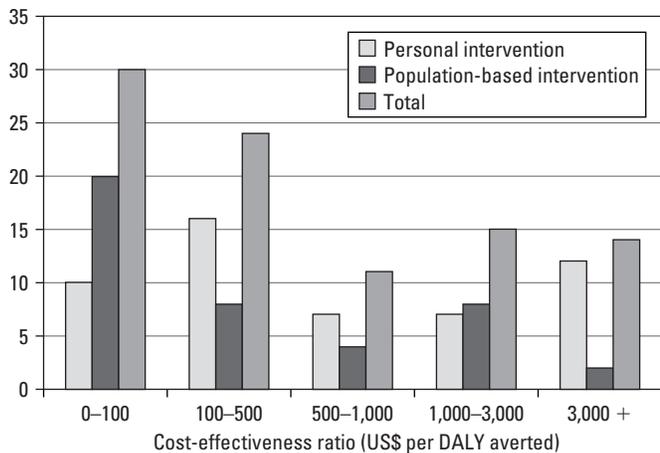
Source: Authors.

Note: Diseases were considered high burden for Sub-Saharan Africa if their total avertable burden was greater than 10 million DALYs. Bars represent the range in point estimates of cost-effectiveness ratios for specific interventions included in each intervention cluster and do not represent variation across regions or statistical confidence intervals. Point estimates for LMICs were obtained directly from the relevant chapters, calculated as the midpoint of range estimates reported in the chapters, or calculated from a population-weighted average of the region-specific estimates reported in the chapters. For details of these intervention clusters, including the specific interventions covered in each, see annex tables 2.B.1 and 2.B.2. Only interventions with cost-effectiveness reported in terms of DALYs are included in this figure. For interventions with cost-effectiveness reported in other units, see annex tables 2.C.1 and 2.C.2.

a. Cost-effectiveness range of aspirin, beta-blockers, and statin to prevent stroke and ischemic and hypertensive heart disease is incremental to salt reduction legislation and health education.

b. Chloroquine as first-line drug, artemisinin combination therapy as second-line drug and sulfadoxine-pyrimethamine as first- or second-line drug.

Number of intervention clusters

Source: Authors.

Figure 2.6 Distribution of Interventions in LMICs by Cost-Effectiveness Ratio

Lessons

Three lessons are broadly applicable. They relate to communicable diseases, noncommunicable diseases, and technological progress.

Communicable Diseases. Interventions to treat communicable diseases have been highly cost-effective in the past and remain so despite new challenges, such as drug-resistant pathogens and vectors. Although much progress has been made in lowering the burden of disease associated with vaccine-preventable illnesses, diarrhea, and to a lesser extent with acute respiratory infections, progress made on other diseases, such as malaria and TB, has been rolled back by such challenges as parasite resistance in the case of malaria and the HIV epidemic in the case of TB. An important exception may be diseases for which vaccines have been available, where significant gains in health have been achieved. In general, discerning a link between the availability of effective, affordable interventions in 1993 and a significant effect on the disease burden since that time is difficult because of the problem in defining the appropriate counterfactual of what would have happened in the absence of interventions that were implemented.

Noncommunicable Diseases. Compared with 13 years ago, many more cost-effective interventions have been evaluated and are being used for noncommunicable diseases, which continue to grow in importance as populations undergo the epidemiological transition. Many of these interventions have been available for more than a decade; however, their costs have dropped as key drugs have gone off patent. Acute management of stroke and myocardial infarction using aspirin, beta-blockers, and nitroglycerin costs as little as US$15 to US$30 per DALY averted and ranks among the most cost-effective interventions available in LMICs. Even though many of the interventions were first developed in the industrial world, their benefits are now largely available in the developing world. Thus, the challenge lies in the ability of health care systems in LMICs to adopt these interventions on a large scale.

Technological Progress. Much progress has been made in scientific understanding and in the availability of affordable, population-based and personal interventions for preventing and treating HIV/AIDS; however, adequate scaling up of these interventions remains a challenge, with a few notable exceptions. The international health system has shown remarkable technological agility in responding to this epidemic, demonstrating that the world's scientific-industrial machinery is capable of rising to the challenge of emerging diseases when there is sufficient economic motivation for doing so. For instance, combination antiretroviral treatments are currently available for as little as US$150 for a year's supply in some countries. In contrast, monotherapy with zidovudine, or AZT, which was the standard of care 10 years ago, was less effective, more expensive, and much more prone to drug resistance. As before, the challenge does not appear to be in the availability of interventions either to prevent infection in adults or to effectively ensure against transmission from infected mothers to newborns. Rather, the challenge lies in the willingness and ability to fund and deploy the interventions effectively. Clearly, much more remains to be done to develop affordable treatments. However, without a vaccine, the only feasible solution appears to be to aggressively prevent further transmission while treating patients under well-implemented programs that can achieve the high rates of treatment adherence required to maintain the continued effectiveness of drug therapy.[7] More generally, the challenge of motivating technological advances for diseases that do not threaten the developed world remains to be addressed.

Importance of Health Systems

In describing efficient means of producing health, this chapter has said little about how such efficiency may be translated into practice. The overall cost-effectiveness of a service level or package of interventions, rather than the cost-effectiveness of individual interventions, is the appropriate indicator to determine which interventions should be used. From a planning point of view, taking the infrastructure as fixed, at least in the immediate future, and then asking how it can best be used to deliver the most cost-effective interventions might be sensible. Where infrastructure is limited, expanding access will have to take priority. Other factors related to health system

Table 2.2 Neglected Low-Cost Opportunities and High-Cost Interventions in South Asia and Sub-Saharan Africa

Neglected low-cost opportunities in South Asia	Cost per DALY averted[a] (US$)	Thousands of DALYs averted[a,b] per 20% increase in coverage	Burden of target diseases[a] (millions of DALYs)
CHILDHOOD IMMUNIZATION			
Additional coverage of traditional Expanded Program on Immunization (tuberculosis, diphtheria-pertussis-tetanus, polio, measles)	8	n.e.	28.4
HIV AND AIDS			
Voluntary counseling and testing			
Peer-based programs targeting at-risk groups (e.g., commercial sex workers) to disseminate information and teach specific skills	9–126	n.e.	7.4
School-based interventions that disseminate information to students			
Prevention of mother-to-child-transmission with antiretroviral therapy			
SURGICAL SERVICES AND EMERGENCY CARE			
Surgical ward in a district hospital, primarily for obstetrics, trauma and injury	6–212	at least 1.8	48.0–146.3
Staffed community ambulance			
Training of lay first responders and volunteer paramedics			
TUBERCULOSIS			
Childhood vaccination against endemic TB			
Directly observed short-course chemotherapy	8–263	n.e.	13.9
Isoniazid treatment of epidemic TB			
Management of drug resistance			
LOWER ACUTE RESPIRATORY ILLNESSES OF CHILDREN UNDER FIVE			
Community- or facility-based case management of non-severe cases			
Case management package including community- and facility-based care for non-severe cases and hospital-based care for severe cases	28–264	0.7–1.8	9.7–26.4
CARDIOVASCULAR DISEASES			
Management of acute myocardial infarction with aspirin and beta-blocker			
Primary prevention of coronary artery disease with legislation substituting 2% of trans fat with polyunsaturated fat, at $0.50 per adult			
Secondary prevention of congestive heart failure with angiotensin-converting enzyme inhibitors and beta-blockers incremental to diuretics	9–304	at least 0.1	25.9–39.1
Secondary prevention of myocardial infarction and stroke with polypill containing aspirin, beta-blocker, thiazide diuretic, angiotensin-converting enzyme inhibitor, and statin			
TOBACCO USE AND ADDICTION			
Tax policy to increase price of cigarettes by 33 percent			
Non-price interventions such as advertising bans, health information dissemination, tobacco supply reductions, and smoking restrictions	14–374	at least 2.5	15.7
Nicotine replacement therapy			
MATERNAL AND NEONATAL CARE			
Increased primary care coverage			
Improved quality of comprehensive emergency obstetric care	127–394	at least 1.3	37.7–47.8
Improved overall quality and coverage of care			
Neonatal packages targeted to families, communities, and clinics			

Table 2.2 *(Continued)*

Neglected low-cost opportunities in Sub-Saharan Africa	Cost per DALY averted[a] (US$)	Thousands of DALYs averted[a,b] per 20% increase in coverage	Burden of target diseases[a] (millions of DALYs)
CHILDHOOD IMMUNIZATION			
Second opportunity measles vaccination[c]			
Additional coverage of traditional Expanded Program on Immunization (tuberculosis, diphtheria-pertussis-tetanus, polio, measles)	1–5	n.e.	13.5–31.3
TRAFFIC ACCIDENTS			
Increased speeding penalties, media, and law enforcement	2–12	n.e.	6.4
Speed bumps at the most dangerous traffic intersections			
MALARIA			
Insecticide-treated bed nets[c]			
Residual household spraying[c]	2–24	20.8–37.6	35.4
Intermittent preventive treatment during pregnancy[c]			
SURGICAL SERVICES AND EMERGENCY CARE			
Surgical ward in a district hospital, primarily for obstetrics, trauma and injury	7–215	1.6–21.2	25–134.2
Staffed community ambulance			
Training of lay first responders and volunteer paramedics			
CHILDHOOD ILLNESSES			
Integrated management of childhood illnesses[c]			
Case management of non-severe lower acute respiratory illnesses at the community or facility level			
Case management package including community- or facility-based care for non-severe cases and hospital-based care for severe lower acute respiratory illnesses	9–218	at least 1.2	9.6–45.1
Breastfeeding support to prevent underweight children[c]			
CARDIOVASCULAR DISEASE			
Management of acute myocardial infarction with aspirin and beta-blocker			
Primary prevention of coronary artery disease with legislation substituting 2% of trans fat with polyunsaturated fat, at $0.50 per adult			
Secondary prevention of congestive heart failure with angiotensin-converting enzyme inhibitors and beta-blockers incremental to diuretics	9–273	at least 0.04	4.6
Secondary prevention of myocardial infarction and stroke with polypill containing aspirin, beta-blocker, thiazide diuretic, angiotensin-converting enzyme inhibitor, and statin			
HIV AND AIDS			
Peer-based programs targeting at-risk groups (e.g., commercial sex workers) to disseminate information and teach specific skills			
Voluntary counseling and testing			
Diagnosis and treatment of sexually-transmitted diseases[c]	6–377	n.e.	56.8
Condom promotion and distribution[c]			
Prevention and treatment of tuberculosis co-infection[c]			
Blood and needle safety programs[c]			
Prevention of mother-to-child transmission with antiretroviral therapy			
MATERNAL AND NEONATAL CARE			
Increased primary care coverage			
Improved quality of comprehensive emergency obstetric care	82–409	at least 2.8	29.8–37.7
Improved overall quality and coverage of care			
Neonatal packages targeted to families, communities, and clinics			

(Continues on the following page.)

