SELECTING AN ESSENTIAL PACKAGE OF HEALTH SERVICES USING COST-EFFECTIVENESS ANALYSIS:

A MANUAL FOR PROFESSIONALS IN DEVELOPING COUNTRIES

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Revised: July 1993

ACKNOWLEDGEMENTS

The author would like to thank Dr. José-Luis Bobadilla for his guidance and suggestions throughout the development of this methodology. Considerable input was received from Drs. Julia Walsh and Peter Berman, Data for Decision Making Project, Harvard School of Public Health. The approach for estimating the burden of disease was adapted from the global burden of disease (GBD) methodology developed by Dr. Christopher Murray and Alan Lopez for the World Bank. Caroline Cook and Christopher Murray of the Center for Population Studies, Harvard University have been extremely helpful in providing information on the GBD methodology.

Dr. W.H. Mosley and Dr. R. Morrow of the Johns Hopkins University School of Hygiene and Public Health also provided valuable comments on the first draft of this document. Other reviewers included Timothy Evans of Harvard University, as well as Drs. Richard Baumgartner and Guy Carrin of the World Health Organization. The author is grateful to Drs. Peter Cowley and Mead Over of The World Bank for offering constructive comments and insights.

PREFACE

There is increasing evidence that health resources currently are allocated toward services which are costly and result in limited benefits in terms of life expectancy gains or improvements in the quality of life. In addition, government budgets for public health initiatives and donor agency funding have declined over the past decade. Given limited health care resources, what programs and interventions achieve the greatest health impact for the least investment? Providing a tool and methodology for answering this question is the aim of this manual.

This manual provides practical guidelines for estimating the burden of disease at national or regional level, and for calculating the cost-effectiveness of alternative packages of health interventions. Results from the cost-effectiveness exercise can be used to guide decision making on allocation of resources to health care. The methodology offers an alternative approach to ad hoc planning for health services so that public health systems can provide a cost-effective and essential package of health services to the population.

The task of evaluating the costs and effectiveness of alternative health interventions may appear daunting because of the amount and type of data required, some of which may not be collected routinely by Ministries of Health. The manual was designed to be used by public health officials and consultants who necessarily have not had prior experience with cost-effectiveness analysis, though the document does presume some familiarity with epidemiologic data. Economic concepts are discussed, and the reader is encouraged to review and study the manual in order to become familiar with the approach before beginning the cost-effectiveness exercise. The manual also will be useful for readers who are more familiar with economic evaluation of health programs by providing them with a standardized approach by which to analyze and compare the cost-effectiveness of health interventions.

This document has been reviewed by several health economists and public health specialists and has undergone several revisions. It will be important to test the methodology in a developing country context to improve our understanding of data quality and availability, as well as to evaluate the presentation and clarity of the concepts presented in this document. As a result, this version of the manual can be considered a working document, and feedback on any aspect of the manual is welcome.

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ABBREVIATIONS

AC:	Average Cost
AIDS:	Acquired Immunodeficiency Syndrome
ANC:	Antenatal Care
ARI:	Acute Respiratory Infection, sometimes referred to as Acute Lower Respiratory Infection (ALRI)
BCG:	Bacillus-Calmet-Guerin vaccine for tuberculosis
CBA:	Cost-Benefit Analysis
CEA:	Cost-Effectiveness Analysis
CFR:	Case Fatality Rate
CPI:	Consumer Price Index
CUA:	Cost Utility Analysis
DALY:	Disability Adjusted Life Year
DPT:	Diphtheria-Pertussis-Tetanus Vaccine
EPI:	Expanded Programme on Immunization
FOB:	Freight-on-Board, which refers to unit prices of equipment, supplies, and pharmaceuticals adjusted for transportation costs and customs and importation duties
GBD:	Global Burden of Disease
GNP:	Gross National Product
HIV:	Human Immunodeficiency Virus
HLY:	Healthy Life Year
IADL:	Instrumental Activities of Daily Living
ICD:	International Classification of Diseases
ILO:	International Labour Organization
IPV:	Injectable Polio Vaccine, which comes in the combined DPT-polio vaccine (DPTP)
IV:	Intravenous
LOS:	Length of Stay
MC:	Marginal Cost
NBD:	National Burden of Disease
OPV:	Oral Polio Vaccine
PV:	Present Value
PWAF:	Present Worth of Annuity Factor
QALY:	Quality Adjusted Life Year
TB:	Tuberculosis
TC:	Total Cost
UN:	United Nations
UV:	Ultraviolet
WDR:	World Development Report
WHO:	World Health Organization
WTP:	Willingness-to-Pay

INTRODUCTION

A decline in mortality rates, combined with reduction in fertility rates in developing countries has been associated with a shift in the patterns of morbidity and mortality, from a predominance of infectious and parasitic diseases to greater prevalence of chronic and emerging health problems, such as cardiovascular disease, cancer, and AIDS. This shift, referred to as the epidemiologic transition, has implications for the organization and financing of health services. [1] Namely, new technologies will be needed to treat and diagnose emerging health problems. In addition, aging populations imply increased demand for hospital and long-term care. Because specialty and in-patient services may be more costly to provide on a per unit basis than basic health services offered in outpatient settings, total health care costs are expected to rise in the near future, outstripping current levels of public health care expenditures in some developing countries. Rising health care costs may be passed along to patients in the form of user fees or lower quality services, raising the issue of the affordability and accessibility of health services for the population.

In addition to shifting disease patterns, total real health care resources have declined or stagnated in developing countries in the past decade. In Africa, health spending declined in the 1980s to an average of less than 4% of public expenditures or less than 2% of GNP. [2] Donor agency contributions diminished during this period, requiring governments to allocate resources from their shrinking budgets to cover the recurrent costs of health interventions.

Despite declining real incomes for health, nearly $84 billion or $21 per capita was spent by governments on health services in 1990, and total health expenditures (public and private) were nearly double this figure. [3] Most health care expenditures were utilized by the urban-based hospital sector, with the remaining budget share allocated to community health centers in rural areas. Given this level and distribution of health expenditure, what has been achieved regarding health status?

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[1] Mosley, W.H., Bobadilla, J.L., and Jamison, D.T., "The Health Transition: Implications for Health Policy in Developing Countries," in Jamison, D.T., Mosley, W.H., Measham, A.R., and Bobadilla, J.L., eds., Disease Control Priorities in Developing Countries, Oxford University Press, New York, forthcoming. See also Bobadilla, J.L., Frenk, J., Frejka, T., Lozano, R., and Stern, C., "The Epidemiologic Transition and Health Priorities, in Jamison, D.T., Mosley, W.H., Measham, A.R., and Bobadilla, J.L., eds., Disease Control Priorities in Developing Countries, Oxford University Press, New York, forthcoming.

[2] World Bank, World Development Report, Washington, D.C., 1993.

[3] World Bank, World Development Report, Washington, D.C., 1993.

One approach to investigating this question is to compare the cost-effectiveness of alternative health services to determine whether allocation of public health resources is toward the most efficient and effective interventions. The cost-effectiveness methodology presented in this manual is an outgrowth of two recent efforts undertaken by the World Bank: a review of the epidemiology and cost-effectiveness of selected diseases and disease control interventions contained in the forthcoming Disease Control Priorities in Developing Countries; and the 1993 edition of the World Development Report which focuses on investing in health in developing countries. [4] These publications found a wide variation in the cost-effectiveness of health interventions, ranging from between $1 to $10,000 per person benefitted. [5] While both documents concluded that vaccine-preventable diseases of children were among the most cost-effective interventions, some clinical services, such as chemotherapy for tuberculosis, were found to be cost-effective as well.

The overall conclusion from these two studies was that public expenditures are not directed toward the most cost-effective programs, and that substantial resources are spent on services which result in little gain in life expectancy or quality of life. Limited public funds could be used more effectively to achieve a greater health outcome per dollar invested if Ministries of Health undertook to implement and manage a different set of health initiatives by reallocating resources towards public health and essential clinical services, leaving non-essential services to be financed privately through out-of-pocket payment or insurance coverage. The World Bank emphasizes the need to improve the efficiency of health services and the health sector overall, in order to achieve the greatest returns on investments in health. Policies such as decentralization, improved management practices, increased involvement of the private sector, [6] and reallocation of health resources towards more cost-effective services have been recommended to improve efficiency. [7]

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[4] Jamison, D.T., Mosley, W.H., Measham, A.R., and Bobadilla, J.L., eds., Disease Control Priorities in Developing Countries, Oxford University Press, New York, forthcoming; and The World Bank, World Development Report, 1993, Washington, D.C., 1993.

[5] World Development Report, 1993, Figure 3.2.

[6] Akin, J., Birdsall, N., and deFerranti, D., Financing Health Services in Developing Countries: An Agenda for Reform, The World Bank, Washington, D.C., 1987.

[7] Jamison, D.T., "Disease Control Priorities in Developing Countries: An Overview," in Jamison, D.T., Mosley, W.H., Measham, A.R., and Bobadilla, J.L., eds., Disease Control Priorities in Developing Countries, Oxford University Press, New

York, forthcoming.

According to the World Bank, there are three arguments for public financing or provision of health services. [8] First, the benefits from health services may accrue to more than one individual at a time. For instance, it is not possible to exclude individuals from benefitting from a public information campaign. Nor can the benefits of certain health services, such as immunization, be ascribed to just one individual, since vaccination affects the transmission of disease between individuals. In these two instances, health services can be considered "public goods", and the most appropriate mechanism for financing these programs is through the public sector.

Another rationale for government financing is that, because of market failures, the allocation of resources may be less than socially optimal, and alternative patterns of resource allocation would be associated with greater levels of welfare. Market failures in health can be a consequence of imperfect information between buyers (patients) and sellers (medical and health personnel), among other things. It is important for governments to regulate and provide incentives so that markets become more efficient and result in greater total welfare. The third reason for government financing and provision of health services, is that improved health is associated with declining poverty, so that government provision of a package of cost-effective health services contributes to global access and fulfillment of basic human needs.

Given the potential role for the public sector in health care, the World Development Report concludes that governments need to invest more in cost-effective health programs, while regulating private sector provision of other types of health services. According to the World Bank report, the most cost-effective **public health** interventions at a global level are childhood immunizations provided through the Expanded Programme on Immunization (including vitamin A supplementation and hepatitis B vaccination); school-based health services; information services for family planning and nutrition; programs to reduce tobacco and alcohol consumption; information to improve the household environment; and AIDS prevention. Similarly, the most cost-effective **essential clinical package** includes maternal and prenatal care; family planning; chemotherapy for tuberculosis control; control of sexually transmitted diseases; and case management of serious childhood diseases, such as diarrheal disease, acute respiratory infections, measles, malaria, and acute malnutrition. **The public health and essential clinical package comprise the essential package of health services**, which is expected to vary from country to country, or even within a country by region, depending upon the epidemiologic profile and the status of the health system. This manual provides a framework for determining the composition of this essential package for each country.

This manual contains practical guidelines for state, regional, and national health planners on how to collect, analyze, and interpret cost and effectiveness data to evaluate an essential package of health services. The purpose of this document is to familiarize health professionals (staff from ministries of health, planning, and finance, university researchers,

[8] The World Bank, World Development Report, Washington, D.C., 1993.

public health specialists, and consultants) with the methods of cost-effectiveness analysis of health interventions. This document synthesizes and contributes to cost-effectiveness approaches previously described in the literature, and the methodology presents a simplified approach in order to facilitate its use in the field. This manual is not a textbook on resource allocation or economic approaches to project evaluation, since many excellent documents have been written on these subjects. A more sophisticated reader is encouraged to review the bibliography for additional reference materials.

Because disease patterns are unique to each country and health systems have distinguishing features, this standardized methodology cannot address potential nuances which may arise during the cost-effectiveness analysis of health interventions. As a result, the study team is expected to customize the approach in order to accommodate country-specific studies, while maintaining the basic integrity of the methods presented in this manual.

The manual is organized as follows. Chapter 1 provides background information on the role of cost-effectiveness analysis in health planning. Chapter 2 describes how the cost-effectiveness exercise can be organized and implemented. In Chapter 3, a methodology for estimating the burden of illness, the number of disability-adjusted life years (DALYs) lost from a disease is presented. The fourth chapter focuses on evaluating the number of DALYs gained from different health interventions. A costing methodology is presented in Chapter 5, and approaches to cost-effectiveness analysis of alternative disease control strategies are discussed in Chapter 6. Suggested formats for documentating assumptions, as well as for data collection and analysis are presented in the Appendix. Although the cost-effectiveness analysis can be performed using a hand-held calculator, computerized analysis is encouraged.

CHAPTER 1:

THE ROLE OF COST-EFFECTIVENESS ANALYSIS IN IDENTIFYING AN PACKAGE OF HEALTH INTERVENTIONS

1.1 What is Cost-effectiveness Analysis?

Resources for the delivery of health services are limited in every country and choices need to be made as to which health services should be financed by the government. Resource allocation decisions imply making tradeoffs between funding one type of health program or another. For example, choosing to construct a hospital may take funding, personnel, and materials away from other health services. In order to evaluate which tradeoffs are "worth" the cost, health planners can use the methodology of cost-effectiveness analysis. Because health effects are measured in common units across interventions, cost-effectiveness ratios can be compared. In cost-effectiveness analysis (CEA), the economic cost (see Chapter 5) of a health intervention is divided by an estimate of the health effects (see Chapter 4): the interventions with the smallest ratios are considered to be the most cost-effective. By this approach, health interventions can be ranked according to their cost-effectiveness ratios, and the most cost-effective programs selected as health priorities for funding by governments. For this manual, health effects are measured as the number of disability-adjusted life years (DALYs) gained from interventions.

CEA is one economic method which can be used to evaluate health services. Other approaches rely on different measures of health intervention effectiveness. For CEA, health effects are measured in physical units, such as the number of children fully immunized, the number of cases of disease prevented or treated, and the number of deaths averted. These output measures may or may not correspond directly with actual health benefits. Other types of cost-effectiveness analyses combine the impact of health interventions on both morbidity and mortality using a more comprehensive measure. Examples include the cost per disability-adjusted life year saved, and the cost per quality-adjusted life year (QALY) saved. In the latter case, individuals are asked to evaluate their preferences for 1) additional years of healthy life; 2) additional years of disease; 3) improved health status with no impact on additional survival; and 4) additional years of life added but with disablement. [9] These preferences (utilities) are given a value between 0 and 100%, with death equal to 0% utility. This approach is sometimes referred to as cost-utility analysis (CUA) in that the utility valuations of individuals (physic units) are included in the denominator rather than physical units of health effect. Individual preferences for alternative health states can be collected from surveys of patients, the general population, or health care providers; however, patients who are more familiar with the pain and limitations of a disease may weigh alternative health states differently than other population groups. [10]

Finally, cost-benefit analysis (CBA) is a method in which both the costs and benefits are expressed in monetary terms. For instance, the cost of an intervention is compared to the economic value of a person's life, determined either by

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[9] Adapted from Shepard, D.S., and Thompson, M., "First Principles of Cost-effectiveness Analysis in Health," Public Health Reports, Volume 94, Number 6, November-December, 1979.

[10] Torrence, G.W., "Utility Approach to Measuring Health-Related Quality of Life," Journal of Chronic Diseases, Volume 40, Number 6, pp. 593-600, 1987.

what that person is willing-to-pay to extend life or avoid the disability, or by that individual's human capital measured as the value of future earnings (see Box 1.1).

BOX 1.1: APPROACHES TO VALUING LIVES SAVED IN COST-BENEFIT ANALYSIS

In cost-benefit analysis (CBA), both the costs and benefits of health programs are evaluated using a single monetary measure, which overcomes problems of comparing programs with different types of health outcomes. Costs and benefits are expressed either as a ratio, or as a net difference in the gains and losses measured in monetary or financial terms associated with a health program. The impact of a program can be measured using the human capital approach. Saving the life of a working individual results in a health benefit equal to the present value of discounted future expected earnings. However, this approach may undervalue the lives of individuals not employed in the formal sector, such as women, children, and older adults, and understate the value of health programs because psychological benefits for the patient and family are omitted. [1]

Health benefits also can be measured by the amount individuals would be willing to pay to avoid death or disability. One limitation of the willingness-to-pay approach (WTP) is that individuals evaluate health benefits in terms of their personal gains rather than the benefits to society as a whole. Another problem is that responses to WTP questions are dependent upon the resources available to the individual: a wealthy person is willing to spend more to avert death than a poor individual. Thus, the evaluation method may implicitly weight preferences of wealthier individuals more than others. For these reasons, cost-effectiveness analysis is utilized more often than CBA for evaluating health interventions.

[1] Adapted from Over, M., Economics for Health Sector Analysis: Concepts and Cases, Economic Development Institute, The World Bank, Washington, D.C., 1991. See also Weinstein and Fineberg, 1980.

1.2 Role of Cost-effectiveness Analysis in Resource Allocation for Health

CEA is a tool for identifying which health interventions achieve the greatest level of health impact per unit of investment, and the results can be used to evaluate on-going health interventions or to plan for future health programs. In addition, the findings of CEA can assist program managers to identify ways to improve efficiency and effectiveness of service delivery.