Table 2.2 *(Continued)*

High-cost interventions in South Asia	Cost per DALY averted[a] (US$)	Thousands of DALYs averted[a,b] per 20% increase in coverage	Burden of target diseases[a] (millions of DALYs)
DEPRESSION			
Episodic treatment with newer antidepressant drug (selective serotonin reuptake inhibitors)	1,003–1,449	0.4–0.8	14.6
Episodic or maintenance psychosocial treatment plus treatment with newer antidepressant drug (selective serotonin reuptake inhibitors)			
HIGH BLOOD PRESSURE AND CHOLESTEROL			
Primary prevention of stroke and ischemic and hypertensive heart disease with aspirin, beta-blocker, and statin, incremental to policy-induced behavior change, at 15 percent risk of CVD event over 10 years	1,120–1,932	at least 6.7	48.6
Primary prevention of stroke and ischemic and hypertensive heart disease with a polypill, containing aspirin, beta-blocker, thiazide diuretic, angiotensin-converting enzyme inhibitor, and statin, at 15 percent risk of CVD event over 10 years			
LIFESTYLE DISEASES			
Primary prevention of diabetes, ischemic heart disease, and stroke through policy that replaces saturated fat with monounsaturated fat in manufactured foods, accompanied by a public education campaign	1,325–1,865	1.3–1.8	39.5
Primary prevention of diabetes, ischemic heart disease, and stroke through legislation that reduces salt content plus public education			
STROKE (ISCHEMIC)			
Acute management with recombinant tissue plasminogen activator with 48 hours of onset			
Acute management with heparin within 48 hours of onset	1,630–2,967	0.03–0.4	2.2–9.2
Secondary prevention with carotid endarterectomy			
DIARRHEAL DISEASES			
Oral rehydration therapy if the package cost is greater than US$2.30 per child per episode	500–6,390	0.02–2.5	22.3
Rotavirus or cholera immunization			
TUBERCULOSIS			
Isoniazid treatment for latent endemic TB in patients uninfected with HIV	5,588–9,189	n.e.	13.9
SCHIZOPHRENIA AND BIOPOLAR DISORDER			
Antipsychotic medication and psychosocial treatment for schizophrenia	1,743–17,702	0.02–0.12	2.2–2.9
Valproate and psychosocial treatment for bipolar disorder			
CARDIOVASCULAR DISEASES			
Management of acute myocardial infarction with streptokinase or tissue plasminogen activator, incremental to aspirin and beta-blocker			
Secondary prevention of ischemic heart disease with statin, incremental to aspirin, beta-blocker, and angiotensin-converting enzyme inhibitor	638–24,040	0.04–0.3	25.9
Secondary prevention of ischemic heart disease with coronary artery bypass graft			

Table 2.2 *(Continued)*

High-cost interventions in Sub-Saharan Africa	Cost per DALY averted[a] (US$)	Thousands of DALYs averted[a,b] per 20% increase in coverage	Burden of target diseases[a] (millions of DALYs)
DIARRHEAL DISEASES			
Oral rehydration therapy if the cost per episode is greater than US$2.80 per child	500–1,658	0.1–4.6	22
Rotavirus or cholera immunization			
HIV AND AIDS			
Home care treatment[c]	673–1,494	n.e.	56.8
Antiretroviral therapy in populations with low adherence[c]			
TRAFFIC ACCIDENTS			
Random driver breath tests			
Enforcement of seatbelt laws	973–2,146	at least 0.05	6.2–6.4
Child restraint promotion			
HIGH BLOOD PRESSURE AND CHOLESTEROL			
Primary prevention of stroke and ischemic and hypertensive heart disease with aspirin, beta-blocker, and statin, incremental to policy-induced behavior change, at 15 percent risk of CVD event over 10 years	1,920	n.e.	10.6
LIFESTYLE DISEASES			
Primary prevention of diabetes, ischemic heart disease, and stroke through policy that replaces saturated fat with monounsaturated fat in manufactured foods, accompanied by a public education campaign	1,766–2,356	1.4–1.8	9.6
Primary prevention of diabetes, ischemic heart disease, and stroke through legislation that reduces salt content plus public education			
STROKE (ISCHEMIC)			
Acute management with recombinant tissue plasminogen activator within 48 hours of onset	1,284–2,940	0.02–0.3	0.9–3.6
Acute management with heparin within 48 hours of onset			
Secondary prevention with carotid endarterectomy			
TUBERCULOSIS			
Isoniazid treatment for latent endemic TB in patients uninfected with HIV	4,129–5,506	n.e.	8.1
CARDIOVASCULAR DISEASES			
Management of acute myocardial infarction with streptokinase or tissue plasminogen activator, incremental to aspirin and beta-blocker			
Secondary prevention of ischemic heart disease with statin, incremental to aspirin, beta-blocker, and angiotensin-converting enzyme inhibitor	634–26,813	0.03–0.2	4.6
Secondary prevention of ischemic heart disease with coronary artery bypass graft			

Source: Authors.

n.e. = not evaluated.

a. Ranges represent variation in point estimates of cost-effectiveness, DALYs averted, or burden of disease among the different interventions listed in each group. Point estimates of cost-effectiveness and DALYs averted were obtained directly from the relevant chapters or calculated as the midpoint of range estimates reported in the chapters. Burden of disease were obtained from the relevant chapters and from Mathers and others 2006.

b. Avertable DALYs per 20% increase in treatment coverage in a hypothetical sample population of one million people.

c. Only evaluated for Sub-Saharan Africa.

capacity and infrastructure may play a key role in determining the adoption of interventions. The current evidence on the cost-effectiveness of service levels such as district or referral hospitals is weak. Even though part of the problem lies with the difficulty of valuing the health benefits these facilities produce, more could be done. Chapter 3 presents a more detailed discussion of issues pertaining to health systems, but the broader questions of why some cost-effective interventions are used while others are not is a subject for future inquiry.

Even though much of the technology to significantly reduce the burden of disease already exists, few cost-effective interventions are available for some diseases. Shaping research priorities in a manner that is responsive to the treatment needs of the millions of HIV/AIDS patients and of people suffering from mental disorders across the range of LMICs is a challenge.

Setting intervention priorities efficiently can make a dollar go farther in improving health and can substantively increase available resources. Moreover, without demonstrably improved efficiency in health spending, aid agencies and development partners are unlikely to be persuaded to dig deeper into their pockets to pay for further expansions of health programs. Improving efficiency should not, however, detract from the importance of increasing resources that are available for implementing these interventions and of meeting broader internationally agreed-upon development goals such as the Millennium Development Goals. These objectives are complementary.

The lack of reliable data on costs and effectiveness is an important obstacle to efficient priority setting. Despite the relatively good data on the efficacy of interventions in clinical trial settings, reliable effectiveness data are generally lacking. Furthermore, not enough is known about the costs, extent of coverage, and institutional capacity requirements of interventions in developing countries. The messages presented in this chapter represent the best available information about the relative costs of purchasing health through a wide range of interventions. The challenge that lies ahead is for these messages to move beyond the academic realm: ultimately, it is the extent to which policy makers make the commitment to act on them that will save lives.

ACKNOWLEDGMENTS

ANNEX 2.A: INTERVENTION CATEGORIES AND PERTINENT POLICY INSTRUMENTS

The term *intervention* is used to denote actions taken by or for individuals to reduce the risk, duration, or severity of an adverse health condition. Policy instruments encourage, discourage, or undertake interventions. Stopping smoking, for example, is an intervention that an individual can take to reduce his or her risk of a range of diseases, and taxing tobacco products is a potential instrument of government policy to encourage this intervention. Interventions are divided into those that are *population based* and those that are *personal* as follows:

• Population-based primary prevention is directed toward entire populations or population subgroups. These interventions fall into three broad categories: personal behavior change, control of environmental hazards, and population-oriented medical interventions (for example, immunization, mass chemoprophylaxis, and screening and referral).
• Personal interventions are directed toward individuals and can be provided at home; at clinics (community, private, work-based, or school-based); at district hospitals; or at referral hospitals.

Primary prevention aims at reducing the level of one or more identified risk factors to reduce the probability of the initial occurrence of a disease (for instance, providing medication for established hypertension to prevent stroke or myocardial infarction).

Cure of a condition aims at removing the cause and restoring function to what it was before.

Acute management consists of time-limited interventions that decrease the severity of acute events or the level of established risk factors to minimize their long-term effect (for instance, providing thrombolytics for acute myocardial infarction or angioplasty to reduce stenosis in coronary arteries).

Secondary prevention (or *chronic care*) consists of ongoing interventions aimed at decreasing the severity and frequency of recurrent events of chronic or episodic diseases (for instance, providing selective serotonin reuptake inhibitors for severe unipolar depression).

Rehabilitation aims at restoring or partially restoring physical, psychological, or social function resulting from a previous condition.

Palliation aims at reducing pain and suffering from a condition for which no cure or means of rehabilitation is currently available. It may range from the use of aspirin for headaches to the use of opiates to control terminal cancer pain.

Policy instruments are activities that governments or other entities that wish to encourage or discourage interventions or to expand the potential interventions could undertake. The following are five major instruments of policy:

• Information, education, and communication seek to improve the knowledge of individuals and service providers about the consequences of their choices.
• Taxes and subsidies on commodities, services, and pollutants seek to effect appropriate behavioral responses.
• Regulation and legislation seek to limit the availability of certain commodities, to curtail certain practices, and to define the rules governing the financing and provision of health services.
• Direct expenditures seek to provide or to finance the provision of selected interventions (such as immunizations); to provide infrastructure (for instance, medical schools) that facilitates the provision of a range of interventions; or to alter infrastructure so as to influence behavior (for example, by installing speed bumps).
• Research and development, either undertaken directly or encouraged through subsidies, are central to the goal of expanding the range of interventions available and reducing their costs.