While the use of CEA for program management is important, the primary emphasis of the methodology is on planning and evaluating health interventions so that resources can be allocated in a more cost-effective manner at national or regional level. For example, cost-effectiveness analysis can be used to determine whether implementation of a new program or health initiative appears feasible in terms of the cost per unit of health outcome. If initial estimates indicate the program will be too resource intensive, modifications can be made in program design prior to implementation to improve the cost-effectiveness of the intervention. The type of delivery strategy, ranging from on-demand services, campaigns and

acceleration strategies, as well as mobile or targeted approaches have different implications for resource use and cost-effectiveness of services. One of the most important uses of cost-effectiveness analysis is to evaluate alternative delivery strategies, such as whether mobile teams are more cost-effective than campaigns in treating children with Vitamin A deficiency. Moreover, CEA can be used to determine whether health interventions provided through public facilities are more or less cost-effective than their counterparts delivered through the private health care system. This type of analysis can be used to ascertain which health interventions should be financed and/or delivered by the public sector.

CEA can also inform decision makers whether adding new components to existing interventions represents a cost-effective choice. Examples include combining hepatitis B immunization into the current EPI vaccine schedule or providing a greater range of health services through school-based programs. CEA can help demonstrate if extra health benefits of combined or clustered interventions are worth the additional cost. Moreover, this approach can be used to determine whether to expand an intervention into another geographic area or target population. For example, certain population groups may be at greater risk for disease, such as lower income families or certain occupational groups. One study in Indonesia finds that, while not as cost-effective as routine services, tetanus immunization campaigns are justified because they reach less educated mothers whose children were more at risk for disease. [11]

Further, the results of CEA can be shared with the public so that consumers may get more value for their own investment in health services. These figures can provide consumers with needed information in order to make the most efficient choices regarding the type of health care provider to treatment.

Finally, in some developing countries, donor funding for health services represents a large proportion of total government health expenditures. Evaluation of the cost-effectiveness of alternative health interventions can guide international priorities for investing in health programs, as well as provide governments with quantitative information for selecting and choosing among donor projects.

[11] Berman, P., Quinley, J., Yusuf, B., Anwar, S., Mustani, O., Azof, A., and Iskandar, "Maternal Tetanus Immunization in Aceh Province, Sumatra: The Cost-effectiveness of Alternative Strategies," Social Science and Medicine, Volume 33, Number 2, pp. 185-192, 1991.

1.3 Potential Constraints in the Use of the CEA Methodology

A discussion of the role of cost-effectiveness analysis in health would be incomplete without mentioning some of the critiques and constraints in using the methodology to determine health priorities. The first type of critique is one of perspective: this methodology stems from a social planning perspective in which health officials and planners design an efficient and socially optimal health system, rather than relying upon consumer sovereignty and the marketplace to determine how resources will be distributed.

Another criticism stems from the requirements of the methodology for greater amounts of data and more complex analyses to confirm what public health specialists may already suspect are health priorities for government funding. Namely, that public health and basic health services are more cost-effective and need to be provided within the public domain. While these trends may be generally true, the epidemiologic profile and health care infrastructure of each country or region will determine, in large part, the cost-effective package of health interventions. The methodology depends on measurement of the effectiveness of health interventions on alleviating disability and preventing premature death. In some cases, it may be difficult to quantify accurately the total benefit of health interventions, particularly in cases when there are multiple risk factors involved in the disease process, or when health interventions mutually reinforce or negate each other. While some have argued that this is a limitation of the methodology, it is more appropriately viewed as a limitation of the type and quality of data available currently on the effectiveness of health interventions.

Cost-effectiveness ratios are snapshots of the relationship between the costs and benefits of a intervention at one point in time. However, the ranking of cost-effective interventions depends upon the relative importance of diseases, the age structure of the population, the type of health care infrastructure, and the level of scale at which programs are implemented. Changes in any one of these variables will affect the relative cost-effectiveness of interventions. As a result, the ranking of interventions will fluctuate over time and need to be re-evaluated as higher quality information becomes available. For this reason, it is important to conduct country-specific exercises to acquire sufficient information to determine the essential package of health services.

In some cases, it may be better to implement a less cost-effective intervention if it is believed that the higher fixed costs of the program in the short run will be outweighed by lowered costs in the long run. For instance, it may be more cost-effective in the long run to construct water and sanitation facilities in rural areas. The initial fixed costs of the investment will be extremely high, but the potential gains in health benefits in the future may be worth the initial expense. In addition, investing in interventions which lead to eradication of disease may be worth the extra cost in the present time.

Finally, there are other criteria besides cost-effectiveness which are used to determine health priorities, such as equity or quality of care. Health interventions which are costly and save the lives of a few people may be better investments

than health interventions which are inexpensive but have limited health impact on a larger population group. An example may be control programs against lassa fever compared with interventions to diagnose the common cold. The objective of CEA is to provide additional, quantitative information for the health planning process, not to replace other criteria which may be equally important to society. Cultural and social acceptability of health interventions may supersede a rational decision-making approach, and community demand for less effective health programs than those identified through the analysis may be more important factors for setting priorities.

1.4 Advantages of CEA for Health Planning

Why is it important to conduct a cost-effectiveness exercise of health interventions at the regional or national level? Cost-effectiveness analysis integrates a wide body of information into a single measure, requiring collaboration and participation of different disciplines, such as public health, epidemiology, economics, and medicine. As a single measure, cost-effectiveness ratios can be used to guide information needs for ongoing program management and the planning process, as well as stimulate research on the underlying causes and risk factors for the burden of disease and on the cost of providing health interventions through alternative strategies.

More importantly, cost-effectiveness analysis provides an alternative to ad hoc and subjective health planning based on historical trends or political preferences. The analysis helps to circumscribe the policy debate by introducing quantitative information. Because CEA provides a common terminology for health planners, health professionals and other officials, this methodology can be used to justify support for health priorities and programs, or to reject possible options because they do not represent an efficient use of resources. Unlike most planning processes, assumptions regarding both the costs and outcomes of health interventions are made explicit during the analysis, which helps to restrict the arbitrariness of choices made by policy makers who often rely on implicit assumptions and preferences. As a consequence, modifications in health budgets and priorities can be based on changes in the quantity, quality, or timing of inputs rather than on subjective opinions and impressions.

While demanding in terms of data requirements and analysis, the techniques presented in this manual will provide a much-needed, and more methodical approach for assessing the relative worthiness of health interventions. The end result will be better investment in cost-effective health services which are affordable to the government and which address the needs of the population.

CHAPTER 2:

ORGANIZING THE COST-EFFECTIVENESS EXERCISE

2.1 The Multi-Disciplinary Team

Creating a core technical group responsible for organizing and implementing the cost-effectiveness exercise is essential. The composition of the multi-disciplinary team will depend upon the training and availability of individuals. As a whole, the team needs to have members with previous experience in implementation of public or private sector health programs, health program evaluation, economic analysis, community surveys, and computer analysis. The cost-effectiveness study team must include members who will be able to determine the quality of information collected and whether alternative sources need to be pursued. It is preferable that some of the team members be aware of and have access to data sources, such as hospital records, Ministry of Health documents, or survey research findings. Finally, cost-effectiveness results must be transformed into meaningful policy options, which will require team members with knowledge of both implementation and policy issues.

In order to facilitate collection and analysis of a wide range of epidemiologic and economic data, it is suggested that the core team be composed of professionals who have expertise in one or more of the following disciplines:

- epidemiology
- economics
- demography
- health planning and management
- medicine and/or public health
- accounting and financial analysis

The core team can be complemented by other individuals who have one or more of the following skills:

- statistics
- computer programming and analysis
- social science and anthropology

Although it may be difficult for officials from the Ministry of Health, Ministry of Finance, or Ministry of Planning to participate in the cost-effectiveness exercise on a full-time basis, their involvement can help ensure that the results of the cost-effectiveness exercise are linked to the overall decision making process. Local consultants, university groups, and other technical experts can conduct field research and provide valuable advice to the cost-effectiveness study team.

2.2 Preparation for the Cost-effectiveness Study

In order to begin the cost-effectiveness exercise, training of team members in the methods presented in this manual will be important, and may be conducted in several phases. In the first phase, team members can become oriented toward the general concepts of economic evaluation of health services, and the uses of cost-effectiveness analysis results for health planning. In addition, the first phase of training can include a review of the terminology and concepts presented in this

manual. A review of basic data requirements and sources for estimating the national burden of disease, as well as the methods for calculating disease burden could be the focus of the second phase of training. Likewise, during the third phase, data sources and requirements, as well as methods for calculating the cost of alternative health interventions can be accomplished. Practice in computer data analysis will be helpful throughout the training period.

Training may be considered part of the initial phases of the cost-effectiveness exercise, and could last as long as two to three weeks, depending upon the previous experience of the study team. While formal training can provide the basic framework from which to start the exercise, in most cases, much of the learning and understanding of concepts will come from collecting and analyzing data for the actual cost-effectiveness study. Therefore, team members should not expect to know everything before they begin the analysis, as each country-specific exercise will have its own distinctive analysis issues.

2.3 Organizing and Dividing the Work

Because of the scope of the cost-effectiveness analysis, it is suggested that data collection and analysis be divided among team members according to expertise. The cost-effectiveness exercise also can be conducted in phases, which will also help reduce the total time requirement for each individual team member. For instance, those experts familiar with the country's demography and epidemiology can begin to estimate the burden of disease. Once the national or regional burden of disease is evaluated, then team members can assemble to identify and discuss potential disease control interventions which will be evaluated based on their potential efficacy in treating or preventing disease, as well as their feasibility of implementation. Once a short list of interventions has been determined, the economists, accountants, and other experts in health program evaluation can proceed to determine the cost and cost-effectiveness of these alternative interventions. The entire team would then reassemble to compare the cost-effectiveness of health interventions, and to discuss and interpret the results for health policy.

In calculating regional or national burden of disease (NBD), it may be useful to further subdivide the team into those responsible for analyzing one of three groups of diseases in the analysis. Group 1 consists of communicable, maternal and perinatal diseases; Group 2 includes noncommunicable diseases; and Group 3 contains injuries. Working in smaller groups focused on a narrow range of diseases will improve the reliability and quality of the results. Care needs to be taken to maintain consistency of methods and assumptions used for different tasks of the analysis among each subgroup.

In evaluating the costs of health interventions, the team could be subdivided into those individuals responsible for estimating the cost of hospital-based interventions, those provided through public sector health centers, or those services delivered in private facilities. Table 2.1 illustrates how the work can be subdivided among team members.

TABLE 2.1
PROPOSED DIVISION OF WORK FOR THE COST-EFFECTIVENESS STUDY

Phase of the Exercise	Tasks	Personnel
Phase 1: Estimating the National or Regional Burden of Disease	Collect data on population age and gender composition; analyze epidemiologic data concerning major causes of premature mortality and morbidity; quantify the number of disability-adjusted life years lost due to each disease based on the methodology proposed in Chapter 3.	Epidemiologists Demographers Public health specialists Physicians
Phase 2: Determine most efficacious health interventions	From a review of efficacy studies, determine the most efficacious health interventions to prevent and treat diseases; estimate the number of disability-adjusted life years gained for each disease/intervention pair (see Chapter 4).	Epidemiologists Public health specialists Demographers Physicians Program managers
Phase 3: Calculate the cost of alternative health interventions	Based on the "short list" of health interventions, conduct cost analyses for each based on the methods proposed in the manual in Chapter 5.	Economists Accountants and finance specialists Public health specialists Program managers
Phase 4: Calculate the cost-effectiveness of interventions	Compare the costs and effectiveness of health interventions; discuss and interpret the findings of the analysis for health policy (see Chapter 6).	Entire team
Phase 5: Identify research priorities	Based upon the experience of conducting the analysis of the burden of disease or the costs of health interventions, identify areas where data need to be collected and information improved for the future.	Entire team

Cost-effectiveness analysis of health interventions can be conducted as a distinct study over a period of several months; or the analysis could become an integral part of the overall health planning process, conducted on an annual or routine basis. In this case, data needs can be identified and evaluated during the planning cycle. The team is encouraged to learn and utilize these methods for on-going health planning.

CHAPTER 3:

ESTIMATING THE NATIONAL OR REGIONAL BURDEN OF DISEASE USING THE NUMBER OF DISABILITY-ADJUSTED LIFE YEARS LOST

3.1 Assessing the Burden of Disease

The approach recommended in this manual is based on generating a composite indicator, referred to as the number of disability-adjusted life years lost (DALYs), of the burden of disease which incorporates both the years of life lost due to premature mortality and those lost from varying degrees of disability associated with disease. Terminology referring to the number of healthy years of life or DALYs lost will be used interchangeably throughout this manual, although the latter indicator refers to a specific measure of disease burden derived for the Global Burden of Disease methodology. [12] Using a composite measure of disease burden is intuitively appealing in that it incorporates morbidity-related healthy years of life lost, and therefore provides a better picture of the total burden of disease in a society. A further innovation of this approach is that the number of DALYs can be disaggregated by gender and age, providing additional information from which health policy and resource allocation decisions can be made. Relying on aggregate statistics of the burden of disease, irrespective of the age at which disease occurs and the gender of those affected, can mask important areas where cost-effective interventions can improve the health of a population. The following sections describe techniques which can be used to calculate the number of DALYs. Team members are encouraged to examine this chapter to become familiar with the general concepts prior to undertaking the exercise. In order to understand the data requirements and types of assumptions and

[12] The methodology presented here is based, in large part, on the experience of the Ghana Health Assessment Team: "A quantitative method of assessing the health impact of diseases in less developed countries," International Journal of Epidemiology, Volume 10, pp. 73-80, 1981. In addition, methodological innovations described in other studies are included as well. See Prost, A., and Prescott, N., "Cost-effectiveness of blindness prevention by the Onchocerciasis Control Programme in Upper Volta," Bulletin of the World Health Organization, Volume 62, Number 5, pp. 795-802, 1984; Barnum, H., "Evaluating Healthy Days of Life Gained from Health Projects," Social Science and Medicine, Volume 24, Number 10, pp. 833-841, 1987; and, Over, M., Economics for Health Sector Analysis: Concepts and Cases, Economic Development Institute, World Bank, Washington, D.C., 1991 (see pp. 185-198).

Since the time this manual was first conceived, the World Bank has supported the development of a comprehensive methodology for estimating the global burden of disease (GBD), which is presented in the World Development Report, 1993. This approach measures the cost per disability adjusted life year gained (DALYs). Because the GBD methodology requires substantial amounts of data and is currently being field-tested, it is not possible to describe the detailed approach in the current version of this manual.

calculations, careful review may be required.

3.1.1 Calculating the Number of Healthy Life Years or DALYs Lost From Disease

This section explains a general method for estimating the number of healthy life years lost from disease, which can serve as a starting point for calculating the number of DALYs lost in a population. The number of healthy life years lost from disease is based on classification of sick individuals into one of four possible outcomes following the onset of disease: 1) immediate or premature death; 2) death following a period of disability; 3) permanent disability; and 4) recovery from the disease following acute illness. In Figure 1, the first two outcomes, premature mortality and death after disability are located on the same branch of the diagram. This is because those individuals who are disabled prior to death are a subset of the total number of individuals who eventually succumb to the disease. The other two categories (recovery and permanent disability) represent distinct states. Thus, 100% of all sick individuals are accounted for by the proportion of those who die prematurely; suffer long-term disabilities, or recovery fully from disease.

FIGURE 3.1
POSSIBLE HEALTH OUTCOMES RESULTING FROM DISEASE

Case of Disease

Disability Before Death

Recovery

Permanent Disability

Death

Figures 3.2a-3.2d illustrate a hypothetical time horizon between the onset of disease and the resulting health outcome. The horizontal axis of each of these figures is the number of years an individual is expected to live.

Figure 3.2a: Number of Healthy Years of Life Lost/Person Due to Immediate Death

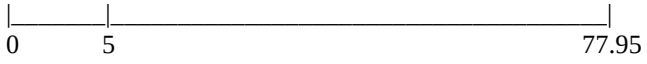


Figure 3.2b: Number of Healthy Years of Life Lost/Person Due to Disability Before Death

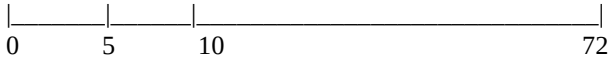


Figure 3.2c: Number of Healthy Years of Life Lost/Person Due to Permanent Disability

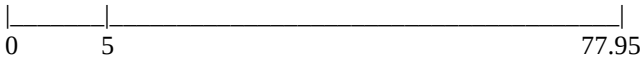
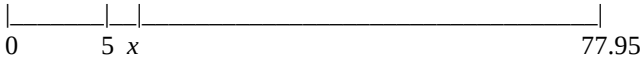


Figure 3.2d: Number of Healthy Years of Life Lost/Person Due to Acute Illness



Suppose, as in Figure 3.2a, a female child contracts poliomyelitis at age five and immediately dies. If the child had survived, she would be expected to live an additional 77.95 years (from the standardized life expectancy tables shown in Box 3.3). Therefore, this death episode results in a total of 77.95 years of healthy life lost for this individual. Figure 3.2b represents a time horizon for a female child who contracts the disease at age five but who survives until age ten with a disability. The total number of healthy years of life lost for this child has two components. First, the total number of years lost from premature death, which is equivalent to additional years of life expected at the age of death (10) is 72.99 years (from the standardized life tables). Second, the loss in healthy life in a *qualitative* manner resulting from disability between ages five and ten must be considered. Assume that over this five year period, the child was able to function at 50% capacity, so that the total number of healthy years of life lost is the product of the number of calendar years of disability (5) and the degree of disablement or disability weight of 50% (2.5 years). Adding the two components together, a total of 75.49 healthy life years are lost from disability prior to death (72.99 plus 2.5).