Source: This annex was prepared by Thomas Gaziano, Dean Jamison, and Sonbol Shahid-Salles.

ANNEX 2.B: SUMMARY OF INTERVENTIONS

Table 2.B.1 summarizes personal interventions. A summary of population-based interventions is shown in table 2.B.2.

ANNEX 2.C: SUMMARY OF OTHER INTERVENTIONS

Table 2.C.1 summarizes personal interventions for which cost-effectiveness is evaluated using a measure other than $/DALY averted. A summary of population-based interventions evaluated using measures other than DALYs is shown in table 2.C.2.

Table 2.B.1 Summary of Personal Interventions

Condition	Intervention	Intervention description	Intervention setting	Objective	Target population[a]	Cost-effectiveness[b] (US$/DALY)	Cost-effectiveness range[b] (US$/DALY)	Number of DALYs averted[b] (hundreds)	Number of deaths averted[b]	Quality of cost-effectiveness analysis evidence[c]
African trypanosomiasis	Case finding and treatment	Identification and treatment of *Trypanosoma brucei gambiense* using the card agglutination trypanosomiasis test with parasitological confirmation, allowing for rapid diagnosis and treatment	Clinic	Primary prevention, cure	All ages	15 (Sub-Saharan Africa)	—	—	—	2 (Sub-Saharan Africa)
African trypanosomiasis	Melarsoprol	Used in the second stage of the disease	Clinic	Secondary prevention	All ages	10 (Sub-Saharan Africa)	—	—	—	2 (Sub-Saharan Africa)
African trypanosomiasis	Eflornithine	Used in the second stage of the disease	Clinic	Secondary prevention	All ages	20 (Sub-Saharan Africa)	—	—	—	2 (Sub-Saharan Africa)
Alcohol abuse	Brief advice to heavy drinkers by primary health care providers	During primary health care visits, provision of advice by physicians through education sessions and psychosocial counseling	Clinic	Primary prevention	Adolescents and adults	642	—	1.75	—	5
Bipolar disorder	Lithium, valproate, with optional psychosocial treatment, hospital-based	Episodic treatment in a hospital setting with lithium or valproate with or without maintenance or episodic psychosocial treatment	District or referral hospital	Secondary prevention	Adults over 15	4,417	3,590–5,244	1.00	—	5
Bipolar disorder	Lithium, valproate, with optional psychosocial treatment, community-based	Episodic treatment of bipolar disorder in a community setting using lithium or valproate with or without maintenance or episodic psychosocial treatment	District or referral hospital	Secondary prevention	Adults over 15	3,113	2,498–3,728	1.35	—	5
Cataract	Extracapsular surgery	Extracapsular cataract extraction with implantation of a posterior chamber intraocular lens; removal of the lens and the front portion of the capsule, which are then replaced with an artificial lens	District or referral hospital	Cure	Adults over 40	183	—	—	—	3
Congestive heart failure	ACE inhibitor and beta-blocker, with diuretics	Use of ACE inhibitor and an optional beta-blocker (metoprolol), incremental to diuretics	District hospital	Secondary prevention	Adults	150	27–274	11.59	—	5

	Intervention	Description	Setting	Type	Age group				
Dengue	Improved case management	No specific treatment: early recognition of symptoms such as intense continuous abdominal pain, persistent vomiting, restlessness or lethargy; supportive treatment includes fluid replacement and electrolytic therapy	Clinic or district hospital	Acute management	All ages	587	—	—	2
Depression	Drugs with optional episodic or maintenance psychosocial treatment	Antidepressant drugs (tricyclic antidepressant or selective serotonin reuptake inhibitor) used alone or in combination with psychosocial treatment for episodic depression or maintenance treatment	District or referral hospital	Secondary prevention	Adults over 15	1,699	657–2,741	3.96	5
Diarrheal disease	Oral rehydration therapy for package costing $5.50 per episode	Case management of acute diarrheal infection with oral rehydration salt solutions, for package costing $5.50 per child per episode	Clinic	Acute management	Children	1,062	—	16.57	5
Epilepsy	First-line treatment with phenobarbital	First line treatment with phenobarbital to treat epilepsy patients	District hospital	Secondary prevention	All ages	89	—	2.99	5
Epilepsy (refractory)	Second-line treatment with phenobarbital and lamotrigine or surgery	Antiepileptic drugs, phenobarbital and lamotrigine, or a combination of phenobarbital and surgery to treat epilepsy patients unresponsive to phenobarbital	Referral hospital	Secondary prevention	All ages	3,027	2,994–3,060	0.29	5
HIV/AIDS	Mother-to-child transmission prevention	All pregnant women offered screening to prevent mother-to-child transmission; administration of a short-course of AZT, lamivudine, or nevirapine to mothers prepartum and intrapartum and to newborns postpartum and to reduce the risk of mother-to-child transmission; also includes breastfeeding advice	Clinic	Primary prevention	Mothers and infants	192	7–377	—	2
HIV/AIDS	Sexually transmitted infection diagnosis and treatment	Sexually transmitted infection screening and treatment promotion to prevent future infection and to identify and treat high-risk populations	Clinic	Primary prevention, cure	Adolescents and adults	57 (Sub-Saharan Africa)	9–105 (Sub-Saharan Africa)	—	2 (Sub-Saharan Africa)

Table 2.B.1 *(Continued)*

Condition	Intervention	Intervention description	Intervention setting	Objective	Target population[a]	Cost-effectiveness[b] (US$/DALY)	Cost-effectiveness range[b] (US$/DALY)	Number of DALYs averted[b] (hundreds)	Number of deaths averted[b]	Quality of cost-effectiveness analysis evidence[c]
HIV/AIDS	Treatment of Kaposi's sarcoma	Treatment before or after antiretroviral treatment; including failed antiretroviral treatment; local or systemic treatment of lesions to provide largely cosmetic benefit	Clinic or district hospital	Primary prevention, palliation	All ages	52,449	34,968–69,930	—	—	3
HIV/AIDS	Treatment of opportunistic infections	Opportunistic infection prophylaxis; necessary for patients without access to antiretroviral treatment, for immunosuppressed patients waiting for antiretroviral treatment to take effect, for patients who refuse or cannot take antiretroviral treatment, for patients for whom antiretroviral treatment fails, and for groups of patients who are unable to recover sufficient CD4 cells despite good inhibition of viral replication	Clinic or district hospital	Primary prevention, cure	All ages	156	3–310	—	—	3
HIV/AIDS	Tuberculosis coinfection prevention and treatment	Preventive therapy, short-course chemotherapy, or co-trimoxazole prophylaxis	Clinic	Primary prevention, cure	All ages	121 (Sub-Saharan Africa)	6–235 (Sub-Saharan Africa)	—	—	2 (Sub-Saharan Africa)
HIV/AIDS	Home care	Home visits providing basic care to sick AIDS patients or comprehensive schemes that provide palliative care, nutrition, psychosocial support and counseling, and links to primary and secondary health care	Household	Secondary prevention, palliation	All ages	673 (Sub-Saharan Africa)	—	—	—	2 (Sub-Saharan Africa)
HIV/AIDS	Antiretroviral therapy	Combination therapy with multiple antiretroviral drugs associated with prolonged survival in treated patients	Clinic	Primary prevention	All ages	922 (Sub-Saharan Africa)	350–1,494 (Sub-Saharan Africa)	—	—	3 (Sub-Saharan Africa)

Condition	Intervention	Description	Level	Type	Population				
Integrated management of childhood illness	Integrated management of childhood illness	Integration of effective interventions to improve child health and nutrition into a coordinated strategy by improving health worker performance, child health service delivery, and family and community practices	Clinic	Primary prevention, secondary prevention, cure	Children	39 (Sub-Saharan Africa)	—	—	3 (Sub-Saharan Africa)
Ischemic heart disease	Aspirin, beta-blocker, and optional ACE inhibitor	Aspirin plus beta-blocker (atenolol) with optional ACE inhibitor (enalapril), with or without hospital availability	District or referral hospital	Secondary prevention	Adults	688	451–926	8.40	5
Ischemic heart disease	Statin, with aspirin and beta-blocker with ACE inhibitor	Statin (lovastatin), incremental to aspirin, beta-blocker (atenolol), and ACE inhibitor (enalapril), with or without hospital availability	District or referral hospital	Secondary prevention	Adults	2,028	1,864–2,193	3.54	5
Ischemic heart disease	Coronary artery bypass graft	Placement of grafts (usually saphenous vein or internal mammary artery) to bypass stenosed coronary arteries, while maintaining cerebral and peripheral circulation by cardiopulmonary bypass	Referral hospital	Secondary prevention	Adults	36,793	—	0.76	5
Leishmaniasis	Case finding and treatment	Combination of identification and treatment, vector control where feasible, and (in zoonotic foci) control of animal reservoirs	Clinic or district hospital	Primary prevention	All ages	9	—	—	2
Lower acute respiratory infections (nonsevere)	Case management at community or facility level	Nonsevere infection diagnosed by breath rate and treated by a community health worker or at a health facility, with amoxicillin, acetaminophen, and possibly salbutamol	Clinic, community	Cure	Children under 5	129	50–208	5.15	17.36
Lower acute respiratory infections (severe and very severe)	Case management at hospital level	Severe or very severe infection diagnosed by breath rate and with x-ray tests and treated at a hospital with antibiotics and possibly salbutamol, oxygen, and prednisolone	District hospital	Cure	Children under 5	4,530	2,916–6,144	0.48	1.57	5