Figure 3.2c reflects the number of healthy life years lost for an individual who contracts the disease and becomes permanently disabled over their life span. The total number of years lost is equal to the additional years of life expected at the age of onset of the disease, adjusted for the degree of disability or a disability weight. In this case, a total of 38.975 healthy years of life are lost (77.95 years x 50% disability). Finally, an individual may contract the disease, be confined to bed or stop working during the period of acute illness, and then recover fully from the disease. Figure 3.2d shows the individual contracts the disease at age 5 and recovers from the illness at point *x* (i.e., 14 days later), from which time the individual is expected to live an additional 77.95 years. The total number of healthy years of life lost from acute disease is equal to the number of days of acute illness (14), multiplied by the degree of disablement (50%). This figure is divided by 365.25 days per year, resulting in 0.019 years of healthy life lost. Table 3.1 summarizes the results for each of the four possible health outcomes from polio infection. Notice these figures cannot be added together, since each episode of illness can only result in one of the four outcomes. The variables following each category of health outcome (identified as A through D) will be used in the presentation of the approach for calculating the number of healthy life years or DALYs lost in a population.

TABLE 3.1: HYPOTHETICAL EXAMPLE OF THE NUMBER OF HEALTHY YEARS OF LIFE LOST PER PERSON WITH POLIOMYELITIS

Type of Health Outcome	Number of Healthy Life Years Lost/Person Depending Upon Health Outcomes of Disease
Immediate Death (A)	77.95
Death Following Disability (B1)	72.99
Disability Before Death (B2)	2.5
Permanent Disability (C)	38.975
Acute Illness (D)	0.019

In order to estimate the burden of disease for a country or region, it is important to know the total number of persons (total individuals, or by gender) who are afflicted with each disease, as well as the percent of those afflicted who fall into each of the appropriate health outcome categories (A through D above). The number of individuals in a population who are likely to contract a disease is represented by the incidence rate (see Section 3.1.2 for a more formal definition). Suppose in this hypothetical example, that the incidence of polio is 0.22/1,000 population, and the case fatality rate is 5%. A crude estimation of the **total** number of persons (per 1,000) who are expected to die from polio is the product of the incidence rate and the case fatality rate (0.22/1000 x 5%), which is equal to 0.011 deaths per 1,000 population per year. A fraction of these deaths will be immediate, while the remainder will be accompanied by disability until death (represented by the variable D_{od}). Multiplying the total number of deaths per 1,000 by a percentage equal to (1 - D_{od}) gives the number of individuals per 1,000 who die immediately. Assuming in this example that D_{od} is 10%, a total of 0.0099 deaths occur immediately as a result of disease per 1,000 population: [(1.0-0.10) x (0.011/1,000)]. The difference between the total number of deaths in a population (0.011/1000) and the total number of immediate deaths (0.0099) provides a rough estimate of the number of persons who are disabled prior to death in the population, or 0.0011/1,000. This figure is used to estimate the number of healthy life years lost for both categories B1 and B2 above.

Similarly, the total number of individuals who are expected to be permanently disabled is the product of the incidence rate and an estimate of the percent of cases which will result in permanent disabilities (Q). Suppose that Q is 90% in this hypothetical example, so that the total number of individuals permanently disabled is 0.198 per 1,000, which corresponds to category C. Finally, to estimate the number of individuals who recover fully from the disease (category D), subtract the case fatality rate (CFR) and the percent of disabled population (Q) from the number one (1), and multiply this figure by the incidence rate [(1.0 - 0.05 - 0.9) x 0.22/1,000 = 0.011/1,000).

Table 3.2 summarizes the figures calculated so far in this theoretical example. The first column corresponds to the number of healthy years of life or DALYs lost per person, and the second column refers to the number of individuals in each

category based on incidence, disability (D_{od}), and recovery rates. The number of healthy years of life lost per 1,000 population for each category (column 3) is the product of the number of healthy life years lost per person (column 1) and the number of individuals affected in each category in the population (column 2). For this example, a total of 8.572 healthy life years are lost per 1,000 population. If calculations are based on a population of 500,000, the total number of healthy life years lost in the total population would be 4,286 (500 x 8.572). The total number of healthy life years lost per 1,000 (second column) should be equal to the incidence rate: this is a method for checking the consistency of the calculations. Notice also that many of the calculations are carried to the third and fourth decimal place, since rounding will affect the numbers of healthy life years when projected to the total population level.

TABLE 3.2: HYPOTHETICAL EXAMPLE OF THE NUMBER OF HEALTHY LIFE YEARS LOST PER 1,000 POPULATION

Type of Health Outcome	Number of Healthy Years of Life Lost Per Person (1)	Number of Individuals in Each Category per 1,000 Population (2)	Number of Healthy Years of Life Lost per 1,000 Population (3)	Percent (4)
Immediate Death (A)	77.95	0.0099	0.7717	9
Death Following Disability (B1)	72.99	0.0011	0.0803	~1
Disability Before Death (B2)	2.5		0.00275	nil
Permanent Disability (C)	38.975	0.198	7.717	90
Acute Illness (D)	0.019	0.011	0.0002	nil
Subtotal		0.22	8.572	~100

The distribution of healthy life years or DALYs lost per 1,000 between mortality and morbidity categories can be assessed using this framework. For example, in Table 3.2, column 4, 90% of all healthy life years lost from polio is attributable to permanent disability. In addition, the analysis could disaggregate the number of healthy life years or DALYs lost by gender (male or female) or by age interval, if sufficient data exist.

Another example may help to illustrate the general approach. Suppose that the incidence of leprosy in 0.5/1000. The average age at death is 30 years, and the average age at onset of the disease is 20 years. The case fatality rate is 25%; D_{od} is 50%; the percent permanently disabled is 75%, and the degree of disablement is 25%. It is assumed there is no period of acute illness. What is the number of healthy life years or DALYs lost per person and per 1,000 population? Table 3.3 provides the answers: see if you can generate these values yourself using the standardized life table for males.

TABLE 3.3: HYPOTHETICAL EXAMPLE FOR CALCULATING THE NUMBER OF HEALTHY LIFE YEARS LOST PER 1,000 POPULATION FROM LEPROSY (males)

Type of Health Outcome	Number of Healthy Years of Life Lost Per Person (1)	Number of Individuals in Each Category per 1,000 Population (2)	Number of Healthy Years of Life Lost per 1,000 Population (3)	Percent (4)
Immediate Death (A)	56.97	0.0625	3.561	~ 30
Death Following Disability (B1)	47.47	0.0625	2.967	~ 25
Disability Before Death (B2)	2.5		0.156	0.5
Permanent Disability (C)	14.2425	0.375	5.341	44.5
Acute Illness (D)	0	0	0	0
Subtotal		0.5	12.025	~100

The preceding examples demonstrate the logic underlying the approach to estimating the number of healthy life years or DALYs lost in a population. More formally, the following variables are used to estimate the number of healthy years of life lost in a population:

A_o = Average age of onset of the disease in the population [13]

A_d = Average age of death from the disease [14]

$E(A_o)$ = Life expectancy at age of onset, from standardized life tables

$E(A_d)$ = Life expectancy at age of death, from standardized life tables [15]

CFR = Case fatality rate (%)

D_{od} = Proportion of the population who die from the disease, but who suffer a period of disability prior to death (%)

Q = Percent of those who are permanently disabled by the disease over their remaining life span (%)

D = Degree of disablement of individuals who suffer temporary illness, temporary disability, or permanent disabilities (%)

t = Average duration (days) of temporary disablement from acute illness among those who neither die nor become permanently disabled

[13] This figure could be equivalent to the actual age at death, if mortality ensues immediately without a period of prolonged disability.

[14] The average age at death and the life expectancy at age of death will vary according to whether an individual dies prematurely without any period of disability prior to death, or whether there is some temporary disability for the individual. If the average values differ substantially for any disease, the study team is encouraged to use actual values, rather than averages for each health outcome category.

[15] See footnote 13.

BOX 3.1: FORMULAS USED TO CALCULATE THE NUMBER OF HEALTHY LIFE YEARS LOST (DISEASE BURDEN)

A = Years of Life Lost from Premature Death/1,000 Population:

$[E(A_o) \times (1-D_{od})] \times [CFR \times I]$

B1 = Years of Life Lost from Premature Death Associated with Prior Disability Before Death/1,000 Population:

$[E(A_d) \times D_{od}] \times [CFR \times I]$

B2 = Years of Life Lost from Disability Prior to Premature Death/1,000 Population

$[(A_d - A_o) \times D_{od} \times D] \times [CFR \times I]$

C = Years of Life Lost from Permanent Disability/1,000 Population:

$[E(A_o) \times D \times Q \times I]$

D = Years of Life Lost from Acute Illness/1,000 Population:

$[\{(t \times D)/365.25\}] \times [(1 - CFR - Q) \times I]$

The total number of healthy years of life or DALYs lost at regional or national level is equivalent to the number of healthy years of life or DALYs lost per 1,000 population, multiplied by the total population size (expressed in thousands).

3.1.2 Data Requirements and Sources

Examples of epidemiologic data used to estimate the burden of disease in Ghana (1979), as well as recent figures found in the Disease Control Priorities in Developing Countries (forthcoming) are reproduced in Appendixes A.1a and A.1b. Information needs for estimating the burden of disease are list below. The study team is encouraged to collect data by gender and age interval, if possible, in order to increase the comprehensiveness of the analysis.

- ✓ A comprehensive list of diseases
- ✓ Annual incidence rates of diseases
- ✓ Case fatality rates
- ✓ Estimates of the percent of population who die from the disease following a period of disability
- ✓ Estimates of the percent of the population who are permanently disabled by disease
- ✓ Estimates of the degree of disability experienced by those individuals both permanent and temporarily disabled
- ✓ Average duration of acute illness episodes and remission rates
- ✓ Age at onset and age at death
- ✓ Life expectancy at age of onset and age of death

1) Comprehensive list of diseases: Appendix A.2 contains a comprehensive list of diseases which can be used to form the backbone of the analysis of burden of disease. This list comes from the Global Burden of Disease (GBD) methodology and is divided into 131 categories derived from the 9th Revision of the International Classification of Diseases. This list covers all possible causes of death and nearly 95% of the potential causes of morbidity. The list of diseases is subdivided into Group 1: communicable, maternal, and perinatal diseases; Group 2: noncommunicable diseases; and Group 3: injuries (both unintentional and intentional). Detailed disaggregation of the burden of disease increases the ability of the cost-effectiveness study team to identify which diseases are responsible for the greatest loss of healthy life, and provides an opportunity to confirm or contradict previously held conceptions regarding disease patterns. On the other hand, such a detailed analysis may not be possible in particular countries or regions because of a lack of information. In this case, the team can rely on major disease headings, such as respiratory infections or nutritional disorders (i.e., the lettered categories in Appendix A.2) for the calculations.

2) Incidence rates (I): Incidence rates measure the number of new cases of a disease per 1,000 population within a year and reflect the probability of developing the disease in a specific time period. [16] Several methods can be used to assess incidence rates, though they vary in accuracy, reliability, and cost of data collection. Data collected from on-going disease surveillance and monitoring systems represent the best source for estimating incidence rates. Data on reported cases of disease to health

[16] Lilienfeld, A.M., and Lilienfeld, D.E., Principles of Epidemiology, Oxford University Press, New York, p. 138-41, 1980.

care institutions, such as hospitals or health centers, can be used to estimate incidence of disease, by dividing the total number of new cases for each disease category by the catchment population. However, these data are often viewed with skepticism because of a lack of uniform case definition, exclusion of cases reported to non-governmental and private health care facilities, failures or delays in transmitting data to central authorities, and differences in motivation of health care professionals to report disease. [17] In addition, reporting of cases increases during epidemic periods which may affect the reliability of estimates. The catchment population can be difficult to estimate if the hospital serves as a reference center. Hospital-based incidence rates need to be compared with alternative estimates to determine a representative rate for the population as a whole.

More accurate estimates of the incidence of disease can be obtained through community-based surveys. It is beyond the scope of this manual to describe survey methods, though tradeoffs are always made between the accuracy of the results and the cost of obtaining them. [18] It is also important to understand that the type of survey can influence the accuracy and reliability of the estimated incidence. For instance, one study in Cameroon contrasted three methods for estimating polio incidence, ranging from a house-to-house survey, a survey of school children, and a review of hospital and clinic registers. Disease incidence appeared to be highest in rural areas using the house-to-house method, and lowest using hospital records. The school lameness survey was thought by the researchers to be the most sensitive measure of incidence rates in this case. [19]

[17] Walsh, J.A., "Prioritizing for Primary Health Care: Methods for Data Collection and Analysis," in Walsh, J.A., and Warren, K.S., eds. Strategies for primary health care: Technologies appropriate for the control of disease in the developing world, Chicago: University of Chicago Press, 1986.

[18] Community-based methods are reviewed in Rothenberg, R.B., et al (1985); Dabis, F., et al (1989); and Gray, R.H. (1986).

[19] Heymann, D.L., et al (1983).

Another approach for assessing disease incidence is the cluster sampling methodology originally designed to measure immunization program coverage rates. [20] Cluster sampling is based on random selection of 30 sites (clusters) within a selected geographic area. Within each cluster, a starting point is chosen randomly, and interviewers visit households to obtain a range of health information on seven individuals within a specified age range. This results in a total sample of 210 individuals (30 x 7) from which to evaluate coverage of health programs, incidence and prevalence of disease, and other epidemiologic and health information, such as nutritional status or utilization of clinics. In addition, rapid assessments can be used to evaluate incidence rates. These surveys, however, are conducted usually in a nonrandom sample of households, selected by the interviewer on the basis of convenience and cost, rather than on representativeness. One drawback to rapid assessments is that the results may not be generalizable to the population as a whole.

More often, data from surveys reveal the prevalence of disease within a community rather than the incidence rate. However, incidence rates can be crudely approximated from the duration of disease and point prevalence. The following formula can be used to make this calculation: Incidence (per 1,000 population) = Prevalence (per 1,000 population) / Duration (days). [21]

In cases where incidence rates cannot be determined through community surveys or hospital records, the opinions of team members or other professionals may be used to provide estimates of incidence rates (see Box 3.2). Information from studies in other countries could also serve as the basis of estimating rates, though this approach is one of last resort.

3) Case fatality rates (CFR): A case-fatality rate is defined as the number of individuals dying from a specific disease after diagnosis compared to the number of individuals with the disease, and represents the risk of dying during a specific time period. Case fatality figures are not rates but proportions. [22] Analysis of death certificates can provide information on cause of death and age-specific death rates. When these data are not available, reviews of health facility records can be used to determine case fatality rates. These figures may be biased in that only the most seriously ill tend to visit a health facility, and these individuals tend to have a higher probability of dying. If facility rates are used in the cost-effectiveness analysis, comparisons with estimates from other sources or with expert opinions can be used to corroborate initial assumptions. Community surveys and epidemiological studies also can provide information on case-fatality rates for selected diseases in a specified geographic area. Finally, in the absence of survey data, expert opinions and data from other countries may be incorporated into the analysis, but only as a final recourse.

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[20] See Rothenberg, R.B., et al (1985).

[21] Lilienfeld and Lilienfeld, Principles of Epidemiology, Oxford University Press, New York, p. 35, 1980.

[22] Ibid., p. 74, 1980.

4) Proportion of individuals who are temporarily disabled prior to death (D_{od}): This figure represents the percent of individuals who die from the disease, but who suffer a period of disability before death. Information on this variable can be obtained through reviews of hospital records of patients who suffer from highly fatal diseases, such AIDS, to determine the percent of patients who outlive the initial illness episode, but who eventually succumb to the disease. Another source of information may be medical and public health textbooks which describe the course of disease. These percentages also can be estimated by experts who are familiar with the course and outcomes of illness episodes.

5) Proportion of individuals permanently disabled (Q): This category represents the percent of individuals who will become permanently disabled within a year, but who do not die from disease until much later in life, such as victims of poliomyelitis infection. This proportion may be estimated from community surveys, such as lameness surveys conducted in schools. [23] Expert opinion also can be used to generate this proportion when survey information is lacking.

6) Degree of disablement (D): For calculating the number of healthy life years lost, a qualitative assessment of the degree of disablement is required for three distinct health states: 1) the degree of disablement between the onset of illness and death; 2) degree of disablement for those who are permanently disabled; and, 3) degree of disablement during temporary, acute illness. The degree of disablement is likely to vary among the different disease states. For instance, the degree of disablement will be different for an individual with permanent disabilities, than for an individual who is temporarily disabled prior to death. In this manual, a simplifying assumption is that D is constant over different health states, although the study team is encouraged to include accurate assessments of disability if possible.

One approach to estimating the degree of disablement, is to use activity scales, such as the Instrumental Activities of Daily Living (IADL). This scale assigns a value between zero (0) and five (5) for activities considered essential for daily living, such as bathing, toileting, eating, dressing, marketing, and walking. Total dependency upon others is assigned a score of 0, and full functioning, a score of 5. The scores for each activity are summed and divided by the total possible score. For example, if an individual receives a score of 20 out of a possible 30, then the percent disablement would be 20/30 or 67%. The Ghana Health Assessment team used a different scoring method, based on expert judgements, in which 100% represented no disability, and zero (0) represented total non-function and death. [24] Alternatively, expert opinion can also be utilized to assess the percent disablement of a typical person with the disease. Section 3.2 describes the disability weights used in estimating the GBD which combined activity scales with estimates of psychological and cognitive functioning.

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[23] See La Force, M., Lichnevski, M.S., Keja, J., and Henderson, R.H., "Clinical survey techniques to estimate prevalence and annual incidence of poliomyelitis in developing countries," Bulletin of the World Health Organization, Volume 58, pp. 609-620, 1980.

[24] Ghana Health Assessment Team (1981).

7) Average duration of acute disease (t): This is the average number of days of acute illness prior to recovery. Data may be obtained from standard medical or public health textbooks which describe symptoms and the course of illness. Average duration of illnesses specific to a local community can be collected from hospital or health center records. Expert opinion or information from other countries are alternative data sources.

BOX 3.2: APPROACHES FOR SOLICITING EXPERT OPINIONS [1]

The Delphi Technique

The Delphi technique is one approach for obtaining missing data or for corroborating uncertain information needed to estimate the burden of disease for the cost-effectiveness analysis. In this method, experts are surveyed (independently and anonymously) for their estimates of epidemiologic information, as well as the rationale behind their recommendations. These experts can also rate the quality of information they are using to generate their estimates. Individual opinions are collected, summarized, and returned to each expert for a second opinion. The process is repeated until a consensus is reached or until a certain number of rounds (three, for instance) are completed. The theory behind the technique is that repetition will improve the quality of estimates and reduce individual biases. [2] If disagreement persists after several rounds of the exercise, the range of values may be used in a sensitivity analysis.

Nominal Group Technique

The Nominal Group Technique involves a silent generation by experts of epidemiologic estimates which are complied and shared with group members. Following an open group discussion, the five most important responses are ranked anonymously by each member. The results of the first vote are presented to the group, and another round of discussion and ranking ensues until a consensus is reached. One of the main advantages of the nominal group technique is that individuals are prevented from dominating the discussion and persuading the group that their estimates are best. Everyone's opinions have equal weight. On the other hand, opportunity for collaborative thinking and creativity is limited.

Focus Groups

Focus groups can be used to solicit information from experts in the absence of reported data. In this method, a focus group leader poses open-ended questions and leads a discussion of the issues to gain in-depth information on the groups' beliefs and ideas. This approach may be useful for obtaining estimates on the degree of disablement of individuals with a disease and other subjective figures. It is important to rely on a group of experts which represents the range of opinions and expertise; otherwise the results can be skewed. In addition, a trained focus group leader is necessary for this approach. [3]

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[1] For a thorough review of these methods, refer to Reinke, W.A., Health Planning for Effective Management, Oxford University Press, 1988.

[2] See Weistein and Fineberg, p. 79, 1980.

[3] Refer to Debus, M., Handbook for Excellence in Focus Group Research, Academy for Educational Development,

Washington, D.C., 1987.

8) Average age of onset of disease (A_o) and age at death (A_d): This is the average age at which illness symptoms or signs appear and the average age when death ensues. Information on these parameters are contained in public health and medical reference texts, or may be determined by epidemiologic surveys or expert opinions. In cases where death reporting is of high quality, analysis of death certificates provides information on the age at death. The average age of death may vary according to the health state under consideration. For example, the average age of death for those individuals who die immediately from disease is younger than for those who experience a period of morbidity prior to death.

9) Life expectancy at age of death $E(A_d)$ and age of onset of disease $E(A_o)$: Standardized life expectancy figures will be used for this cost-effectiveness analysis based on model life tables generated for a Western mortality profile. Because this model is derived from the largest number and broadest variety of mortality patterns, it is believed to represent the most general mortality pattern. [25] Box 3.3 provides life expectancy figures for both females and males, based on a maximum life expectancy at birth of 82.50 years for women, and 76.19 years for men. A standardized life table is selected for the cost-effectiveness study because life expectancy figures specific to each region or country reflect the health status of the population and not the maximum obtainable life expectancy under optimal conditions. Reliance on country-specific life expectancy figures in high mortality countries can result in underestimation of the total disease burden. [26] For these reasons, the standardized rates need to be used in the cost-effectiveness analysis.

[25] United Nations, Department of International Economics and Social Affairs, Manual X: Indirect Techniques for Demographic Estimation, New York, 1983.

[26] For further discussion of this point, please refer to Musgrove, P., The Burden of Death at Different Ages: Assumptions, Parameters, and Values, Human Resources Division, Technical Department, Latin America and the Caribbean Region, The World Bank, Washington, D.C., August 1991.

Much of the data required to determine the disease burden at national or regional level may be difficult to collect because of lack of routine documentation. In some instances, different sources of information may result in inconsistent estimates of rates. The task is to determine which figure(s) to include in the analysis based upon subjective estimates of data quality and the ability to verify figures with other data sources. A sensitivity analysis using alternative figures is recommended highly, and techniques are presented in Chapter 5. In cases of missing information, subjective estimates need to be made and the assumptions carefully recorded so estimates of disease burden can be re-evaluated in light of new or more complete information. The table in Appendix A.3 can be used to document all assumptions for calculating the number of healthy life years or DALYs lost per 1,000 population. Calculations of the number of healthy life years or DALYs lost can be made using the format contained in Appendix A.4. Appendix A.5 can be used to summarize and rank the number of healthy life years or DALYs lost per 1,000 population by disease category, gender, or age interval.

BOX 3.3: STANDARDIZED LIFE EXPECTANCY BY AGE AND GENDER

AGE AT DEATH OR DISABILITY (YEARS)	ADDITIONAL LIFE EXPECTANCY AT AGE x (FEMALES)	ADDITIONAL LIFE EXPECTANCY AT AGE x (MALES)
0	82.50	76.19
1	81.84	75.58
5	77.95	71.71
10	72.99	66.76
15	68.02	61.80
20	63.08	56.97
25	58.17	52.21
30	53.27	47.47
35	48.38	42.68
40	43.53	37.92
45	38.72	33.26
50	33.99	28.72
55	29.37	24.40
60	24.83	20.26
65	20.44	16.37
70	16.20	12.80
75	12.28	9.61
80	8.90	7.04
85	6.22	5.06
90	4.25	3.60
95	2.89	2.57
100	2.00	1.86

SOURCE: Family Model West, Level 26 in Ansley, J., Demeny, Paul., and Vaughan, Barbara, Regional Model Life Tables and Stable Populations, Second Edition, Academic Press, New York, 1982.

3.2 An Alternative Approach for Evaluating the Burden of Disease

A related, but more comprehensive approach for evaluating the burden of disease is based on the global burden

of disease (GBD) methodology developed by the World Bank for the World Development Report. The burden of disease is measured as the number of discounted disability adjusted life years lost (DALYs) per disease category by age and gender. This section describes the similarities and differences between the innovative GBD methods and the approach previously described in this manual. The study team is encouraged to include as many aspects of the GBD approach in the cost-effectiveness exercise, depending upon data availability and time constraints.

The GBD methodology is based on a detailed disaggregation of diseases using the 9th Revision of the International Classification of Diseases as the general framework for calculating the number of DALYs lost. The first difference is that the GBD concentrates on numbers of healthy life years lost from two health outcomes (premature mortality and disability), rather than from the four alternative health states previously described in Section 3.1.1.

Second, the GBD method disaggregates the number of DALYs by age and gender. Age intervals used in the GBD analysis include: 0-4; 5-14; 15-29; 30-44; 45-59; 60-69, and greater than 70 years of age. This particular classification of age groups is recommended, but others may be substituted based on data availability and age structure of the population. For instance, in a high mortality country, it may be important to subdivide the 0-4 age group into two parts: children less than one year and those between 1-4 years of age. Similarly, in countries with younger populations, it may be reasonable to change the upper limit to individuals over 60 rather than over 70 years. In other instances, the age interval between 15-44 years could be combined to simplify the analysis.

According to the GBD methodology, the number of DALYs lost from premature mortality was based on estimates of mortality by cause derived from vital registration data, model-based estimates, and epidemiological estimates for particular diseases. Several models were generated to translate cause-specific mortality to total mortality by age and gender, based on experience of countries with good vital registration systems. [27] However, when reported data were not available, the GBD approach relied on a computer model to generate mortality rates from other epidemiologic information, such as age and gender-specific data on the incidence of disease, case-fatality rates, or remission rates. [28]

[27] Excerpted from the World Development Report, Appendix B.2, 1993.

[28] A remission rate is the percent of cases of disease which are self-limiting and which do not result in permanent disability or death. These rates can be determined from clinical experience, medical textbook information, or expert opinion.

Based on the age and gender profile of mortality in a country, the total number of DALYs lost from premature death was estimated. The GBD adjusts this total number by weighting different age groups. The rationale for weighting by age stems from the belief that a year of healthy life is not valued equally over the life span, and that society places higher value on some ages over others. One approach to age weighting values healthy years of life according to the economic productivity of those years, so that economically productive ages (between 15 and 59) are given a higher weight than childhood and post-retirement ages. [29] In some societies, however, older individuals may be valued more for their wisdom and experience, and this would would require a different kind of weighting scheme. Readers are encouraged to review previous studies by Barnum (1987), Prost and Prescott (1984), and the manual by Over (1991) for assistance in developing a system of weights. Box 3.4 describes the weighting strategy used for calculating the GBD.

BOX 3.4
DERIVATION OF AGE WEIGHTS USED IN THE GLOBAL BURDEN OF DISEASE CALCULATIONS

Age weights utilized in the global burden of disease methodology are based on the exponential formula:

ka (exp)-Ba

where **k** is a constant (0.16243) chosen so that the total number of DALYs is the same as if the age weights were uniform; **B** is 0.04; and **a** refers to age. The figure below illustrates the value of a year of healthy life lost which shows a curve rising steeply from zero at birth to a peak at about age 25, declining gradually as age increases. While childhood years are valued less than other years on a per year basis, it is important to remember that death in childhood results in a loss of healthy life years over a period of time, so that the total value of a childhood death is the sum of the values for each year. In the absence of discounting, the greatest loss of DALYs arises from premature infant deaths.

[29] Productivity weights have been used in studies of onchocerciasis control (see Prost and Prescott, 1984); as well as used to adjust the number of healthy life years lost in Ghana (refer to Barnum, H., 1987).

The technique used for estimating the number of DALYs lost from disabilities differed from that used for premature mortality in the GBD approach. A group of experts estimated the incidence, age of onset, and duration of disability for each disease and for each age interval and gender. Diseases were assigned to one of six disability groups which were given a weight based on expert opinion. The disability weights ranged from zero, representing perfect health, to one, representing death. Therefore, the disability weight refers to the class of disability described in Box 3.5 below, and not the specific disease. [30] Although inclusion of disability weights is similar to the methodology described in Section 3.1.1, the weights utilized for the GBD also included some estimate of the psychiatric, cognitive, or degree of pain experienced by individuals as well.

BOX 3.5
DISABILITY CLASSES AND DISABILITY WEIGHTS
USED IN GLOBAL BURDEN OF DISEASE CALCULATIONS

Level	Disability Weight	Physical Activity	Cognitive, Psychiatric, or Pain
1	0.096	Limits the capacity to perform one or more domestic, occupational, educational, or recreational activities	Very mild pain, cognitive disability or Axis II diagnosis (DSM-IIR)
2	0.22	Limits ability to perform many domestic, occupational, educational, or recreational activities	Mild pain, cognitive disability or Axis II diagnosis (DSM-IIR)
3	0.40	Limits ability to perform most domestic, occupational, educational, or recreational activities; and limits ability to perform some instrumental activities of daily living	Moderate pain, cognitive disability or Axis II diagnosis (DSM-IIR)
4	0.60	Limits ability to perform most instrumental activities of daily living	Severe pain, cognitive disability or Axis II diagnosis (DSM-IIR)
5	0.81	Limits ability to perform some activities of daily living	Very severe pain, cognitive disability or Axis II diagnosis (DSM-IIR)
6	0.92	Limits ability to perform most instrumental activities of daily living	Obtunded

[30] Excerpted from the World Development Report, Appendix B.2.

To take into account the time preference of saving or losing one year of healthy life or DALY today versus in the future, the GBD methodology used a 3% discount rate to adjust the number of DALYs lost due to death and disability. The discount rate and age weights were combined to estimate the number of DALYs (discounted value) lost in a given year. The second figure in Box 3.4 represents the discounted value of one DALY lost at each particular age. In this manual, the discussion and use of discounting is presented in Chapter 4.

Finally, both the number of DALYs (discounted) resulting from premature mortality and disability were aggregated by age interval and gender to determine the total number of DALYs lost. The results of the GBD exercise are summarized in Appendix A.6 and Appendix A.7. For both males and females, premature death from communicable, maternal, and perinatal diseases accounts for the majority of DALYs lost worldwide. However, among females, disability from non-communicable diseases is greater than that resulting from premature mortality. Among the regions and countries of the world, India has the largest number of DALYs lost (292 million), followed by Sub-Saharan Africa (282 million), and China (201 million).

3.3 Issues Pertaining to Estimating the Regional or National Burden of Disease

A presentation of approaches for calculating the total number of healthy life years, or DALYs, lost due to disease would be incomplete without a discussion of some of the limitations of the use of the methods in situations where data are incomplete or of limited quality. The first approach presented in this manual in Section 3.1.1 relies on average figures for epidemiological variables, such as the age at death and onset of disease, case-fatality rates, and the degree of disablement. Use of average figures is satisfactory if age-specific data are not available. However, the average age at death and age at onset assumes that the probability of the event is equal for all age groups, which is not likely to be the case, particularly for chronic and highly infectious diseases. Diseases associated with lifestyle behaviors will not be uniformly distributed in the population. Furthermore, it is likely that mortality rates and case-fatality rates will be higher for disabled individuals than for the rest of the population, and that the degree of disablement will vary among individuals and over time. Reliance on averages is one of the weaknesses of the first approach presented, and use of age and gender specific causes of death and disability represents one of the methodological advantages of the GBD approach.

Because each disease entity is examined separately and the total number of healthy life years or DALYs lost represents the summation of the number of years across all types of diseases, both approaches described in this manual (GBD and that for calculating the number of healthy life years) cannot accomodate the non-linear relationship between risk factors and disease, as well as the potential positive and negative interactions between diseases in affecting health. So that the summation of the burden of individual diseases may not equal the total disease burden in a community. For instance, there is evidence to suggest that measles immunization not only prevents cases of measles, but also has a positive effect on diarrheal disease mortality. There appears to be synergism between tuberculosis and HIV infection. Further, the risk of

mortality and morbidity is continual over the life span, so that preventing one DALY from communicable disease in childhood may be offset by a DALY lost later in life from other illnesses. Use of standardized life expectancy tables represents an attempt to handle competing risk.

CHAPTER 4:

SELECTING HEALTH INTERVENTIONS AND ESTIMATING THE NUMBER OF DISCOUNTED HEALTHY LIFE YEARS OR DALYs GAINED

4.1 Analysis of Interventions

Because this cost-effectiveness analysis is based on gains associated with health interventions, the next step is to identify appropriate health services and to estimate their effectiveness in reducing disease burden.

4.1.1 Guidelines for Selecting Interventions

For each disease category, a range of possible interventions needs to be identified which are the most feasible to implement; the most efficacious in preventing or treating disease; and, the most acceptable to the community. The aim of the exercise is to determine "best practice" interventions, given the level of institutional, technical, and political support. Because health systems in developing countries are replete with logistical constraints, selecting health interventions based on **current** practice standards runs the risk of planning for lower quality and inaccessible health services. For instance, one may find that health centers plagued by shortages of medicines and supplies are relatively inexpensive to operate because resource use is low.

On the other hand, the analysis could aim to assess the costs and health outcomes of an **optimal** design of health services. While optimal implementation of health programs is a priority for nearly every country, these goals rarely are achieved even in the developed world. In addition, actual implementation and coverage of programs may differ greatly from policies stated in health planning documents.