Table 2.B.1 *(Continued)*

Condition	Intervention	Intervention description	Intervention setting	Objective	Target population[a]	Cost-effectiveness (US$/DALY)	Cost-effectiveness range[b] (US$/DALY)	Number of DALYs averted[b] (hundreds)	Number of deaths averted[b]	Quality of cost-effectiveness analysis evidence[c]
Lower acute respiratory infections	Case-management package at community, facility, and hospital levels	Comprehensive case-management strategy covering nonsevere infection being treated by a community health worker or at a health facility, severe infection treated at a hospital, and very severe infection treated at a hospital	Clinic or district hospital	Cure	Children under 5	398	—	11.26	37.86	5
Malaria	Intermittent preventive treatment in pregnancy with sulfadoxine-pyrimethamine	Intermittent preventive treatment in areas with high and stable transmission of *Plasmodium falciparum* malaria; two curative doses of sulfadoxine-pyrimethamine given during the second and third trimesters of pregnancy during prenatal care visits	Clinic	Primary prevention	Pregnant women	19 (Sub-Saharan Africa)	13–24 (Sub-Saharan Africa)	208.00 (Sub-Saharan Africa)	827.80 (Sub-Saharan Africa)	5 (Sub-Saharan Africa)
Malaria	Intermittent preventive treatment in pregnancy with drug other than sulfadoxine-pyrimethamine	Intermittent preventive treatment in areas with high and stable transmission of *Plasmodium falciparum* malaria; two curative doses of antimalarial treatment given with a possible change in first-line therapies from chloroquine to sulfadoxine-pyrimethamine, chloroquine to artemisinin combination therapy, or sulfadoxine-pyrimethamine to artemisinin combination therapy	Clinic	Primary prevention	Pregnant women	7 (Sub-Saharan Africa)	2–11 (Sub-Saharan Africa)	—	77,500.00 (Sub-Saharan Africa)	5 (Sub-Saharan Africa)
Maternal mortality	Increased primary care coverage	Increased percentage of women accessing routine prenatal, intranatal, and postnatal care	Clinic or district hospital	Primary prevention	Pregnant women	132 (South Asia), 88 (Sub-Saharan Africa)	—	13.09 (South Asia), 27.88 (Sub-Saharan Africa)	32.00 (South Asia), 77.00 (Sub-Saharan Africa)	5 (South Asia), 5 (Sub-Saharan Africa)
Maternal mortality	Improved quality of comprehensive emergency obstetric care	Increased percentage of women with severe complications receiving comprehensive emergency obstetric care	Clinic or district hospital	Acute management	Pregnant women	127 (South Asia), 87 (Sub-Saharan Africa)	—	13.28 (South Asia), 28.28 (Sub-Saharan Africa)	32.00 (South Asia), 78.00 (Sub-Saharan Africa)	5 (South Asia), 5 (Sub-Saharan Africa)

Condition	Intervention	Description	Facility level	Type	Population					
Maternal mortality	Improved overall quality of care	Improvements to quality of prenatal and delivery care; enhanced package including availability of doctor and full range of basic and comprehensive emergency obstetric care (all six essential obstetric functions: administering antibiotics intravenously or intramuscularly, administering oxytocics intravenously or intramuscularly, manually removing the placenta, administering anticonvulsants intravenously or intramuscularly, carrying out instrumental delivery, and removing retained products of conception; optional nutritional supplementation	Clinic	Primary prevention, acute management	Pregnant women	147 (South Asia), 83 (Sub-Saharan Africa)	133–160 (South Asia), 82–85 (Sub-Saharan Africa)	21.90 (South Asia), 53.05 (Sub-Saharan Africa)	56.20 (South Asia), 153.20 (Sub-Saharan Africa)	5 (South Asia), 5 (Sub-Saharan Africa)
Maternal mortality	Improved quality of care and coverage	Improvements to quality of prenatal and delivery care and increase in the proportion of women receiving needed care; enhanced package including availability of doctor and full range of basic and comprehensive emergency obstetric care (all six essential obstetric functions noted above); optional nutritional supplementation	Clinic	Primary prevention, acute management	Pregnant women	152 (South Asia), 86 (Sub-Saharan Africa)	138–167 (South Asia), 85–86 (Sub-Saharan Africa)	23.51 (South Asia), 56.93 (Sub-Saharan Africa)	60.29 (South Asia), 164.14 (Sub-Saharan Africa)	5 (South Asia), 5 (Sub-Saharan Africa)
Myocardial infarction	Aspirin and beta-blocker	Aspirin with or without beta-blocker (atenolol)	District or referral hospital	Acute management	Adults	14	13–15	1.04	—	5
Myocardial infarction	Streptokinase, with aspirin and beta-blocker	Incremental use of streptokinase, in addition to aspirin and beta-blocker (atenolol)	District or referral hospital	Acute management	Adults	671	—	1.04	—	5
Myocardial infarction	Tissue plasminogen activator, with aspirin and beta-blocker	Incremental use of tissue plasminogen activator in addition to aspirin and beta-blocker (atenolol)	District hospital	Acute management	Adults	15,869	—	0.42	—	5
Myocardial infarction and stroke	Polypill	Combination treatment with aspirin, beta-blocker, thiazide diuretic, ACE inhibitor and statin, based on 10-year risk of cardiovascular disease	District hospital	Secondary prevention	Adults	409	—	—	—	5

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Table 2.B.1 *(Continued)*

Condition	Intervention	Intervention description	Intervention setting	Objective	Target population[a]	Cost-effectiveness[b] (US$/DALY)	Cost-effectiveness range[b] (US$/DALY)	Number of DALYs averted[b] (hundreds)	Number of deaths averted[b]	Quality of cost-effectiveness analysis evidence[c]
Neonatal mortality	Maternal and child health package with no neonatal care after birth	Mother and child health package that includes family planning, prenatal care, and comprehensive obstetric care	Clinic or district hospital	Primary prevention	Mothers and infants	1,060 (South Asia), 924 (Sub-Saharan Africa)	—	—	—	4 (South Asia), 5 (Sub-Saharan Africa)
Neonatal mortality	Family, community, or clinical neonatal package	Healthy home care practices, including exclusive breastfeeding, warmth protection, clean cord care, care seeking for emergencies; if birth outside a facility, then clean delivery kit	Clinic, community or household	Primary prevention	Mothers and infants	349 (South Asia), 345 (Sub-Saharan Africa)	305–394 (South Asia), 338–351 (Sub-Saharan Africa)	—	—	4 (South Asia), 5 (Sub-Saharan Africa)
Neonatal mortality	Combined maternal and child health with neonatal packages	Family planning, prenatal care, and comprehensive obstetric care packages, as well as healthy home care practices, including exclusive breastfeeding, warmth protection, clean cord care, care seeking for emergencies; if birth outside a facility, then clean delivery kit	Clinic, community or household	Primary prevention	Mothers and infants	839 (South Asia), 789 (Sub-Saharan Africa)	—	—	—	4 (South Asia), 5 (Sub-Saharan Africa)
Panic disorder	Drugs with optional psychosocial treatment	Anxiolytic drugs (benzodiazepine), tricyclic antidepressants or selective serotonin reuptake inhibitor used with or without psychosocial treatment	District or referral hospital	Secondary prevention	Adults over 15	734	384–1,084	0.83	—	5
Parkinson's disease	Ayurvedic treatment and levodopa or carbidopa	Levodopa (l-dopa), carbidopa, or ayurvedic therapy for partial relief of symptoms	District hospital or referral hospital	Secondary prevention	Adults over 45	1,132	752–1,512	0.13	—	5
Parkinson's disease	Levodopa or carbidopa and deep brain stimulation	Levodopa or carbidopa and deep brain stimulation	District hospital or referral hospital	Secondary prevention	Adults over 45	31,114	—	0.15	—	5

Schizophrenia	Antipsychotic drugs with optional psychosocial treatment, hospital-based	Maintenance treatment in a hospital setting with antipsychotic drugs, neuroleptic antipsychotic drug, or an atypical antipsychotic drug, with or without psychosocial treatment	District hospital or referral hospital	Secondary prevention	Adults over 15	11,920	4,105–19,736	0.60	—	5
Schizophrenia	Antipsychotic drugs with optional psychosocial treatment, community-based	Maintenance treatment in a community-based setting with antipsychotic drugs, neuroleptic antipsychotic drug, or an atypical antipsychotic drug, with or without psychosocial treatment	Community	Secondary prevention	Adults over 15	9,834	2,472–17,197	0.70	—	5
Stroke (ischemic)	Aspirin	Aspirin dose within 48 hours of onset of acute stroke	Clinic or district hospital	Acute management	Adults over 15	149	—	1.62	0.12	5
Stroke (ischemic)	Heparin and recombinant tissue plasminogen activator	Heparin within 48 hours of onset of stroke or thrombolytic therapy using recombinant tissue plasminogen activator within 3 hours of onset	District hospital	Acute management	Adults over 15	1,977	1,278–2,675	1.22	1.70	5
Stroke (recurrent)	Aspirin and dipyridamole	Daily aspirin dose or combination of aspirin and extended release dipyridamole	Clinic or district hospital	Secondary prevention	Adults over 15	81	70–93	1.77	14.29	5
Stroke (recurrent)	Carotid endarterectomy	Carotid endarterectomy surgery to remove harmful plaque from the carotid arteries	Referral hospital	Secondary prevention	Adults over 15	1,458	—	4.93	39.82	5
Stroke and ischemic and hypertensive heart disease	Polypill by absolute risk approach	Combination treatment with aspirin, beta-blocker, thiazide diuretic, ACE inhibitor, and statin based on 10-year risk of cardiovascular disease	District or referral hospital	Primary prevention	Adults	2,128	773–3,483	61.65	—	5
Tobacco addiction	Nicotine replacement therapy	Smoking cessation treatments in the form of nicotine replacement therapy	Clinic	Primary prevention	Adults	396	—	37.14	452.05	5
Trachoma	Trichiasis surgery	Trichiasis surgery (eyelid correction) to prevent blindness and reduce likelihood of other conditions	District hospital or referral hospital	Secondary prevention	Adults over 40	39	—	—	—	3

(Continues on the following page.)