This manual encourages formulation of health interventions founded on the **best possible** practice standards specific to a particular region or province. Because health planning is an on-going process, it is envisioned that the characteristics of the best possible standard of health services will approximate an optimal delivery system over time. While there are no hard and fast rules for identifying the best possible practice and delivery standards in the health sector, one approach is to examine and compare output indicators from a sample of different health facilities, such as the number of visits per month, the length of stay or number of bed-days for hospital services, coverage of the population, or the productivity of health staff. For example, World Bank experience suggests that well-functioning health centers operate on 0.6 contacts per capita per year. [31] Facilities which have output indicators above average for the sample could be considered models for establishing best practice standards. In addition, qualitative indicators, such as facility-specific mortality rates or degree of patient satisfaction may also be incorporated into the subjective assessment of best practice. Using the Delphi method or other approach, the experience of cost-effectiveness study team members supervising and managing health facilities and interventions will be helpful determining best practice standards.

[31] World Bank, Africa Technical Department, Human Resources and Poverty Division, A Framework and Indicative Cost Analysis for Better Health in Africa, Technical Working Paper Number 8, Washington, D.C., May 1993.

Best practice standards may also be set according to the minimum package of services which need to be provided to cover a particular segment of the population. For instance, district hospitals must be able to perform a reasonable range of surgeries, as well has have functioning diagnostic and laboratory facilities. Appendix A.8 contains a standardized list of services and inputs required for a prototypical health center and district hospital in an African setting. The characteristics of these services and facilities are illustrative and need to be tailored to each country or region in the analysis.

Another factor influencing the choice of health interventions is the time horizon under which programs are expected to be implemented. For example, an intervention might result in health benefits 30 years in the future, and require extensive infrastructure development which is not available or cost-*ineffective* compared to other strategies requiring fewer inputs at the present time. Planning tends to be performed with a short time horizon in mind, as it is politically expedient for national and local governments and donor organizations to see the results of health investments. However, short-term planning based on cost-effectiveness analysis may preclude implementation of programs which have lasting benefits and which save costs in the long run.

At the outset, it is necessary to determine whether preventive or curative strategies will be the subject of evaluation, as these alternative approaches require different types of inputs and have differential effectiveness in reducing disease burden. A list of potential preventive and curative interventions for selected diseases is contained in Appendix A.9. [32] For instance, acute respiratory infection in children can be reduced either through better nutrition, pneumonia or measles vaccination, indoor pollution control, or distribution of antibiotics.

As discussed previously, some health interventions give rise to multiple health benefits. For example, measles vaccine has some protective effect against lower acute respiratory infections and has been shown to alleviate the severity of diarrheal disease in children. Nutrition programs affect nutritional status, incidence of micronutrient deficiencies, and low birth weight. The benefits of individual water and sanitation programs are spread over a wide range of water-borne and parasitic diseases. Therefore, evaluating the costs of disease-specific interventions, and weighing them against one type of disease category can result in an under-valuation of that program. One potential way around the problem is to evaluate clusters of health care interventions. Examples of clusters include expanding the EPI to incorporate hepatitis B and yellow fever vaccination in appropriate country programs, as well as vitamin A and iodine supplementation in regions where deficiencies are prevalent. In addition, individual chemotherapy for treatment of worm infections could be combined with

[32] A similar classification scheme is contained in Jamison, D.T., "Disease Control Priorities in Developing Countries: An Overview," in Jamison, D.T., Mosley, W.H., Measham, A.R., and Bobadilla, J.L., eds., Disease Control Priorities in Developing Countries, Oxford University Press, New York, forthcoming.

community-wide efforts to lower overall contamination rates in the environment in order to slow the rate of reinfection.

Health interventions can be delivered in a variety of settings, from public hospitals, to private clinics and practitioners. The choice of provider, as well as the skills (education) of the user have implications for the effectiveness of programs, as well as the type of resources used in the delivery of services, which affects the cost and quality of the service. Although the cost of services will be the focus of the next chapter, it is important to consider the potential cost implications of alternative health interventions in a qualitative manner prior to embarking on a detailed cost-effectiveness analysis of every possible intervention and design option available. In addition, it is important to isolate the most efficacious services and strategies for evaluation.

The present configuration of health facilities and providers in developing countries circumscribes the type of services which can be provided in the short run, and at what quality and cost. Because the resource allocation exercise cannot be undertaken as if the health system is a *tabula rasa*, reallocation of resources within the health sector is likely to incur resistance and additional costs. For instance, if primary health services are currently provided through a system of public health posts, restructuring the health system to include these services in public hospitals or private facilities will entail additional training, redistribution of resources, dissemination of information on where to seek care, and possibly legislation to regulate the level of quality and cost to the consumer in private facilities. However, costs which are incurred in the present time to restructure the system may result in enormous gains in efficiency and improvements in health status, the value of which may far exceed the original cost.

Therefore, several factors need to be considered before in order to select a set of interventions to be evaluated using cost-effectiveness analysis. These factors include the 1) standard of best practice; 2) health care infrastructure and organization; 3) focus on prevention or treatment; 4) potential for clustering of interventions; 5) feasibility and acceptability of interventions; 6) potential cost of interventions and alternative strategies; and 7) the effectiveness of the strategy in reducing disease burden. Techniques, such as focus groups or the Delphi method, can be used to narrow the list of interventions included in the cost-effectiveness analysis, to those strategies which appear to be inexpensive and efficacious.

4.1.2 Estimating the Impact of Interventions on Disease Burden

In order to calculate the number of healthy life years or DALYs gained from health interventions, the impact of each intervention on reducing disease burden must be estimated. Since few empirical studies have evaluated the effectiveness of interventions in various settings, this aspect of the cost-effectiveness exercise is the most subjective. Effectiveness of some interventions may be known in a qualitative way (e.g., high or low effectiveness), but a limited amount of quantitative information exists on the impact of many types of interventions. For instance, health education is effective, but its impact on disease burden is not well-documented. With additional attention placed on evaluating the effectiveness of programs, these data will become available and more reliable over time.

Health interventions can affect the incidence of disease, the case-fatality rate, or the degree of disability. In addition, improved population coverage, through provider and patient compliance will be effective in reducing disease burden. Preventive health interventions, such as immunization and malaria spraying, are designed to affect the incidence of disease. Improvements in diagnosis, treatment, and management of disease will have benefits in the form of reduced case fatality rates, and may also help to lessen the degree of disability that an individual experiences. Screening programs may increased the incidence rate as new cases of the disease are diagnosed earlier (lead time bias); but this may be associated with lower case fatality rates in the long run.

However, factors beyond the health sector can influence the incidence and case fatality rates of diseases. Some of these factors are specific to the individual (such as the initial health endowment), while other factors are related to the overall socioeconomic conditions of a community, such as the level of household income and education. In addition, the effectiveness of a health intervention may be positively or negatively influenced by underlying factors, such as environmental conditions. For example, the efficacy of diarrheal control programs using oral rehydration salts may depend upon whether a child lives in an hygienic or contaminated environment. Since the relationship between risk factors and disease is nonlinear and not well-defined, the assumption that a health intervention influences health outcomes directly is optimistic.

Because of the paucity of information on program effectiveness, it is recommended that effectiveness estimates be based on judgements and opinions of health professionals, using supporting information from pilot studies. Appendix A.10 contains data on the efficacy of different interventions, although many of these figures are specific to particular regions and strategies and may not be generalizable to other contexts. Some of the figures refer to efficacy rates under ideal conditions, whereas, others take into account community effectiveness. [33] Community effectiveness represents how well an intervention prevents or treats disease within a community, which is a function of coverage of the population, compliance by both the

[33] The reader is encouraged to review the relevant chapters in Jamison, D.T., Mosley, W.H., Measham, A.R., and Bobadilla, J.L., eds, Disease Control Priorities in Developing Countries, Oxford University Press, 1993. concerning the source and methods used to calculate specific intervention effectiveness.

patient and the provider, and the ability to screen and accurately diagnose individuals (See Box 4.1). For this methodology, effectiveness of a health intervention can be derived in the following manner: [34]

1) Efficacy rate x Coverage rate = Percent impact (reduction) on incidence rates

2) Efficacy rate x Compliance rates = Percent impact (reduction) on case fatality rates or degree of disablement (D)

Compliance rates refer to how well patients adhere to treatment regimens, as well as the technical skills of health personnel. It is recommended that a range of effectiveness estimates be used in the cost-effectiveness analysis to test the sensitivity of the results to these assumptions. Appendix A.11 contains a form which can be used to document health intervention effectiveness assumptions.

4.2 Calculating the Number of Healthy Life Years or DALYs Gained

Program effectiveness measures can now be used to calculate the total number of healthy life years or DALYs gained. Only in the special case of disease eradication is the total number of healthy life years gained from a program equivalent to those lost due to disease. For this methodology, it is recommended that an estimate be made of the percent reduction in the incidence rate, case fatality rate or other relevant variables, resulting from implementation of a health intervention. For instance, assume that an immunization program can achieve a 50% coverage rate within a year, and the incidence of measles without vaccination is approximately 39/1,000. Vaccine efficacy is estimated to be 95%. A 47.5% reduction in the incidence rate can be attained through the program (95% x 50%): the new incidence rate would be 39/1,000 multiplied by (100%-47.5%) or 20.475/1,000. This figure is used to recalculate the total number of healthy life years or DALYs lost per 1,000 population **with the health intervention** using the formulas and approaches described in Chapter 3.

[34] Improvement in diagnostic accuracy of medical technologies or screening programs are likely to reduce the case fatality rate and alter the degree of disablement of individuals. The manual does not explicitly cover these aspects of the impact of health interventions on disease burden, although a similar approach can be used by the study team to include these components into the analysis.

Similarly, suppose that treatment with a course of cotrimoxizole syrup for acute lower respiratory infections (ARI) in children less than five years of age is 90% effective in reducing mortality from infection. Coverage of the rural population with village health workers trained to administer the antibiotic is expected to reach 25%. In this hypothetical case, the health intervention reduces the original case fatality rate of ARI from 70% by 22.5% (0.25 x .90) to 54%. The total number of healthy life years lost/1,000 population with the intervention is recalculated using this figure.

Additional recalculations can be made to parameters describing the degree of disability (D) or the percent of individuals who die from the disease, but who suffer from a period of disability prior to death (D_{od}). Judgements and expert opinions may form the basis of estimates of health impact for these variables. [35]

4.2.1 Examples for Calculating the Number of Healthy Life Years or DALYs Gained

Table 4.1 summarizes the number of healthy life years or DALYs lost according to each health outcome category for poliomyelitis and leprosy based on figures in Tables 3.2 and 3.3. [36] From this example, it appears that leprosy results in the greatest number of healthy life years or DALYs lost per 1,000 population (12.025) compared to poliomyelitis (8.572). In a population of 500,000, this results in 6,013 DALYs lost from leprosy versus 4,286 from polio.

[35] Other parameters which can be affected by health interventions include the percent of total cases resulting in permanent disability (Q), the duration of acute illness (t), or remission rates. However, in order to simplify the analysis, the cost-effectiveness team could focus on percent reduction in the case fatality and incidence rates rather than the other variables in the analysis.

[36] Epidemiologic information comes from the Ghana Health Assessment Team (1981).

Table 4.2 provides estimates of the effectiveness of alternative health interventions for reducing the disease burden resulting from polio alone. An oral polio vaccine (OPV) intervention is compared with an injectable polio vaccine (IPV) program. [37] Because the vaccine efficacy of IPV is higher, it has a greater effect on reducing the incidence rate than OPV (76.8% versus 64%). Under the OPV strategy, the new incidence rate would be 0.08 contrasted with 0.05 for the IPV program.

BOX 4.1: ASSESSING THE EFFECTIVENESS OF HEALTH PROGRAMS ACCORDING TO THE MEASUREMENT ITERATIVE LOOP [1]

A related method for estimating health program effectiveness was developed by Tugwell, et al (1985). In this model, the impact of health interventions on health status is expressed as a function of the effectiveness of the intervention and the level of population coverage. **Effectiveness** of a health intervention depends on the 1) efficacy of the technology used; 2) diagnostic accuracy; 3) compliance of health care providers; and, 4) compliance of patients. Efficacy is a measure of the extent to which the intervention works under ideal circumstances. Examples include vaccine efficacy rates and therapeutic efficacy. Technological efficacy of vaccines is dependent upon its potency and composition; similarly, the efficacy of drug treatments is determined by dosage level. The gold standard for determining efficacy is the randomized clinical trial. Diagnostic accuracy is the degree to which patients with a condition are correctly discriminated from those without the condition. For instance, in an ARI control program, diagnostic accuracy refers to the percent of children with lower respiratory tract infection correctly diagnosed using the WHO algorithm. [2] Provider compliance is a measure of the quality of care given, and refers to the extent to which appropriate preventive or case management protocols are followed and recommended by health care providers. Finally, patient compliance refers to whether individuals abide by the treatment protocols made by the health care provider. Compliance rates are affected by the frequency of patient contact required by the intervention, as well as the level of understanding and perceived efficacy of the treatment.

EFFECTIVENESS (%) = EFFICACY (%) x DIAGNOSTIC ACCURACY (%) x HEALTH PROVIDER COMPLIANCE (%) x PATIENT COMPLIANCE (%)

Coverage depends upon 1) accessibility of the health service, and 2) acceptability of the service by the population, and measures the degree to which an intervention is utilized by all individuals who could benefit from it. Accessibility is a measure of the ability of patients to receive care and is a function of the distribution of health services in a community, as well as the presence of economic, social, and cultural barriers to access. Acceptability of a program is related to the perceived benefits of the program by the population, which is also a function of the perceived quality of care.

COVERAGE (%) = ACCESSIBILITY (%) x ACCEPTABILITY (%)

IMPACT (%) = EFFECTIVENESS (%) x COVERAGE (%)

Estimating health impact as a function of coverage and effectiveness variables is an appealing method because it includes factors which influence the ability of health services to reach and serve the population in the most effective manner. However, there are several limitations to the methodology, particularly in its application to economic evaluation of health projects. First, the underlying theory behind calculation of the impact fraction is based on conditional probabilities which are assumed to be independent of one another. [3] Because the relationships described are multiplicative, if any of the variables are zero (0), the entire health impact reduces to zero. Further, some of these parameters are not best represented as a fraction or percent because they are more qualitative in nature. For example, acceptability of health services may be difficult to express as a percentage. Some of these factors may influence total health impact through an additive or non-linear function which is not captured in this model. Finally, the parameters which determine impact are not subject to variation independent of cost, and they influence both the costs and effectiveness of programs simultaneously. The approach developed by Tugwell, et al (1985) assumes that these factors are technological constants, when in fact there is a wide range over which these parameters can vary and still result in a cost-effective mix of services.

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[1] Tugwell, P., Bennett, K.J., Sackett, D.L., and Haynes, R.B., "The measurement iterative loop: a framework for critical appraisal of need, benefit, and costs of health interventions," Journal of Chronic Diseases, Volume 38, pp. 339-351, 1985. For an application of this approach to cost-effectiveness analysis, see Shepard, D.S., Sanoh, L., and Coffi, E., "Cost-Effectiveness of the Expanded Program on Immunization in the Ivory Coast: A Preliminary Assessment," Social Science and Medicine, Volume 27, Number 3, pp. 369-377, 1986.

[2] World Health Organization, Programme for Control of Acute Respiratory Infections, Fourth Programme Report: 1988-1989, WHO/ARI/90:7.

[3] Community effectiveness (probability of a benefit) = Pr (Coverage) x Pr(Diagnostic accuracy/coverage) x Pr(Health provider compliance/coverage and diagnostic accuracy) x Pr(Efficacy of treatment/Coverage and diagnostic accuracy and health provider compliance) x Pr(Patient compliance/coverage and diagnostic accuracy and health provider compliance and efficacy of treatment). Assuming independence of probabilities, then community effectiveness reduces to the product of efficacy, diagnostic accuracy, health provider compliance, patient

[37] This example is purely illustrative. Injectable polio vaccine is often manufactured as a combined vaccine with DPT (as DPTP). However, in this example, IPV terminology is used in order to restrict the range of benefits to polio alone, without considering additional health benefits in protecting against pertussis, tetanus, or diphtheria.

compliance, and coverage.

Table 4.3 contains revised figures of the number of healthy life years or DALYs lost under each of the polio immunization strategies. The number of healthy years of life or DALYs lost in the population of 500,000 declines significantly under the IPV vaccine program, from an original number of 6,013 to 974. Similarly, the OPV program reduces the number of healthy years or DALYs lost in the population from 4,286 to 1,588 per year. In Table 4.4a, the number of healthy life years or DALYs lost for each poliomyelitis intervention is compared to the original estimates. The number of healthy life years or DALYs gained is the difference between the original number of healthy life years or DALYs lost and the recalculated figures under each immunization strategy (see Table 4.4b). As one can see, the IPV program results in the greatest number of healthy life years or DALYs gained (3,312) for the entire population of 500,000 in this example. Whereas, the outcome of the OPV program is 2,728 DALYs gained. Similar figures can be calculated for each health intervention option for each individual disease category. Comparisons among disease categories can be facilitated by using Appendixes A.12 and A.13.