Table 2.B.1 *(Continued)*

Condition	Intervention	Intervention description	Intervention setting	Objective	Target population[a]	Cost-effectiveness[a] (US$/DALY)	Cost-effectiveness range[b] (US$/DALY)	Number of DALYs averted[b] (hundreds)	Number of deaths averted[b]	Quality of cost-effectiveness analysis evidence[c]
Trachoma	Tetracycline or azithromycin	Tetracycline or azithromycin to treat the initial trachoma infection through either mass treatment of all children younger than 10 or through targeted treatment of infected children and household members	Clinic	Primary prevention	Children and adults	6,269	3,752–8,785	—	—	3
Tuberculosis (endemic)	Management of drug resistance	Introduction of resistance testing, second-line drugs, longer treatment regimen (12–18 months), and rigorous bacteriological and clinical monitoring; standardized or individualized regimen	District hospital	Secondary prevention, cure	Adults over 15	318	208–429	—	—	5
Tuberculosis (endemic, infectious or noninfectious)	Directly observed short-course chemotherapy	Short-course chemotherapy of infectious or noninfectious tuberculosis (with or without transmission, non-HIV-positive), diagnosed via directly observed treatment strategy	Clinic	Primary prevention, cure	Adults over 15	301	84–551	—	—	5
Tuberculosis (endemic, latent)	Isoniazid treatment	Isoniazid treatment of latent infection (with or without x-ray exclusion of active cases; non-HIV-infected population)	District hospital	Secondary prevention	Adults over 15	13,158	9,450–16,867	—	—	5
Tuberculosis (epidemic)	Management of drug resistance	Management of drug resistance (standard regimen) for epidemic TB conducted via introduction of resistance testing, second-line drugs, longer treatment regimen (12–18 months), and rigorous bacteriological and clinical monitoring	District hospital	Secondary prevention, cure	Adults over 15	207	201–212	—	—	5
Tuberculosis (epidemic, infectious)	Directly observed short-course chemotherapy	Short-course chemotherapy of infectious TB (allowing for transmission, non-HIV positive) carried out for epidemic TB	Clinic	Primary prevention, cure	Adults over 15	102	15–189	—	—	5

Condition	Intervention	Description	Facility	Prevention	Population				
Tuberculosis (epidemic, latent)	Isoniazid treatment	Isoniazid treatment of latent infection (x-ray exclusion of active cases; non-HIV-positive population) is conducted for epidemic tuberculosis	District hospital	Secondary prevention	Adults over 15	197	45–348	—	5
Unwanted pregnancy	Family-planning programs	Intrauterine devices, voluntary sterilization, condoms and other barrier methods, implants, and oral contraceptives	Clinic	Primary prevention	Women of childbearing age	117	—	—	3
Zinc deficiency	Supplements with oral rehydration salts	Provision of zinc as an adjunct to oral rehydration salts in treating diarrhea in young children	Clinic or district hospital	Primary prevention	Children under 5	73	—	—	3

Source: Authors.

ACE = angiotensin — converting enzyme

Note: — = not available.

a. Refers to the age group to whom the intervention is targeted and not necessarily the one that is benefiting.

b. Ranges in cost-effectiveness reflect the variation in point estimates for specific interventions included in each intervention cluster and do not represent either variation across regions or statistical confidence intervals. Point estimates were obtained directly from the relevant chapters, calculated as the midpoint of range estimates reported in the chapters, or calculated from a population-weighted average of the region-specific estimates reported in the chapters. DALYs and deaths potentially avertable are for a 20 percentage point increase in intervention coverage in a hypothetical sample population of 1 million.

c. See table 2.1.

Table 2.B2 Summary of Population-Based Interventions

Condition	Intervention	Intervention description	Intervention setting	Objective	Target population[a]	Cost-effectiveness (US$/DALY)	Cost-effectiveness range[b] (US$/DALY)	Number of DALYs averted[b] (hundreds)	Number of deaths averted[b]	Quality of cost-effectiveness analysis evidence[c]
Adolescent health and nutrition	School health and nutrition programs	Inclusion of deworming of intestinal worms and schistosomiasis; prompt recognition and treatment of malaria; insecticide-treated bednets; micronutrient supplements; breakfast, snacks, other meals; first-aid kits; referral to youth-friendly clinics; and counseling and psychosocial support	Community, school	Population-oriented medical intervention	School-age children	37	—	—	—	3
Alcohol abuse	Excise tax	25 to 50 percent increase in the current excise tax rate on alcoholic beverages	Policy level	Instrument of policy	Adolescents and adults	1,377	1,249–1,504	0.62	—	5
Alcohol abuse	Advertising ban and reduced access to beverage retail	Reduced access to alcoholic beverage retail outlets by reducing the hours of sale or advertising bans on television, radio, and billboards	Policy level	Instrument of policy	Adolescents and adults	404	367–441	0.44	—	5
Alcohol abuse	Excise tax, advertising ban, with brief advice	50 percent increase in the current excise tax rate on alcoholic beverages, combined with advice, education sessions, and psychosocial counseling; possible inclusion of random driver breath testing and advertising bans	Policy level	Instrument of policy	Adolescents and adults	631	601–661	2.85	—	5
Chagas disease	Vector control	Vector control activities including spraying combined with housing improvement, community involvement in surveillance, and strong programs of health education	Community	Control of environmental hazard	All ages	284 (Latin America and the Caribbean)	—	—	—	1 (Latin America and the Caribbean)

Coronary artery disease	Legislation substituting 2% of trans fat with polyunsaturated fat at $0.50 per adult	Legislation replacing 2% of dietary trans fat from partial hydrogenation in manufactured foods with polyunsaturated fat, at a cost of $0.50 per adult, and assuming a 7% reduction in coronary artery disease	Policy level	Instrument of policy	Adults	48	—	—	—	5
Coronary artery disease	Legislation substituting 2% of trans fat with polyunsaturated fat at $6 per adult	Legislation replacing 2% of dietary trans fat from partial hydrogenation in manufactured foods with polyunsaturated fat, at a cost of $6 per adult, and assuming a 7–40% reduction in coronary artery disease	Policy level	Instrument of policy	Adults	838	199–1,478	—	—	5
Dengue	Vector control	Chemical vector control using larvicides and insecticide space sprays (including emephos, permethrin, methoprene, pyriproxyfen, and *Bacillus thuringiensis israelensis*) to protect drinking water, or environmental vector control, such as removal of standing water	Community or district hospital	Control of environmental hazard	All ages	2,566	1,992–3,139	—	—	2
Dengue	Immunization	Dengue immunization (a vaccine is currently undergoing clinical trials in Southeast Asia)	Community clinic or district hospital	Population-oriented medical intervention	Children	1,440	—	—	—	2
Diabetes, ischemic heart disease, and stroke	Legislation with public education to reduce salt content	Legislated reduction in salt content of manufactured foods and an accompanying public education campaign	Policy level	Instrument of policy	All ages	1,937	—	18.73	—	5
Diabetes, ischemic heart disease, and stroke	Media campaign to reduce saturated fat	Media campaign to reduce saturated fat content in manufactured foods and replacing part of the saturated fat with polyunsaturated fat	2,617	Instrument of policy	All ages	2,617	—	13.86	—	5
Diarrheal disease	Breastfeeding promotion	Promotion of exclusive breastfeeding (recommended for six months) to new mothers, in which no other food or drink, including water, is permitted, except for supplements of vitamins and minerals and necessary medicines	Community, clinic, or district hospital	Personal behavior change	Adult women	930	—	0.43	1.33	5

Table 2.B.2 *(Continued)*

Condition	Intervention	Intervention description	Intervention setting	Objective	Target population[a]	Cost-effectiveness (US$/DALY)	Cost-effectiveness range[b] (US$/DALY)	Number of DALYs averted[b] (hundreds)	Number of deaths averted[b]	Quality of cost-effectiveness analysis evidence[c]
Diarrheal disease	Cholera or rotavirus immunization	Immunization for endemic cholera with live oral vaccine or rotavirus immunization with rhesus-human rotavirus reassortant-tetravalent vaccine (currently under development) in populations at risk of an outbreak	Clinic	Population-oriented medical intervention	Children	2,712	2,478–2,945	0.62	1.98	5
Diarrheal disease	Improved water and sanitation at current coverage of amenities and other interventions	Improved water supply and excreta disposal where established infrastructure currently exists, in urban or rural settings for at least five years	Community	Control of environmental hazards	All ages	4,185	1,974–6,39	3.52	315.30	5
Diarrheal disease	Hand pump, standpost, or house connection where clean water supply is limited	Installation of hand water pump, standpost, or house connection where clean water supply is limited and associated infrastructure currently do not exist	Community	Control of environmental hazards	All ages	159	—	—	—	1
Diarrheal disease	Water sector regulation with advocacy where clean water supply is limited	Surveillance of drinking water quality and quality of service by the water supply utility in terms of coverage, quantity, continuity, control of sanitary hazards, and cost, as well as advocacy of lower connection charges	Policy level, community	Instrument of policy, control of environmental hazards	All ages	47	—	—	—	1
Diarrheal disease	Construction and promotion of basic sanitation where facilities are limited	Construction of low-cost excreta disposal facilities such as household pit latrines, ventilation-improved latrines, or pour-flush toilets, combined with public promotion of sanitation and hygiene	Policy level, community	Instrument of policy, control of environmental hazards	All ages	141	11–270	—	—	1

Disease/condition	Intervention	Description	Delivery level	Type	Population					
Down syndrome	Prenatal screening with option of pregnancy termination	Prenatal genetic screening program, incorporating maternal serum triple screening of all pregnant women, for trisomy of chromosome 21, to allow parents to determine whether to continue with an affected pregnancy	Clinic, district hospital	Population-oriented medical intervention	Pregnant women	15	—	—	—	5
Emergency medical care	Training volunteer paramedics with lay first responders	Identification and training of community member first responders and paramedics to act in health emergencies, recognize life- or limb-threatening situations, transport patients, and provide basic first aid	Policy level	Instrument of policy	All ages	6	—	18.42	74.00	5
Emergency medical care	Staffed community ambulance	Introduction or promotion of training programs for emergency responders and ambulance drivers in urban or rural settings for countries that lack ambulances and training programs	Policy level	Instrument of policy	All ages	120	60–179	34.84	140.00	5
Haemophilus influenzae type B (Hib)	Vaccine containing Hib	Hib vaccination (three or four doses), given concurrently with diphtheria-pertussis-tetanus	Clinic	Population-oriented medical intervention	Infants and children	733[d]	—	29.25	113.83	5
Hib, and hepatitis B, diphtheria, pertussis, and tetanus	Pentavalent vaccine	Hib vaccination (three or four doses) and hepatitis B (three or four doses) given concurrently with diphtheria-pertussis-tetanus	Clinic	Population-oriented medical intervention	Infants and children	296[d]	—	—	—	5
Hepatitis B	Hepatitis B vaccination	Hepatitis B (three or four doses) given through intramuscular injection	Clinic	Population-oriented medical intervention	Infants and children	23,520[d]	—	—	—	5