TABLE 4.1a: NUMBER OF HEALTHY LIFE YEARS or DALYs LOST (females)

Type of Health Outcome for Poliomyelitis (from Table 3.2)	Number of Healthy Years of Life Lost Per Person (1)	Number of Individuals in Each Category per 1,000 Population (2)	Number of Healthy Years of Life Lost per 1,000 Population (3)	Number of Healthy Years of Life Lost in the Population (4)
Immediate Death (A)	77.95	0.0099	0.7717	385.85
Death Following Disability (B1)	72.99		0.0803	40.15
Disability Before Death (B2)	2.5	0.0011	0.00275	1.375
Permanent Disability (C)	38.975	0.198	7.717	3,858.50
Acute Illness (D)	0.019	0.011	0.0002	0.10
Subtotal		0.22	8.572	~ 4,286

TABLE 4.1b: NUMBER OF HEALTHY LIFE YEARS or DALYs LOST (males)

Type of Health Outcome from Leprosy (from Table 3.3)	Number of Healthy Years of Life Lost Per Person (1)	Number of Individuals in Each Category per 1,000 Population (2)	Number of Healthy Years of Life Lost per 1,000 Population (3)	Number of Healthy Years of Life Lost in the Population (4)
Immediate Death (A)	56.97	0.0625	3.561	1,780.50
Death Following Disability (B1)	47.47		2.967	1,483.50
Disability Before Death (B2)	2.5	0.0625	0.156	78
Permanent Disability (C)	14.2425	0.375	5.341	2,670.50
Acute Illness (D)	0	0	0	0
Subtotal		0.5	12.025	6,013

TABLE 4.2: ESTIMATION OF EFFECTIVENESS OF POLIO IMMUNIZATION STRATEGIES MEASURED AS REDUCED INCIDENCE OF THE DISEASE

INTERVENTION	Oral Polio Vaccine	Injectable Polio Vaccine
Coverage rate (a)	80.0%	80.0%
Efficacy rate (b)	80.0%	96.0%
Incidence/1,000 population (I)	0.22	0.22
Percent Reduction in Incidence (a x b) = (c)	64.0%	76.8%
New Incidence Rate {I x (1-c)}	0.08	0.05

TABLE 4.3: NUMBER OF HEALTHY LIFE YEARS LOST UNDER ALTERNATIVE POLIO IMMUNIZATION STRATEGIES

Type of Health Outcome Under an OPV Immunization Strategy	Number of Healthy Years of Life Lost Per Person (1)	Number of Individuals in Each Category per 1,000 Population (2)	Number of Healthy Years of Life Lost per 1,000 Population (3)	Number of Healthy Years of Life Lost in the Population (4)
Immediate Death (A)	77.95	0.0036	0.28069	140.345
Death Following Disability (B1)	72.99		0.0292	14.6
Disability Before Death (B2)	2.5	0.0004	0.001	0.50
Permanent Disability (C)	38.975	0.072	2.8062	1,403.10
Acute Illness (D)	0.019	0.004	~0	0
Subtotal		0.08	3.117	~ 1,558

Type of Health Outcome Under an IPV Immunization Strategy	Number of Healthy Years of Life Lost Per Person (1)	Number of Individuals in Each Category per 1,000 Population (2)	Number of Healthy Years of Life Lost per 1,000 Population (3)	Number of Healthy Years of Life Lost in the Population (4)
Immediate Death (A)	77.95	0.00225	0.1754	87.7
Death Following Disability (B1)	72.99		0.0182	9.10
Disability Before Death (B2)	2.5	0.00025	0.0006	0.30
Permanent Disability (C)	38.975	0.045	1.754	877
Acute Illness (D)	0.019	0.0025	~ 0	0
Subtotal		0.05	1.948	~ 974

TABLE 4.4a: COMPARISON OF THE NUMBER OF HEALTHY LIFE YEARS OR DALYs LOST WITH AND WITHOUT A HEALTH INTERVENTION

HEALTHY LIFE YEARS OR DALYs LOST/1,000 FROM:			
Health Outcome	Original Values of Healthy Life Years Lost	Life Years Lost from an OPV Intervention	Life Years Lost from an IPV Intervention
A	0.7717	0.28069	0.1754
B1	0.0803	0.0292	0.0182
B2	0.00275	0.001	0.0006
C	7.717	2.8062	1.754
D	0.0002	0	0
	8.572	3.117	1.948
HEALTHY LIFE YEARS OR DALYs LOST IN THE POPULATION OF 500,000:			
Health Outcome	Original Values of Healthy Life Years Lost	Life Years Lost from an OPV Intervention	Life Years Lost from an IPV Intervention
A	385.85	140.345	87.7
B1	40.15	14.6	9.1
B2	1.375	0.50	0.3
C	3,858.50	1,403.10	877
D	0.10	0	0
	4,286	1,558.05	974.10

TABLE 4.4b: ESTIMATION OF THE NUMBER OF HEALTHY LIFE YEARS OR DALYs GAINED FROM POLIO INTERVENTIONS

HEALTHY LIFE YEARS OR DALYs GAINED/1,000 FOR:		
Health Outcome	Life Years Gained from an OPV Intervention	Life Years Gained from an IPV Intervention
A	0.491	0.5963
B1	0.0511	0.0621
B2	0.00175	0.00215
C	4.91	5.963
D	0.0002	0.0002
Total	5.455	6.624
HEALTHY LIFE YEARS OR DALYs GAINED IN THE POPULATION FROM:		
Health Outcome	Life Years Gained from an OPV Intervention	Life Years Gained from an IPV Intervention
A	245.51	298.15
B1	25.55	31.05
B2	0.875	1.075
C	2,455.40	2,981.50
D	0.10	0.10
Total	2,728	3,313

4.3 Discounting the Number of Healthy Life Years or DALYs Gained

Each case of disease prevented or successfully treated saves the loss of a healthy year of life or DALY over a period of years depending upon the age of onset and age of death of the disease. For instance, prevention of a childhood death can result in a stream of healthy life years gained over a period of nearly 80 years. Individuals have different preferences as to when the benefits of health interventions occur, otherwise, "saving 100 lives 10 years in the future would be the same as

saving 100 lives this year". [38] Benefits occurring in the present time have a greater importance than those which take place in the future. Because there is a clear social preference for receiving benefits sooner rather than later, the total number of healthy life years or DALYs gained must be adjusted to reflect the social rate of discount: the relative value of benefits occurring at different times.

Another reason for modifying the analysis is that investments in the health sector occur in the present, while benefits may not be realized until far in the future. Because the benefits of alternative programs may occur over different time horizons, it is important to place both the benefits and the costs in terms of their present value. Without discounting (choosing a social discount rate of zero), it will always be logical to postpone any health intervention because a greater number of benefits can be achieved in the future. To appreciate this argument, suppose that a health intervention can save 1,000 lives per year and costs $1,000 ($1 per life saved). The health planner is faced with two choices: to spend the $1,000 today and achieve 1,000 years of life saved, or to invest the resources in a bank and earn 30% interest, so that in the following year, 1,300 life years can be saved. If the lives saved in the second year are not discounted, the health planner would always defer the project until another year in order to save a greater number of life years. Because postponing a project indefinitely is not a viable option, discounting future benefits is necessary. [39]

[38] Prescott, N., et al, 1984, p. 1053.

[39] The author owes much of this analogy to Mead Over. For additional details, refer to Economics for Health Sector Analysis: Concepts and Cases, 1991.

4.3.1 Source of Discount Rates

Selection of the appropriate discount rate for evaluation of health interventions has significant consequences for the results of the cost-effectiveness analysis. While there is substantial debate over the most appropriate discount rate to use in evaluating health projects, there seems to be a general trend toward using a rate of 3%. [40] One could conduct a sensitivity analysis using a range of discount rates between 3% and 15% to demonstrate how the choice of a discount rate affects the ranking of health interventions. Table 4.5 illustrates the effect of the discount rate on the number of healthy life years or DALYs gained, which shows that as the discount rate rises, the magnitude of the health benefit declines.

Discount rates can be collected from several sources. Documents published by the World Bank, such as the World Development Report, as well as those published by the International Monetary Fund (International Financial Statistics) usually contain information on the real rate of interest, or social discount rate. In addition, central banks in the country have information on interest rates. Because the Ministry of Planning and Finance may be involved in project evaluation (e.g., commercial or agricultural projects), these agencies may also be a good source of information on the range of discount rates to apply to the health sector.

In the absence of data, real discount rates can be calculated as the difference between the nominal interest rate (lending rate) and the inflation rate. However, because some countries have exceedingly high inflation rates, negative discount rates can result. While the negative rate could reflect a society's preference for money in the future over the present, this is not likely to reflect the social tradeoff for health benefits. In this case, the 3% discount rate needs to be selected.

4.3.2 Method for Discounting

The number of discounted healthy life years or DALYs gained can be computed as the product of the number of healthy life years or DALYs gained per case and a present worth of annuity factor (PWAF). The number of healthy life years or DALYs gained per case is calculated as the number of healthy life years or DALYs gained/1,000 population divided by the original incidence rate of the disease. Calculations can be made as illustrated in Table 4.5 for each type of health outcome (A through D). For example, the number of healthy life years or DALYs gained/1,000 for the OPV immunization program for reduced premature mortality (A) is 0.491/1,000. Dividing this figure by the incidence rate of 0.22 cases/1,000 results in a total number of healthy life years or DALYs gained per case of 2.232.

Both the present value (PV) and the present worth of annuity factors (PWAF) are listed in Appendix A.14 for discount rates between 3% and 15% over a period of 85 years. The columns on the left-hand side of the table contain figures of the value of preventing a case one year in the future, or the present value of one case discounted at a particular rate:

[40] Murray, C.J.L., "Rational approaches to health priority setting in international health," Journal of Tropical Medicine and Hygiene, Volume 93, pp. 000-000, 1990.

Present Value of a Case in year n = { $1 / (1 + r)^n$ }, where r is the discount rate and n is year in the future in which health benefits occur. To read this table, first locate the column of the appropriate discount rate, and read down the column until reaching the appropriate year in the future is identified. The figure in this "cell" represents the present value of one case in year n. According to this table, one case prevented in year 10 at a 3% discount rate is equivalent to 0.7441 case. These figures are logical, in that a case prevented in a future year is valued as a fraction of one case prevented in the present time. Similarly, one case prevented in year 50 at a 10% discount rate is equal to 0.0085. This table shows that the farther in the future a health benefit occurs, the less this event is valued.

The right-hand columns of Appendix A.14 correspond to present worth of annuity factors, in that the figures represent the cumulative value (in present terms) of preventing a case of disease and receiving a health benefit (healthy year of life or DALY saved) over the duration of the benefit. For instance, preventing childhood mortality results in a stream of health benefits accruing over a period of nearly 80 years; while preventing death later in life results in a shorter time over which to accrue health benefits. The number of additional years of life an individual would be expected to have at the age of death or age of onset (from standardized life tables) is used to select the PWAF.

Notice that the present value in year 1 is exactly the same figure on both sides of Appendix A.14, but that in year 2, the figure reflects the sum of the present value of a case prevented (at 3%) in both the first (0.9709) and second years (0.9426) for a total value of 1.9135. To select the present worth of annuity factor, locate the 3% discount rate column and read down the column marked "YEAR" to 78 (equal to $E(A_d)$ in the polio example). The reader should find the number 30.010, which is the PWAF to use for discounting. The cost-effectiveness study team is encouraged to practice and become familiar with this table prior to initiating the cost-effectiveness analysis.

To compute the discounted number of healthy life years or DALYs saved per case, the PWAF and the original value for the number of healthy life years gained are multiplied together. For instance, from Table 4.5, the total number of healthy life years or DALYs gained per case via the OPV immunization strategy (24.79) can be multiplied by 30.0100 (the PWAF), resulting in 744 discounted healthy life years or DALYs gained. Comparing the discounted and undiscounted DALYs reveals that discounting decreases the total health benefits occurring in the future. Appendix A.15 can be used to summarize the results from discounting the number of healthy years or DALYs gained at regional or national levels.

TABLE 4.5: EFFECT OF THE DISCOUNT RATE ON THE NUMBER OF HEALTHY LIFE YEARS OR DALYs GAINED FOR POLIO IMMUNIZATION STRATEGIES

Health Outcome	Life Years or DALYs Gained	Life Years or DALYs Gained/1000	Life Years or DALYs Gained/Case	Discounting Period (Years)	Discount Rate (%)	PWAF	Discounted DALYs Gained	Discount Rate (%)	PWAF	Discounted DALYs Gained
OPV IMMUNIZATION STRATEGY										
A	245.51	0.491	2.232	78	3	30.010	66.98	15	6.6665	14.88
B1	25.55	0.0511	0.232	78	3	30.010	6.96	15	6.6665	1.547
B2	0.875	0.00175	0.0080	78	3	30.010	0.24	15	6.6665	0.0533
C	2,455.40	4.91	22.32	78	3	30.010	669.82	15	6.6665	148.80
D	0.10	0.0002	0.0009	78	3	30.010	0.027	15	6.6665	0.006
TOTAL	2,728	5.455	24.79			30.010	744		6.6665	165
IPV IMMUNIZATION STRATEGY										
A	298.15	0.5963	2.710	78	3	30.010	81.327	15	6.6665	18.066
B1	31.05	0.0621	0.282	78	3	30.010	8.463	15	6.6665	1.88
B2	1.075	0.00215	0.0098	78	3	30.010	0.294	15	6.6665	0.065
C	2,981.50	5.963	27.10	78	3	30.010	813.27	15	6.6665	180.66
D	0.10	0.0002	0.0009	78	3	30.010	0.027	15	6.6665	0.006
TOTAL	3,312	6.624	30.10			30.010	903		6.6665	201

NOTES: Figures for the life years or DALYs gained in the population and per 1,000 population are derived from Tables 4.4a and 4.4b.
Number of healthy life years gained per case = healthy life years gained/1000 divided by the incidence rate (0.22/1000).
Discounted DALYs or healthy life years gained per case = PWAF x healthy life years gained per case.

TABLE 4.6
NUMBER OF DISCOUNTED DALYs GAINED FOR A FIVE-YEAR OPV PROGRAM

OPV IMMUNIZATION	CODE	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	TOTAL
Healthy Life Years or DALYs Lost Without Intervention/1,000 (See Table 4.1)	A	8.572	8.572	8.572	8.572	8.572	42.86
Efficacy	B	80%	80%	80%	80%	80%	
Coverage	C	30%	40%	50%	60%	80%	
Reduction in Incidence Rates	D	24%	32%	40%	48%	64%	
Healthy Life Years or DALYs Lost With Intervention/1,000	E	6.515	5.829	5.1432	4.457	3.09 [41]	25.03
Number of Healthy Life Years or DALYs Gained with Intervention/1,000	F	2.057	2.743	3.429	4.115	5.482	17.826
Discount Rate		3%	3%	3%	3%	3%	
Present Worth of Annuity Factor	G	30.010	30.010	30.010	30.010	30.010	30.010
Healthy Life Years or DALYs Gained/Case	H	9.35	12.47	15.59	18.70	24.92	81.03
Discounted DALYs Gained	I	289.94	374.22	467.86	561.19	747.85	2,441
Present Value	J	0.9709	0.9426	0.9115	0.8885	0.8262	
Discounted DALYs Gained at T=0	K	281.51	352.74	426.45	498.625	617.87	2,177

NOTES AND FORMULAS:

Reduction in Incidence Rates (D) = B x C
Healthy Life Years or DALYs Lost with the Intervention (E) = A x (1 - D)
Healthy Life Years or DALYs Gained with the Intervention (F) = A - E
Heathy Life Years or DALYs Gained per Case (H) = F / Original Incidence Rate
Discounted Healthy Life Years or DALYs Gained (I) = F x G
Discounted Healthy Life Years or DALYs Gained in Pre-project Year (K) = I x J

[41] Figures in this column differ from those found in Table 4.1 due to rounding.

The foregoing discussion focuses solely on the discounted value of healthy life years or DALYs gained for a health intervention which is implemented for one year. How can health benefits be valued for an intervention which has a 5 or 10-year time horizon? Instead of discounting once based on the period over which health benefits accrue, all discounted benefits are discounted again back to a pre-intervention year (see Table 4.6). [42] In step one, multiply the number of healthy life years or DALYs gained per case by the PWAF to estimate the discounted number of DALYs (e.g., 290 in the first year of the project up to 748 in the fifth year of the project). In the second step, each of these figures is multiplied by the present value of health benefits occurring *x* years in the future (read the left-hand side of Appendix A.14). For instance, discounted healthy life years or DALYs gained in the fifth year of the project need to be multiplied by the present value of a healthy life in year 5 or 0.8262. In year 5 of the intervention, a total of 618 discounted DALYs gained are attributable to the intervention. Finally, the number of discounted DALYs for each project year can be added together to estimate the total health impact (2,177 in Table 4.6).