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Table 2.B.2 *(Continued)*

Condition	Intervention	Intervention description	Intervention setting	Objective	Target population[a]	Cost-effectiveness (US$/DALY)	Cost-effectiveness range[b] (US$/DALY)	Number of DALYs averted[b] (hundreds)	Number of deaths averted[b]	Quality of cost-effectiveness analysis evidence[c]
HIV/AIDS	Condom promotion and distribution	Targeted distribution and placement of condoms in locations such as bars or brothels; distribution linked to voluntary counseling and testing and sexually transmitted infection care to ensure universal access; information, education, and communication, including education through literature, classroom, and clinical settings and radio, newspapers, and television	Community or Community, clinic	Personal behavior change	Adolescents and adults	82 (Sub-Saharan Africa)	52–112 (Sub-Saharan Africa)	—	—	1 (Sub-Saharan Africa)
HIV/AIDS	Blood and needle safety	Screening of all blood for transfusions; sterilization for all injections; harm reduction for injecting drug users, including needle exchange and drug substitution programs	All levels, including community clinics to referral hospitals	Population-oriented medical intervention	All ages	84 (Sub-Saharan Africa)	7–161 (Sub-Saharan Africa)	—	—	2 (Sub-Saharan Africa)
HIV/AIDS	Voluntary counseling and testing	Routine and voluntary confidential HIV counseling and testing	Clinic	Population-oriented medical intervention	Adults	47	10–85	—	—	2
HIV/AIDS	Peer and education programs for high-risk groups	Targeting community members (for example, students or commercial sex workers) to disseminate information and teach specific skills	Community	Personal behavior change	Adolescents and adults	37	6–68	—	—	2
Lymphatic filariasis	Annual mass drug administration	Two annual, single-dose, two-drug regimens are recommended: ivermectin plus albendazole in African countries that are coendemic for onchocerciasis, and diethylcarbamazine plus albendazole for all other endemic countries	Clinic, community	Population-oriented medical intervention	All ages	15 (South Asia)	4–27 (South Asia)	—	—	4 (South Asia)

Lymphatic filariasis	Diethyl carbamazine salt	Fortification of salt with diethyl carbamazine	Policy level	Instrument of policy	All ages	22 (South Asia)	1–43 (South Asia)	—	4 (South Asia)
Lymphatic filariasis	Vector control	Integrated vector control to reduce overall prevalence of microfilaria parasites, such as polystyrene beads in vector (mosquito) breeding habitats	Policy level	Instrument of policy	All ages	160 (South Asia)	43–277 (South Asia)	—	4 (South Asia)
Malaria	Insecticide-treated bednets	Impregnation of bednets with deltamethrin, one treatment of permethrin, or two treatments of permethrin, with the bednets either purchased or subsidized	Household	Control of environmental hazards	All ages	11 (Sub-Saharan Africa)	5–17 (Sub-Saharan Africa)	376.00 (Sub-Saharan Africa)	1,429.60 (Sub-Saharan Africa)	5 (Sub-Saharan Africa)
Malaria	Residual household spraying	One or two doses of malathion, DDT, deltamethrin, or lambda-cyhalothrin applied to household surfaces	Household	Control of environmental hazards	All ages	17 (Sub-Saharan Africa)	9–24 (Sub-Saharan Africa)	376.00 (Sub-Saharan Africa)	1,429.60 (Sub-Saharan Africa)	5 (Sub-Saharan Africa)
Measles	Second opportunity vaccination in a fixed facility	Second opportunity to receive a dose of measles vaccine (either through routine or supplemental immunization activities) at a fixed facility	Clinic	Population-oriented medical intervention	Infants and children	4	—	—	—	5
Meningitis	Neisseria meningitidis vaccine	Neisseria meningitidis vaccine for serogroups A, C, Y, W135 only; unconjugated polysaccharides given subcutaneously; one dose with repeat three to five years later for those at high risk	Clinic	Population-oriented medical intervention	Children	12,632 (Sub-Saharan Africa)	—	—	—	5 (Sub-Saharan Africa)
Problems requiring surgery	Surgical ward or services in district hospital or community clinic	Surgical ward in a district hospital or community clinic to provide care for a wide range of conditions, such as trauma, childbirth, and abdominal conditions	District hospital, clinic	Instrument of policy	All ages	136	54–217	—	—	5
Onchocerciasis	Ivermectin	Annual dose of ivermectin	Clinic, community	Population-oriented medical intervention	Adults over 40	37	—	—	—	3
Soil-transmitted helminthic infections	Albendazole	Annual albendazole anthelmintic drug treatment to reduce morbidity through the deworming of Ascaris, Trichuris, and hookworm in school-age children	Community, school	Population-oriented medical intervention	School-age children	3	—	127.76	1.98	5

(Continues on the following page.)

Table 2.B2 *(Continued)*

Condition	Intervention	Intervention description	Intervention setting	Objective	Target population[a]	Cost-effectiveness (US$/DALY)	Cost-effectiveness range[b] (US$/DALY)	Number of DALYs averted[b] (hundreds)	Number of deaths averted[b]	Quality of cost-effectiveness analysis evidence[c]
Tetanus	Tetanus toxoid vaccination, mix of strategies	Tetanus toxoid vaccination via a mix of strategies depending on local needs, including fixed facilities, immunization campaigns, mobile delivery, and community outreach	Clinic, community	Population-oriented medical intervention	Infants and children	1,411	—	—	—	5
Tobacco addiction	Taxation causing 33% price increase	A 33 percent price increase due to tobacco taxes to discourage tobacco use, prevent initiation (and subsequent addiction) among youths, increase the likelihood of cessation among current users, reduce relapse among former users, and reduce consumption among continuing users	Policy level	Instrument of policy	Adolescents and adults	22	—	37.27	1,905.99	5
Tobacco addiction	Nonprice interventions	Advertising bans on television, radio, and billboards; health information and advertising in the form of health warning labels on tobacco products; interventions to reduce tobacco supply, such as smuggling control; restrictions on smoking	Policy level	Instrument of policy	Adolescents and adults	353	—	—	—	5
Traffic accidents	Increased speeding penalties, enforcement, media campaigns, and speed bumps	Minimizing exposure to high-risk scenarios by installation of speed bumps at hazardous junctions, increased penalties for speeding, and other effective road-safety regulations combined with media coverage and better enforcement of legislation	Policy level	Instrument of policy	Adults	21	3–38	0.67	197.16	5
Traffic accidents	Enforcement of seatbelt laws, promotion of child restraints and random driver breath testing	Mandatory seat belt and child-restraint laws, enforcement of drunk-driving laws, and random breath testing of drivers	Policy level	Instrument of policy	Adults	2,449	999–3,899	0.32	93.87	5

Condition	Intervention	Description	Level	Type	Target group					
Tuberculosis (endemic)	BCG vaccine	Live attenuated vaccine, BCG; recommended at birth or at first contact with health services in areas of high incidence	Clinic or district hospital	Primary prevention Population-oriented medical intervention	Children	68	55–82	—	—	5
Tuberculosis, diphtheria, pertussis, tetanus, polio, measles	Traditional Expanded Program on Immunization (EPI)	Scaling up of EPI; a fixed increment of coverage added for each year 2002–11 to reach 90 percent; coverage increases assumed to result from switching to more effective and intensive implementation strategies rather than additional infrastructure investments	Community	Population-oriented medical intervention	Infants and children	7	—	—	—	5
Undernutrition and malnutrition	Sustained child health and nutrition program	Possible inclusion of prenatal care, women's health and nutrition, breastfeeding promotion and counseling, complementary feeding, growth monitoring and promotion, micronutrient supplementation, micronutrient fortification, supplementary feeding using local supplies, oral rehydration, and immunization and deworming; actual mix depends on local capabilities and conditions	Community, clinic	Population-oriented medical intervention	Children under five	225	—	—	—	3
Underweight children	Child survival program with nutrition component	Community-based nutrition programs to prevent growth faltering, control morbidity, and improve survival by promoting breastfeeding, providing education and counseling on optimal child feeding, preventing diarrheal disease, and monitoring growth	Community	Population-oriented medical intervention	Children under five	42	—	—	—	2

Source: Authors.

BCG = bacillus Calmette – Guérin; DDT = dichlorodiphenyl trichloroethane; EPI = expanded program on immunizations

Note: — = not available.

a. Refers to the age group to whom the intervention is targeted and not necessarily the one that is benefiting.

b. Ranges in cost-effectiveness reflect the variation in point estimates for specific interventions included in each intervention cluster and do not represent either variation across regions or statistical confidence intervals. Point estimates were obtained directly from the relevant chapters, calculated as the midpoint of range estimates reported in the chapters, or calculated from a population-weighted average of the region-specific estimates reported in the chapters. DALY and deaths potentially avertable are for a 20 percentage point increase in intervention coverage in a hypothetical sample population of 1 million.

c. See table 2.1.

d. Cost-effectiveness ratio calculated from deaths averted only.