4.4 Issues and Limitations of Discounting

There are some methodological issues to consider regarding the process of discounting the number of healthy life years or DALYs gained in the cost-effectiveness analysis.

1) Social versus individual preferences: Discount rates may not represent accurate tradeoffs in society between the present and the future. These tradeoffs can vary between societies and among different groups within the same society. For instance, individuals economically struggling to survive are likely to have a shorter time horizon over which they value health benefits, than individuals who are wealthier. Moreover, discount rates may change for an individual over time: an older individual may appreciate choices affecting mortality more than an adolescent, for example.

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[42] The following formula can be used:

$$\sum_{t=1}^{t-1} \left\{ 1/(1+r)^{t} \right\} \left\{ H_t \sum_{n=1}^{n} \{1/(1+r\}^{n} \right\}$$

where, t= the duration of the project, r is the real discount rate, H_t= the number of healthy days of life gained per case in each year of the project, and n=the time stream of health benefits following the intervention.

2) *Adult versus childhood diseases*: Without discounting (discount rate of zero), a program which prevents child deaths will have a greater number of healthy life years or DALYs gained compared to a program which prevents or cures adult death. The years of life gained by preventing an infant death happen mostly in the future; whereas, the time horizon over which the years of life saved for an adult is shorter. As the discount rate increases, the value of healthy days occurring in the present declines, thereby increasing the importance of adult mortality over child mortality, and by valuing morbidity events more than mortality. Thus, the ranking of health interventions by the number of discounted healthy life years gained will be influenced by the choice of discount rate. [43]

A related issue is the time at which morbidity and mortality occur in the life cycle of disease. For instance, in the case of poliomyelitis, most of the mortality events occur early in an individual's life, with morbidity occurring into the future. Weighing morbidity and mortality equally will result in an undervaluation of mortality when discounting. Does a year of life lost due to 100% disability in five years have the same impact on society as a death in five years? Probably not, and this represents one of the limitations of the approach to evaluating health programs.

[43] According to Johannessen (1992), there is only one discounting method (out of four which are currently used) which is neutral with respect to different age groups as it does not discount life expectancy. As a result, cost-effectiveness analysis is less sensitive to the choice of the discount rate in this case.

CHAPTER 5:

EVALUATING THE COSTS OF HEALTH INTERVENTIONS

After the cost-effectiveness study team has identified a set of health interventions and strategies which are effective, economists, accountants, public health specialists and others can undertake a cost analysis in order to determine the most cost-effective, essential package of health care services.

5.1 Approach for Calculating the Cost of Public Health Interventions

The proposed methodology focuses on evaluating the economic cost of health interventions, which measures the resource flow or the total value of resources used to deliver health services. [44] The reader needs to understand that economic costs differ from financial costs. **Economic costs** represent the opportunity cost of using resources and inputs in one intervention rather than in their next best alternative use. [45] On the other hand, **financial costs** refer to actual expenditures or outlays made for a specific health intervention. There are instances where total economic and financial costs coincide, as in the cost of fuel. However, differences do exist between economic and financial costs and have major ramifications for any cost analysis. For example, volunteer labor requires no financial outlay from the Ministry of Health or other organization, and yet, use of volunteers in a health intervention represents an opportunity cost to society, in that these volunteers spend their time in one activity when they could be devoting the same amount of time to an alternative endeavor. Similarly, radio or television broadcast time which is donated does not necessitate expenditures for the Ministry of Health, yet "free" broadcast time precludes transmission of other information and entails a cost. Box 5.1 provides some theoretical background for evaluating the costs of health services.

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[44] The cost analysis methodology is limited to evaluating the cost of *providing* services to the population and excludes the cost to the household for seeking health care. Yet, households often directly pay for transportation and drugs. In addition, the time spent waiting in doctors' offices and away from work has an opportunity cost to society. The most cost-effective disease control strategy to provide may be the most costly to households in terms of the time required. The perceived "cost" by households may deter individuals from seeking care, thereby reducing the effectiveness of the intervention. Additional information could be collected at the household level on the amount, type, and costs of seeking care and incorporated into the analysis.

[45] More formally, economic cost is the "payment required to keep that input in its present employment, or ... the remuneration the input would receive in its best alternative employment." (Nicholson, W., Microeconomic Theory: Basic Principles and Extensions, Fourth Edition, Dryden Press, New York, 1989, p. 309.

While there is no universally utilized framework for evaluating the costs of health services, this manual divides total economic costs into recurrent and capital cost headings, as well as those for variable, semi-variable, and fixed costs. [46] The underlying objective of this framework is to gain a greater understanding of how total economic costs of health interventions change with varying levels of output and types of technology. This framework also allows the cost-effectiveness study team to approximate the marginal cost of an intervention, which will form the basis for selecting the essential package of health services. Definitions of the cost headings and categories used in this framework include:

Variable costs: Costs incurred with each patient contact, such as the cost of drugs, vaccines, and supplies.

Semi-variable costs: Costs of a health intervention which vary in a non-linear way as the number of patient contacts increases or decreases. For example, personnel costs may rise because of increases in service utilization, resulting in a greater need for supervisors, administrators, and health care providers. Vehicle operating costs may also behave like semi-variable costs.

Fixed, specific costs: Costs associated with a health intervention which do not vary with the number of patient contacts in the short run. For instance, initial training costs, and costs of equipment purchased specifically for a health intervention would be included in this category.

Fixed, general costs: Costs associated with the general health system which do not vary with the number of patient contacts in the short run. Examples of these types of costs include construction costs of health facilities, routine administrative and overhead costs of the Ministry of Health, and overhead costs of hospital services.

The cost headings above can be subdivided further into the following categories:

Personnel: Value of labor, including health professionals, administrative staff, and non-health personnel (e.g., drivers), used to provide health services;

Pharmaceuticals: Value of drugs, contraceptives, and vaccines used for the health intervention;

Supplies: Cost of supplies used for each patient contact;

Per Diem: Cost of daily stipends for health workers involved in supervision activities;

Vehicle operation and maintenance: Fuel, oil and repair costs of vehicles used for the health intervention;

Equipment operation and maintenance: Cost of maintaining equipment in operating order;

Promotion: Value of promotional materials used to increase utilization of health intervention;

Training: Cost of initial and ongoing training sessions; and,

[46] This classification scheme is adapted from Murray, C., et al, 1990. The reader is encouraged to review the glossary in order to become familiar with these terms.

Annual value of equipment, vehicles, and buildings: Value of the use of capital items for intervention activities, such as equipment, vehicles and building space.

Tables 5.1. and 5.2 disaggregate the total economic cost of immunization and control of diarrheal disease interventions into the variable, semi-variable, fixed-specific, and fixed-general cost headings described above. Costs included in each category vary according to the type of intervention, the strategy used to implement the health program, and the level of health infrastructure required. For instance, hospital-based services have a greater number of inputs in the fixed, general cost category than services provided in health centers which have more inputs in the fixed, specific category. In addition, some inputs may belong to more than one category: vehicles may be classified as fixed, specific costs or as fixed, general costs, depending upon their use in the intervention.

TABLE 5.1
ORGANIZATION OF COSTS FOR AN IMMUNIZATION PROGRAM

STRATEGY	FIXED, GENERAL	FIXED, SPECIFIC	SEMI-VARIABLE	VARIABLE
Hospital	Building Furniture Sterilizer Administration Beds	Cold Chain	Personnel	Vaccine Supplies
Health Center	Building Furniture	Cold Chain Sterilizer Administration Vehicle Promotion	Personnel Vehicle Operation	Vaccine Supplies
Mobile Team	Building	Vehicle Cold Chain	Personnel	Vaccine Supplies Vehicle operation

TABLE 5.2
ORGANIZATION OF COSTS FOR A DIARRHEAL DISEASE CONTROL PROGRAM

STRATEGY	FIXED-GENERAL	FIXED-SPECIFIC	SEMI-VARIABLE	VARIABLE
Hospital	Building Furniture IV poles Administration Beds	Rehydration Room Rehydration Chair	Personnel	Saline Solution Oral Rehydration Salts Supplies
Health Center	Building Furniture	Vehicle Promotion Rehydration Chair	Personnel Vehicle Operation	Oral Rehydration Salts Supplies
Mobile Team		Vehicle	Personnel	Oral Rehydration Salts Supplies Vehicle operation

Because most public health interventions are implemented through a system of rural primary health care centers or other non-tertiary care facilities, the focus of data collection and cost analysis will be at the health facility level. A sample of health centers which exhibit characteristics of the best possible practice (refer to Chapter 4) can form the basis for evaluating the input requirements and economic costs of alternative interventions and strategies. Facility-based costs can be multiplied by the number of facilities (by type) located in a region or country in order to derive regional or national level costs. Administrative and management costs incurred at regional and/or national level can be added into the delivery cost for each intervention. All costs need to be measured for a period of one year.

BOX 5.1: RELATIONSHIP BETWEEN PRODUCTION AND COSTS OF HEALTH SERVICES

The total cost (TC) of a health program is a function of the level of output produced (Q) and the prices of inputs (P) required to produce that output: TC = f (Q,P). A total cost function expresses a mathematical relationship for the minimum cost of producing a given level of output. Outputs of health programs are produced through combinations of capital goods and labor inputs, and can be represented by a standard production function, Q = f (K,L). Capital inputs common to health services include diagnostic equipment, vehicles, and buildings. Physicians, specialists, nurses, technicians, and auxiliaries provide the labor input necessary to deliver health care. For any given level of output (Q_i), different combinations of capital and labor can be used. For instance, nurses can be substituted for physician care in treating some patients; diagnostic equipment can replace labor inputs as well. The price of inputs (P) is often related to the quality of capital and labor: higher cost medical treatment is often perceived as being of higher quality (q). Therefore, the total cost function can be represented more formally as:

$$TC = f\,(Q\,(K,L),\ P(q))$$

Average cost (AC) or unit costs of health services can be derived from the total cost function, by dividing total cost by the level of output (Q). The marginal cost (MC) of health services is also related to output level, and is the slope of the total cost curve. Marginal cost is the change in total cost resulting from the production of one more unit of output. [1] The shape of the total cost curve for health services in developing countries is not known with certainty; however, it is assumed that total cost rises with the level of output produced by a health facility in either a linear or non-linear manner. In the linear case, average cost is proportional to output over the entire range of output (see Figure 5.1). Because average cost in the linear case also represents the cost of producing one additional unit of output, average cost is equal to marginal cost in this case.

In the case where total cost is non-linear over the range of output, average cost is presumed to look like the familiar U-shaped curve (see Figure 5.2). Between points A and B, average costs decline and production is characterized by increasing returns to scale, which means that it is economically advantageous to increase the level of output in this facility, since the average cost of producing the next unit is cheaper. The range of output between points B and C represent decreasing returns to scale. In this case, it would be wiser to split the operation into two or more facilities because it is more costly to produce additional units of output on average. At point B, given the technology and input combinations used, average cost has reached its minimum value.

An additional important relationship lies between marginal and average costs. In the declining portion of the average cost curve, marginal costs will always lie below average costs; whereas, as average costs rise, marginal costs lie above the average cost curve. The intersection of the marginal and average cost curves (at B) occurs at the lowest point on the average cost curve.

[1] Average cost is equal to total cost divided by output: f **(Q (K,L), P(q))** / **Q**; marginal cost is equivalent to the slope of the total cost curve and can be calculated thus: ∂ f **(Q (K,L), P(q))** / ∂ **Q**.

FIGURE 5.1: EXAMPLE OF CONSTANT RETURNS TO SCALE (CONSTANT MARGINAL COST)

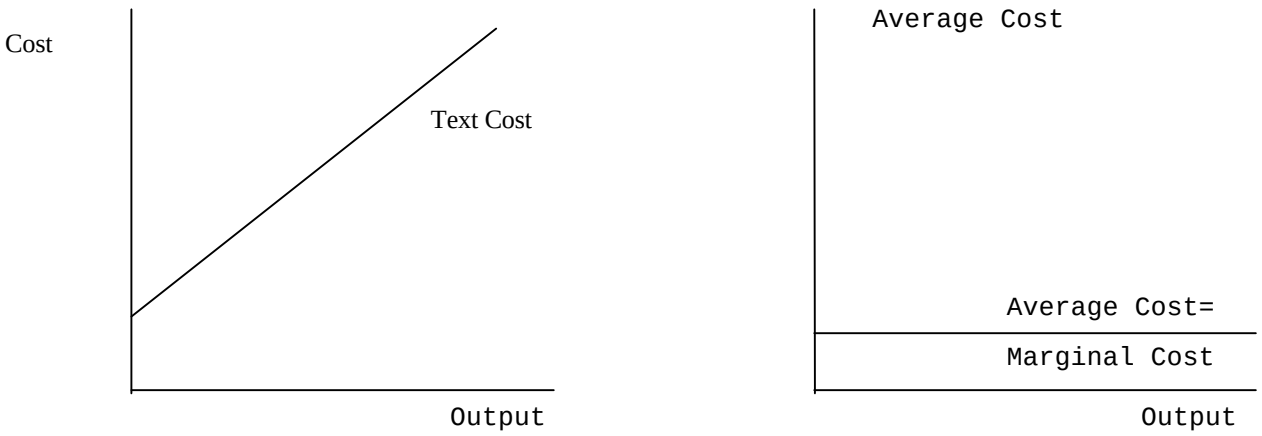
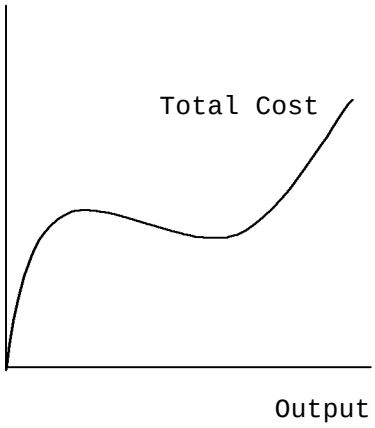
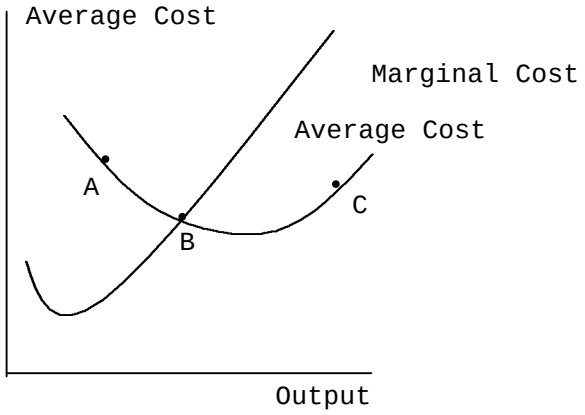


FIGURE 5.2: EXAMPLE OF A CUBIC TOTAL COST CURVE





5.2 Data Required for Cost Calculations

As described previously, the total cost of a health intervention is a function of the 1) the quantity and type of inputs used; 2) the price of those inputs; and 3) the quality of service. Because personnel and equipment are shared frequently among health services within the same facility, it is also necessary to derive rules-of-thumb for allocating a portion of input cost to specific health interventions.

5.2.1 Total Number and Amount of Health Intervention Inputs

Once the list of interventions has been identified by the cost-effectiveness study team, the type and amount of inputs required for implementing health interventions needs to be enumerated. This constitutes listing the "ingredients" of an intervention which make it operational and effective. Appendix A.16 describes possible types of inputs and resources used in the delivery of health services.

There are several approaches to determine the quantity and type of health program inputs. First, a small survey can be conducted in a sample of facilities which provide a model for best possible practice of the intervention in the region, in order to document the type of inputs and amount used. [47] The number and location of facilities surveyed will depend upon resources and time available; however, effort needs to be made to survey an appropriate sample of facilities. For instance, if the intervention will be provided in rural health centers, then inputs used in the provision of hospital services would not be a suitable foundation for the analysis.

A second approach is to base resource requirements for health interventions on other programs in neighboring regions or countries. The limitation of this method is that implementation constraints may be different in the two areas and provide misleading estimates of inputs. A final strategy utilizes expert opinion and professional practice standards to determine the type and amount of inputs needed for a health intervention. While this method may be the quickest, it is subject to error and personal bias, and needs to be used when no other option is available.

[47] Refer to Chapter 4 for additional discussion of the best practice option.

5.2.2 Prices of Inputs

Appendix A.17 provides a list of the unit prices required for the cost analysis. In a perfectly competitive market, the opportunity cost of an input is its market price. [48] Market prices for cost-effectiveness analysis can be based on the original purchase price (historical value) or the replacement price based on market surveys. These surveys are performed by collecting unit price information from a random sample of vendors, and using the average price as the market value for the cost-effectiveness analysis. While historical unit costs are known from previous experience, these prices do not represent the opportunity cost of future resources spent for the purchase of capital items. For this reason, replacement prices are preferred to historical prices in this cost analysis. In order to identify the full market price of inputs used in health interventions, the following suggestions may be helpful:

1) For health personnel (e.g., health workers and administrative staff), the value of all wages and benefits, including those earned in the private sector, the value of free or subsidized housing, transportation, and other perquisites need to be included as part of gross monthly earnings.