Table 2.C.1 Cost Effectiveness of Other Personal Interventions

Condition	Intervention	Intervention description	Intervention setting	Objective	Target population	Cost-effectiveness estimate (US$)	Quality of CEA evidence
Breast cancer	Clinical breast exam	Examination of the breast performed by doctors or other trained health care professionals; annually, biennially, or five yearly; for women ages 40–60	Clinic	Secondary prevention	Women ages 40–60	7125–9907 per death prevented (India); 522–722 per LYS (India)	4
Breast cancer	Screening mammography	Examination of the breasts performed by compressing the breast firmly between a plastic plate and an X-ray cassette that contains special X-ray film; one lifetime or biennially	Clinic	Secondary prevention	Women ages 40–70	12,262–24,493 per death prevented (India); 902–1846 per LYS (India); 2450–14,790a per YLS (Europe); 28,600–47,900 (USA)	2 (USA, Europe); 4 (India)
Breast cancer	Chemotherapy and/or tamoxifen	Tamoxifen and/or chemotherapy for 45-year-old premenopausal women with early-stage breast cancer; for node-positive, node-negative, estrogen-receptor-positive, and estrogen-receptor-negative patients	District hospital	Secondary prevention	Women age 45	12,820–171,700 (USA)	3
Breast cancer	Radiation therapy	Radiation therapy following mastectomy and chemotherapy for node-positive breast cancer in premenopausal women	District hospital	Secondary prevention	Premenopausal women	23,300–44,000 per QALY (USA)	2
Cervical cancer	Nationwide Pap screening program based on five-year intervals	Nationwide Pap screening program based on five-year intervals	District hospital	Secondary prevention	Adult women	769 per YLS (Vietnam)	2
Cervical cancer	Conventional or liquid-based cytology testing	Conventional cytology using the Papanicolaou (Pap) smear and HPV testing every 1 to 10 years; or Liquid-based cytology using the Papanicolaou (Pap) smear and HPV testing every 1 to 5 years	District hospital	Secondary prevention	Adult women	126,500 (USA); 162,400 (Thailand)	2
Cervical cancer	Two-visit HPV testing	HPV DNA testing during the first visit followed by treatment of screen-positive women during the second visit	District hospital	Secondary prevention	Adult women	122 per YLS (Brazil); 167 per YLS (Madagascar); 41 per YLS (South Africa); 117 per YLS (Zimbabwe)	1
Cervical cancer	One-visit VIA	Cervix is viewed after the application of an acetic acid solution; screening and treatment conducted during the same visit	District hospital	Secondary prevention	Women age 35–42	56 per YLS (Brazil); 54 per YLS (Madagascar); 43 per YLS (Zimbabwe)	1
Cervical cancer	Three-visit cytology	Cytology sample obtained during the first visit, colposcopy for screen-positive women conducted during the second visit, and treatment provided during the third visit	District hospital	Secondary prevention	Women age 35–48	589 per YLS (Brazil); 379 per YLS (Madagascar); 331 per YLS (Zimbabwe)	1

Disease	Intervention	Description	Facility	Type	Population	Cost-effectiveness	Reference
Cervical cancer	Chemoradiation therapy	Cisplatin-based chemoradiation regimens on the basis of published and estimated survival.	District hospital	Secondary prevention	Adult women	337–31,400 per LYS (USA)	1
Chronic obstructive pulmonary disease	Inhaled medication	Inhaled ipratroprium bromide or corticosteroid such as fluticasone propionate	Clinic/district hospital	Palliation	Adults	7800–13,400 per QALY (High-income countries)	1
Chronic obstructive pulmonary disease	A-1 antitrypsin augmentation therapy	Intravenous treatment of chronic obstructive pulmonary disease related to severe deficiency; ranges with age and efficacy	Clinic/district hospital	Palliation	Adults	14,400–215,000 per QALY (High-income countries)	1
Chronic obstructive pulmonary disease, asthma, and cardiovascular disease	Mechanical ventilation or oxygen therapy	Mechanical ventilation with inspiratory support, invasive respiration in intensive care unit, or long-term home oxygen therapy	Clinic/district hospital	Palliation	Adults	15,000–19,000 per YLS (High-income countries); 32,350–47,850 per QALY (High-income countries)	1
Colorectal cancer	Flexible sigmoidoscopy every 5 years with or without fecal occult blood test	Flexible sigmoidoscopy enables the physician to look at the inside of the large intestine from the rectum through the last part of the colon, called the sigmoid or descending colon; fecal occult blood test checks stool samples for traces of blood.	District hospital	Secondary prevention	Adults	18,700–25,954 (USA)	2
Colorectal cancer	Double-contrast barium enema every 5 years	A series of x-rays of the colon and rectum taken after the patient is given an enema, followed by an injection of air. The barium outlines the intestines on the x-rays, allowing many abnormal growths to be visible. This is conducted every 5 years.	District hospital	Secondary prevention	Adults	11,503–26,393 per YLS (USA)	2
Colorectal cancer	Colonoscopy every 10 years	Colonoscopy allows the physician to look inside the entire large intestine, from the lowest part, the rectum, all the way up through the colon to the lower end of the small intestine. The procedure is used to look for early signs of cancer in the colon and rectum.	District hospital	Secondary prevention	Adults	9309–22,672 per YLS (USA)	2
Colorectal cancer	Chemotherapy	Adjuvant chemotherapy for stage three colon cancer	District hospital	Secondary prevention	Adults	3,000–7,000 per YLS (High-income countries)	1
Colorectal cancer	Radiation therapy	Preoperative radiation therapy for rectal cancer patients; with varying rates of recurrence and survival advantage with and without radiation treatment	District hospital	Secondary prevention	Adults	909–15,228 per YLS (Sweden)	1

(Continues on the following page.)

Table 2.C.1 *(Continued)*

Condition	Intervention	Intervention description	Intervention setting	Objective	Target population	Cost-effectiveness estimate (US$)	Quality of CEA evidence
Diabetes	Smoking cessation	Counseling and medication such as the nicotine patch	Clinic	Primary prevention	Adolescents and adults	870 per QALY (EAP); 1,170 per QALY (ECA); 1,450 per QALY (LAC); 1,230 per QALY (MNA); 730 per QALY (SAR); 660 per QALY (SSA)	5
Diabetes	Annual eye examination	Dilated eye examination to detect proliferative diabetic retinopathy and macular edema followed by appropriate photocoagulation therapy to prevent blindness	Clinic	Secondary prevention	Adults	420 per QALY (EAP); 560 per QALY (ECA); 700 per QALY (LAC); 590 per QALY (MNA); 350 per QALY (SAR); 320 per QALY (SSA)	5
Diabetes	ACE inhibitor	ACE inhibitors for blood pressure control	Clinic	Secondary prevention	Adults	620 per QALY (EAP); 830 per QALY (ECA); 1,020 per QALY (LAC); 870 per QALY (MNA); 510 per QALY (SAR); 460 per QALY (SSA)	5
Diabetes	Metformin intervention for preventing type 2 diabetes	Metformin therapy for preventing type 2 diabetes among people at high risk, such as those with prediabetes	Clinic	Primary prevention	Adults	2,180 per QALY (EAP); 2,930 per QALY (ECA); 3,630 per QALY (LAC); 3,080 per QALY (MNA); 1,820 per QALY (SAR); 1,640 per QALY (SSA)	5
Diabetes	Cholesterol control	Cholesterol control for people with total cholesterol higher than 200 milligrams/deciliter	Clinic	Secondary prevention	Adults	4,420 per QALY (EAP); 5,940 per QALY (ECA); 7,350 per QALY (LAC); 6,240 per QALY (MNA); 3,680 per QALY (SAR); 3,330 per QALY (SSA)	5
Diabetes	Intensive glycemic control	Intensive glucose control to lower the level of glucose in the person with diabetes to a level close to that of a person without diabetes, for people with HbA1c higher than 8 percent, in order to prevent or delay long-term diabetes complications	Clinic	Secondary prevention	Adults	2,410 per QALY (EAP); 3,230 per QALY (ECA); 4,000 per QALY (LAC); 3,400 per QALY (MNA); 2,000 per QALY (SAR); 1,810 per QALY (SSA)	5
Kidney disease	Hemodialysis	Most common method used to treat advanced and permanent kidney failure; conducted in a treatment center or home.	Clinic, home	Secondary prevention	Adults	42,700–70,000 per YLS (USA); 61,000–99,400 per QALY (USA)	1

Condition	Intervention	Description	Facility level	Type	Population	Cost-effectiveness	No.
Kidney disease	Kidney transplant	Kidney transplant surgery.	District or referral hospital	Cure	Adults	10,000 per LYS (USA); 11,000 per QALY (USA)	2
Kidney disease	ACE inhibitors	ACE inhibitors for all type-1 diabetetics with macroproteinuria and all type-2 diabetics	Clinic	Secondary prevention	Adults	1100–7700 per QALY (USA)	4
Mild to moderate asthma	Quick-releavers in addition to inhaled corticosteriods	Rapid-acting bronchodilators that act to relieve bronchoconstriction and accompanying acute symptoms of wheeze, chest tightness, and cough, e.g., salbutamol; incremental to inhaled corticosteroid treatment	Clinic or district hospital	Palliation	Adults	10,600-13,900 per QALY (High-income countries)	1
Opioid abuse	Naltrexone induced rapid opioid detoxification under sedation (RODS)	Patient is given naltrexone under general anesthetic.	District hospital	Rehabilitation	Adults	2,498 per week of abstinence (Australia)	1
Opioid abuse	Conventional outpatient detoxification	Conventional outpatient detoxification is supervised withdrawal from a drug of dependence that attempts to minimize withdrawal symptoms.	Clinic	Rehabilitation	Adults	12,764 per abstinent patient (Australia)	1
Opioid abuse	Drug-free treatments	Residential or outpatient drug-free treatments as well as self-help group attendance	Clinic	Rehabilitation	Adults	7000–13,000[a] (USA)	1
Opioid abuse	Methadone maintenance substitution	Substitution of short-acting heroin with long-acting orally administered opioid Methodone; includes heroin users living in communities with high HIV prevalence	Clinic	Rehabilitation	Adults	6800 per LYS (High-income countries); 9000 per QALY (High-income countries, high-HIV prevalence)	1
Opioid abuse	Buprenorphine maintenance substitution	Buprenorphine substitution maintenance treatment for non-methadone patients.	Clinic	Rehabilitation	Adults	49,000 per QALY (High-income countries)	1
Osteoarthritis	Lifestyle change	Exercise (aquatic) and calcium supplements	Clinic	Primary/secondary prevention	Adults age 55–75; post-menopausal women	96,119–498,700 per QALY (High-income countries)	1
Osteoarthritis	Replacement surgery	Synovial fluid replacement (hylan G-F 20) for patients with osteoarthritis of the knee; or complete hip joint or knee replacement with implant	Clinic, district hospital	Secondary prevention; tertiary intervention	Elderly men and women	5233–6893 per QALY (High income countries)	1
Osteoporosis	Hormone replacement therapy	Estrogen replacement from age 50, 60, or menopause for healthy women; 5-year to lifetime treatment	Clinic	Primary/secondary prevention	Postmenopausal women and women age 50 and up	5088–23,734 per QALY	1

(Continues on the following page.)

Table 2.C.1 *(Continued)*

Condition	Intervention	Intervention description	Intervention setting	Objective	Target population	Cost-effectiveness estimate (US$)	Quality of CEA evidence
Osteoporosis	Calcium supplements with or without vitamin D	Calcium with or withouth vitamin D supplements, based on evidence that it reduces appendicular fractures; assumes a compliance rate of 70%	Clinic	Primary prevention	Women age 50 to 80	37,633–149,705 per QALY	1
Osteoporosis	Nonestrogen drug treatments	Raloxifene or calcitonin to reduce bone fractures; with or without 5 years of therapy	Clinic	Secondary prevention	Postmenopausal women age 50 to 80	34,166–835,622 per QALY (High income Countries)	1
Osteoporosis	Fluoride	Fluoride appears to decrease the risk of vertebral fracture for women with established osteoporosis; assumes neutral effect on hip fractures	Clinic	Secondary prevention	Postmenopausal women	46,684 per QALY (UK)	1
Pain	Morphine	Providing oral morphine and necessary associated drugs	Clinic	Palliation	All ages	210–408 per year of pain free life added (Chile, Romania, Uganda)	4
Primary care ailments	Limited care	Includes treatment of infection and minor trauma; for more complicated condition, includes diagnosis, advice and pain relief, and treatment as resources permit	Clinic	Cure	All ages	253–380 per DALY (Low income countries); 507–760 per DALY (Middle income countries)	1
Respiratory disease (end stage)	Lung transplant	Surgical replacement with donor lung	District hospital	Cure	Adults	238,200–464,000 per QALY (High-income countries)	1

Source: Authors.
a. Currency units in US$, but not necessarily 2001.

Table 2.C.2 Cost-Effectiveness of Other Population-Based Interventions

Condition	Intervention	Intervention description	Intervention setting	Objective	Target population	Cost-effectiveness estimate (US$)	Quality of CEA evidence
Asthma	Education	Education in addition to exercise program	Clinic	Personal behavior change	Adults	71,500/QALY (High-income countries)	1
Colorectal cancer	Fecal occult blood test	Fecal occult blood test to check stool samples for traces of blood; conducted annually or biennially	District hospital	Secondary prevention	Adults	3,200–12,100 per YLS (High-income countries)	2
Diarrhea	Improved quality of care	Educational interventions to improve quality of care and encourage oral rehydration therapy in hospitals; varies with marginal improvement; low to average prevalence	Clinic/district hospital	Instrument of policy	All ages	14–6000[a] per death averted	4
Diabetes	Lifestyle intervention (type 2 prevention)	Behavioral change for weight reduction by means of a combination of a low-calorie diet and moderate physical activity	Clinic	Personal behavior change	Adults	80 per QALY (EAP); 100 per QALY (ECA); 130 per QALY (LAC); 110 per QALY (MNA); 60 per QALY (SAR); 60 per QALY (SSA)	5
Diabetes	Influenza and pneumococcal vaccinations	Influenza and pneumococcal vaccinations for elderly individuals with type 2 diabetes	Clinic	Population-oriented medical intervention	Elderly	220 per QALY (EAP); 290 per QALY (ECA); 360 per QALY (LAC); 310 per QALY (MNA); 180 per QALY (SAR); 160 per QALY (SSA)	5
Diabetes	Screening	Screening of individuals at increased risk for undiagnosed diabetes	Clinic, district hospital	Population-oriented medical intervention	Adults over 25	5,140 per QALY (EAP); 6,910 per QALY (ECA); 8,550 per QALY (LAC); 7,260 per QALY (MNA); 4,280 per QALY (SAR); 3,870 per QALY (SSA)	5
Diabetes	Annual screening for microalbuminuria	Screening for microalbuminuria and treating those who test positive	Clinic, district hospital	Population-oriented medical intervention	Adults	3,310 per QALY (EAP); 4,450 per QALY (ECA); 5,510 per QALY (LAC); 4,680 per QALY (MNA); 2,760 per QALY (SAR); 2,500 per QALY (SSA)	5
Indoor air pollution-related illness	Liquefied petroleum gas	Substitution of wood, dung, and crop residues with liquefied petroleum gas for cooking and heating	Policy level	Instrument of policy	All ages	103–1746 per healthy year (EAP); 1258–1361 per healthy year (ECA); 806–1447 per healthy year (LAC); 779–785 per healthy year (MNA); 321–558 per healthy year (SA); 534–736 per healthy year (SSA)	5

(Continues on the following page.)

Table 2.C.2 *(Continued)*

Condition	Intervention	Intervention description	Intervention setting	Objective	Target population	Cost-effectiveness estimate (US$)	Quality of CEA evidence
Indoor air pollution-related illness	Kerosene	Substitution of wood, dung, and crop residues with kerosene for cooking and heating	Policy level	Instrument of policy	All ages	12–232 per healthy year (EAP); 172–188 per healthy year (ECA); 109–650 per healthy year (LAC); 98 per healthy year (MNA); 37–65 per healthy year (SAR); 62–87 per healthy year (SSA)	5
Indoor air pollution-related illness	Improved stove	Replacement of traditional open stoves with enclosed stoves that are more efficient and/or have flues for ventilation	Policy level	Instrument of policy	All ages	306–605 per healthy year (EAP); 975–1134 per healthy year (LAC); 379–471 per healthy year (MNA); 13–15 per healthy year (SAR); 21–26 per healthy year (SSA)	5
Indoor air pollution-related illness	Improved stove with kerosene or LPG	Replacement of traditional open stoves with enclosed stoves that use kerosene or LPG	Policy level	Instrument of policy	All ages	26–85 per healthy year (EAP); 522–1416 per healthy year (ECA); 305–784 per healthy year (LAC); 227–624 per healthy year (MNA); 27–182 per healthy year (SAR); 46–304 per healthy year (SSA)	5
Lung cancer	Early detection screening	Screening of high-risk individuals, such as current and former smokers, for lung cancer using helical computed tomography	District hospital	Population-oriented medical intervention	Adults	20,000–100,000 per YLS (USA)	3
Pneumonia	Improved quality of care	Improved quality of care, including education for health providers and treatment of non-severe and severe pneumonia; varies with marginal improvement; low to average prevalence	Clinic/district hospital	Instrument of policy	Children	132–5,000[a] per death averted	4
Pollution-related illness	Control of toxins related to energy industry	Interventions include coal-fired power plant emissions controls, gasoline lead reduction, and desulphuring residual fuel oil	Policy level	Instrument of policy	All ages	less than 0 per LYS (USA)	1
Pollution-related illness	Control of toxins related to agriculture and forestry	Interventions include targeted pesticide bans and emissions standards at processing facilities	Policy level	Instrument of policy	All ages	less than 0 per LYS (USA)	1
Pollution-related illness	Control of toxins related to residential sector	Interventions include radon remediation and sedimentation, filtration, and chlorination of drinking water	Policy level	Instrument of policy	All ages	5320–7730 per LYS (USA)	1

Pollution-related illness	Control of toxins related to industrial sector	Interventions include arsenic emissions standards at copper smelters and asbestos ban for brake linings	Policy level	Instrument of policy	All ages	less than 45,600 per LYS (USA)	
Silicosis	Engineering control	Wet method e.g. spraying a surface or wetting a blade to reduce dust; local exhaust ventilation; total plant ventilation	Policy level	Control of environ-mental hazards	Working adults	105[a] per DALY (USA and Canada); 109[a] per DALY (Western Pacific)	3
Silicosis	Comfort or dust mask	Comfort or dust mask with associated training	Policy level	Instrument of policy	Working adults	111–191[a] per DALY (USA and Canada); 117–174[a] (Western Pacific)	3
Silicosis	Respirator	Half-face or full-face respirator and asso-ciated training	Policy level	Instrument of policy	Working adults	300–305[a] per DALY (USA and Canada); 266–274[a] per DALY (Western Pacific)	3

Source: Authors.
a. Currency units in US$, but not necessarily 2001.

NOTES

1. Few other cost-effectiveness studies have covered a similarly extensive set of health interventions (Dixon and Welch 1991; Jamison and others 1993; Tengs and others 1995), and only one of those studies makes these comparisons on a global scale (Jamison and others 1993). The current World Health Organization project CHOICE (Choosing Interventions That Are Cost-Effective) is a parallel effort to make such global comparisons (Murray and others 2000; http://www.who.int/evidence/cea).

2. Of these 319 cost-effectiveness estimates, 257 were in terms of U.S. dollars per DALY and therefore comparable. Interventions with cost-effectiveness in terms of dollars per DALY were grouped into 121 intervention clusters to facilitate analyses and presentation.

3. *Health system capacity* is often used to describe both the level of care (primary, secondary, and tertiary) and the institutional and organizational capacities. We use the term to refer to the latter.

4. Chapter 15 presents a fuller discussion of these methods. Note that not all chapters have used these standardized costs. Furthermore, the analyses have used U.S. dollars rather than purchasing-power parity dollars (which provide a better measure of input resource intensity and are less susceptible to exchange rate fluctuations) in order to provide a monetary estimate that may be more useful to policy makers and donors.

5. Noneconomic reasons for maintaining certain interventions can include retaining key technical skills that may be required in the future and may lead to the development of new methods that may be more cost-effective (see chapter 66 on referral hospitals for a more in-depth discussion).

6. Some interventions with high potential to reduce the burden of disease may have been excluded due to the way their cost-effectiveness ratios were calculated. For example, nutrition-related interventions are excluded from the table because those evaluated in the volume address either vitamin A deficiency or iodine deficiency both of which are associated with low avertable burden. Also, only the burden children age 0 to 4 was considered, further lowering the avertable burden. Another example is of the integrated management of infant and childhood illness, which is evaluated for Sub-Saharan Africa but not for the South Asia Region.

7. The second and third observations speak more generally to the global public goods nature of health research (see chapter 4 for an in-depth discussion). In relation to both HIV/AIDS and noncommunicable diseases, the responsiveness of the medical research system to threats to populations in developed countries has the potential to bring great benefits to people living in LMICs.

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