2) The prices of some inputs (e.g., housing and fuel) can vary considerably by region. Because the target population for some programs may be exclusively rural or urban, it may be prudent to collect prices in both areas.

3) Since the quality of inputs may be related to prices, it is important to ensure that a constant level of quality is compared across health interventions. In principle, adopting a best practice standard of care, based on model health facilities and interventions currently in operation, can assist in controlling for quality differences in the analysis.

4) The unit prices of imported inputs, such as pharmaceuticals or medical equipment needs to be adjusted to account for costs of international shipping and unloading, taxes, internal transportation to the site of use, and insurance. The export parity price (or f.o.b., freight-on-board price) reflects the market price charged for the input, as well as all costs to load a commodity on a ship or airplane, marketing and transportation costs in the country of origin, export taxes, and charges associated with exportation. Similarly, the parity price at the point of importation (c.i.f., or cost, insurance, and freight) is equal to the f.o.b. price, freight charges to the point of importation, and insurance and unloading charges. F.o.b. or C.i.f. values need to be utilized in the cost-effectiveness analysis in order to account for the sometimes hidden costs of importing a medical or health technology. Rather than collecting detailed information, the study team could estimate a general mark-up over market prices of imported goods to reflect import parity prices.

[48] See Gittinger, J.P., Economic Analysis of Agricultural Projects, Economic Development Institute, World Bank, Washington, D.C., 1982; and Ward, W.A., and Deren, B.J., with D'Silva, E.H., The Economics of Project Analysis: A Practitioner's Guide, Economic Development Institute, World Bank, Washington, D.C., 1990.

There are several problems with relying on market prices for health project evaluation. For instance, many developing countries impose trade and exchange rate barriers that reduce economic efficiency of national economies. [49] In addition, governments may subsidize the cost of producing inputs used in health interventions, such as the cost of vehicles or equipment, so that market prices do not represent their true scarcity value. Price distortions also occur in the labor market in developing countries where there is under-employment and surplus labor. In this case, wages do not reflect the value of the output of an additional unit of labor. [50] Prices in these instances suffer from border and domestic distortions. Shadow wage rates and conversion factors can be used to adjust for these problems, although these modifications will increase the complexity of the cost analysis and may not be warranted, particularly in countries where markets are competitive and economic distortions are minimal. [51] Box 5.2 provides an illustrative example of price adjustments.

BOX 5.2: EXAMPLE OF THE USE OF CONVERSION FACTORS TO TRANSLATE FINANCIAL PRICES TO ECONOMIC VALUES FOR COST-EFFECTIVENESS ANALYSIS

Conversion factors (CFs) can be used to translate financial prices found in market surveys to their economic value by adjusting for both border and domestic price distortions. Usually in developing countries, skilled labor, such as physicians and other trained health personnel are scarce, and one can assume that wage rates reflect the marginal value product of physician's services. Nevertheless, assume for this example that too many physicians are being trained and there is under-employment of physician's services. In this case, the marginal value product (MVP) is probably less than the wages being paid. To adjust for the shadow wage rate (SWR), or economic value of labor, the following example was developed. [1]

Assume that the MVP of physician's services is 150 pesos per day, but that physicians are paid 200 pesos per day. Also assume that the official exchange rate (OER) is 25 pesos per $1, and that the premium of foreign exchange (PREM) is 25%. [2] The standard conversion factor (SCF) is equal to 1/(1+PREM), or 1/1.25= 0.80. To make price adjustments, first estimate a shadow exchange rate (SER) by multiplying (1 + PREM) and OER together: SER = (1+PREM) x OER (1.25 x 25 = 31.25). Second, the standard conversion factor (SCF) is also equal to the official exchange rate divided by the shadow exchange rate: SCF = OER/SER (25/31.25 = 0.8). Third, the economic border value of physician labor is equal to the shadow wage (SWR) multiplied by the standard conversion factor (SCF): 150 pesos per day x 0.80 = 120 pesos per day. The specific conversion factor for physician labor (CF_L) can be estimated as the economic wage divided by the financial wage, or 120 pesos/200 pesos = 0.60. This fraction can be used to adjust the market prices of physician labor in the cost analysis to is economic value. [3]

[1] The shadow wage rate (SWR) is equal to the marginal value product (MVP) which can be estimated as the marginal physical product (MPP), multiplied by the price of the output. The marginal physical product (MPP) is the additional output obtained with the addition of one unit of labor.

[2] The premium of foreign exchange (PREM) represents the additional amount that buyers of traded goods (on average) are willing to pay to obtain one more unit; or that amount, on average, that traded goods are mispriced relative to non-traded commodities when the official exchange rate is used. Information on the foreign exchange premium usually is available from the central government. (From Ward, W.A., et al, 1990, p. 247).

[49] Ward, W.A., et al, p. 54, 1990.

[50] Under perfect competition, wage rates are equivalent to marginal value product, or the value of the extra output obtained by employing one additional unit of labor.

[51] Methods for shadow wage rates and conversion factors price are presented in Ward, W.A., et al, 1990, pp. 66-128; Gittinger, J.P., Chapters 3 and 7; and Squire, L. and van der Tak, H.G., 1975.

[3] This example draws heavily from Ward, W.A., et al, p. 81, 1990.

In addition to market surveys of manufacturers and suppliers, prices of inputs can be found in government inventory records and purchase orders. Donor organization records also are a good source of price information. The United Nations publishes a UNIPAC Catalogue each year which reports prices of pharmaceuticals and supplies distributed by UN organizations. Local wage rates for health and administrative personnel can be obtained from secondary sources, such as the International Labour Organization (ILO), although it is best to utilize the most current data from each country.

5.2.3 Percent Use of Resources

Since the unit of analysis is individual health interventions and not the cost of operating health facilities as a whole, the methodology must include an approach for apportioning the cost of inputs, such as equipment and supplies, which are shared among health activities performed in facilities. These costs, referred to as **joint costs**, occur when a particular input is used for more than one health activity. [52] Shared resources include personnel, vehicles, building space, supplies, and equipment. Allocation of these resource costs to specific health programs can be made on the basis of the rules-of-thumb outlined in Table 5.3.

Subjective judgements are often utilized to allocate an input's use for a specific health intervention, though these estimates need to be confirmed with other data. For instance, vehicle use among interventions can be allocated by reviewing mileage records to determine the distance travelled for specific activities. This value can be divided by the total distance travelled per vehicle to estimate a proportion of vehicle use. In cases where two information sources differ, an average figure can be used. For instance, if the percent use of vehicles based on an interview with the driver is 15%, but an evaluation of vehicle logbooks results in a 25% allocation to a specific intervention, an average allocation of 20% could be used as a base case, with 15% and 25% reflecting the upper and lower bounds for a sensitivity analysis (see Chapter 6).

[52] From a macro perspective, the problem of joint cost is one of defining the service delivery setting for cost analysis of health interventions. For instance, by relying on best practice standards for calculating costs, this methodology circumscribes the range of inputs which can be used in the delivery of services, by including some inputs and excluding others.

TABLE 5.3
RULES OF THUMB FOR ALLOCATING JOINT COSTS OF HEALTH INTERVENTIONS

TYPE OF INPUT	ALLOCATION RULES
Personnel	Percent of working time per activity determined by interviews, observation, diaries, facility records, or expert judgement
Vehicles	Percent use by activity determined by interviews, reviews of vehicle logbooks, or expert judgement
Supplies	Percent use by activity determined by interviews, observation, or expert judgement
Equipment	Percent use by activity determined by interviews, observation, or expert judgement
Building	Share of total physical area, or percent use by activity determined by observation or interviews

Since personnel costs represent up to one-half of total economic costs of health interventions (on average), it is essential to estimate the proportion of personnel time spent on individual health initiatives in the most reliable manner. [53] Information on the amount of time spent by various categories of health workers on different health activities is often difficult to obtain. One study estimates that community level health workers spend less than 25% of their total working time on priority health activities because of conflicting demands in curative care and administrative duties. [54]

The proportion of total working time spent by health personnel on different health activities can be assessed through 1) direct observation; 2) interviews; 3) activity records or diaries; or, 4) review of utilization statistics. The amount of time and resources available to the study team will determine which technique is used to derive an allocation rule. Table 5.4 illustrates the advantages and disadvantages of different methods for determining personnel time allocations. Observation of health workers (time-motion studies) may be the most reliable measure of personnel time distribution, but these studies require a significant financial and time investment. In addition, personnel may alter their work habits if they are aware of being observed for the study (Hawthorne effect).

[53] Brenzel, L., The Costs of EPI, Resources for Child Health Project, Arlington, VA, 1991.

[54] Thomason, J.A., and Kohlemainen-Aitken, Riita-Liisa, "Distribution and Performance of Rural Health Workers in Papua New Guinea," Social Science and Medicine, Volume 32, pp. 159-165, 1991.

Recall bias affects the reliability of interviews, so that questions need to be carefully crafted and field researchers trained in interview techniques. [55] Activity logbooks or diaries are useful if health workers provide accurate assessments of their daily activities. However, health workers may exaggerate their performance if they believe they are being monitored or evaluated. In order to reduce this bias, the study team is encouraged to collect information for at least a two-week period so that any initial variation in performance will be diluted. Confidentiality of these records may inspire more accurate recording of daily activities.

The number of visits for a particular health condition can be divided by the total number of visits made to the facility (on a monthly or yearly basis) in order to generate a crude estimate of the proportion of total personnel time spent on a particular activity. This approach is perhaps the quickest to conduct, although the time intensity of visits may not be related to the proportion of visits, and facility records are often incomplete. Finally, expert judgements on the share of time spent on health activities can be used, but these estimates are subject to individual experience and personal bias. In order to overcome potential biases in approaches to estimating personnel time, it is recommended that several methods be used to verify allocation rules.

TABLE 5.4
ADVANTAGES AND DISADVANTAGES OF DIFFERENT METHODS USED TO ALLOCATE PERSONNEL TIME

METHOD	ADVANTAGE	DISADVANTAGE
Observation	Most reliable	Time consuming; expensive; potential Hawthorne effect; potential sampling bias
Interviews	Obtain large amounts of information; Relatively easy to conduct	Potential recall bias
Diaries	Easy to implement	May affect behavior of health workers which invalidates responses
Review of records	Easy to conduct	Inaccurate due to incomplete records
Expert judgement	Easiest to implement	Inaccurate and open to potential bias

5.3 Formulas for Cost Calculations

[55] Please refer to manuals which describe methods for conducting field surveys for approaches to questionnaire design and interview technique.

Worksheets for calculating the total annual cost of health interventions by cost component are located in Appendix A.18 (A through K), and the formulas used to calculate costs are presented in Table 5.6 below. These tables are as comprehensive as possible, but need to be completed only according to the variety of inputs and range of resources used for each intervention under consideration. The costing framework was designed to cover the universe of total inputs for a variety of health interventions. However, identifying all inputs and focusing on details may be time-consuming and unnecessary, particularly when some cost categories account for a small fraction of total cost. In general, the analysis needs to be oriented toward evaluation of variable and semi-variable costs (e.g., pharmaceutical, personnel, and supplies costs), followed by equipment and other inputs such as training and supervision, essential for implementation.

Identification of the key components of health interventions can help reduce the time required for cost analysis. For instance, evaluation of promotional costs, both recurrent and investment, is pertinent for a health intervention which focuses on improving population acceptability of services. On the other hand, promotion costs may be irrelevant for analysis of hospital-based interventions. Similarly, for an intervention designed to increase coverage of health center services, construction of health facilities is an essential component.

In general, economic costs are calculated as the product of the quantity of inputs, the percent use for a specific health intervention, and the unit cost of the input. However, it may be simpler in some cases to rely on records of expenditures. Depending upon availability of data, annual or monthly expenditures on maintenance of vehicles, equipment, and buildings may be used to calculate the annual economic cost of these categories, rather than relying on the proposed formulas contained in Table 5.5. Similarly, one may find that it is easier to calculate the cost of promotional materials on the basis of annual or monthly expenditures, rather than estimating individual inputs and resource use for this category.

In previous studies, per diem costs for supervision have been subsumed under personnel costs, or ignored all together. The framework in this manual includes a separate category for supervision per diem in order to provide a clearer picture of resource use for essential health intervention activities. In addition, the cost of training is highlighted in this methodology because of its central importance in the quality of care and implementation of new health interventions. Per diem costs for training sessions are subsumed under total training cost, as are the cost of hiring trainers and developing training materials. Because there is some potential overlap between training, per diem, personnel costs in this framework, efforts need to be made not to double count inputs.

Throughout the cost analysis, it is important to maintain the same physical units, particularly when calculating transportation, pharmaceuticals, and promotion costs. The amount of inputs can be measured as the number of individual capsules per treatment regimen or liters of fuel. Unit prices need to correspond to the unit of measurement, such as the price for a full treatment regimen or the unit cost per liter of fuel.

Some inputs such as vehicles and equipment, have a useful life greater than one year. To estimate the annual resource cost of these items, the total value needs to be adjusted by the real discount rate and useful life. The number of years of useful life represents the amount of time before the value of repairs exceeds that of the asset and can be based on the experiences of program managers. As in discounting the number of DALYs, the useful life (in years) and discount rate (3%) are used to select the PWAF (see Appendix A.14). Table 5.5 provides figures of useful life used in other cost-effectiveness studies.

TABLE 5.5
ESTIMATES OF USEFUL LIFE

CAPITAL EQUIPMENT	USEFUL LIFE
Buildings	25 years
Vehicles	2-5 years, depending upon terrain
Refrigeration equipment	5-10 years
Medical equipment (large)	5-10 years
Medical equipment (small)	3-5 years
Audiovisual equipment	3-5 years
Computer equipment	3-10 years, depending upon use

Source: Asia/Near East Bureau Guidance for Costing Health Service Delivery Projects, 1990.

TABLE 5.6
FORMULAS FOR CALCULATING THE COST OF HEALTH INTERVENTIONS

COST CATEGORY		FORMULA FOR COST ANALYSIS
Recurrent Costs	Personnel	Number of personnel x {(Number hours/week on activity / Number of working hours/week)} x Gross monthly salary and benefits x 12
	Pharmaceuticals	**Pharmaceutical cost + Vaccine cost + Contraceptive cost:** Pharmaceutical cost: (Quantity used/person/year x Number of episodes/person/year x Population covered x Unit price Vaccine cost: {(Number of doses utilized/yr + Number of doses wasted/yr) / Number of doses per vial} x Cost/vial Contraceptive cost: (Amount used per person/yr x Persons covered x unit price of contraceptive)
	Per Diem	Frequency of supervision visits/month x 12 x Duration (days) x Per diem rate x Percent use
	Supplies	Quantity used/person/yr x Number of visits x Unit price x Percent use
	Vehicle Operation & Maintenance	**Fuel Cost + Maintenance Cost + Repair Cost:** Fuel Cost = (Number roundtrips per month x 12 x Distance per roundtrip x Cost/unit fuel) / Distance traveled per unit of fuel consumed x Percent use Maintenance Cost = Frequency of maintenance visits/year x Average cost/maintenance visit x Percent use Repair Cost = Frequency of repairs/month x 12 x Average cost of a repair x Percent use
	Equipment Operation & Maintenance	**Repair Costs + Maintenance Costs:** Repair Cost = Frequency of repairs/month x 12 x Average cost/repair x Percent use Maintenance Costs = Frequency of maintenance visits/year x Average cost/maintenance visit x Percent use
	Building Operation & Maintenance	Average expenditures per month for building maintenance X 12 months x Percent use
	Promotion	**Costs of broadcasting + Cost of reproducing printed materials:** Costs of broadcasting = Duration of broadcast (mins or secs) x Frequency of broadcasts/month x 12 x Cost/unit of time x Percent use of broadcast for health activity Cost of printed matter = Volume of materials per month x Frequency of reproduction/month x 12 x Unit cost of reproduction x Percent use of materials for health activity
	Training	**Training Costs + Trainer Costs + Training Materials Costs:** Training Costs = Number of participants per training session x Duration of training session (days) x Per diem rate x Percent use for a health activity Trainer Costs = Number of trainers per session x Gross monthly salary x {Duration (days)/ number of working days per month} x 12 x Percent use for health activity Training Materials = Volume of training materials per session x Frequency of reproduction x Unit cost of reproduction x Percent use for health activity
Capital Costs	Annual Value of Vehicles	(Number of vehicles by type x Percent use x Replacement value) / PWAF based on the useful life of vehicles
	Annual Value of Equipment	(Number of equipment by type x Percent use x Replacement value) / PWAF based on the useful life of equipment
	Annual Value of Buildings	(Number of buildings by type x Area used for the health activity x Unit construction cost per unit of area x Percent use) / PWAF based on the useful life of buildings
	Annual Value of Training	Same as recurrent training costs/ PWAF based on turnover rates
	Annual Value of Promotion	Same as recurrent promotion costs/PWAF based on the useful life of materials

5.4 Example of Cost Calculations for Polio Prevention

This section builds upon the hypothetical example of polio immunization and examines the total costs of alternative strategies using the formulas developed in this chapter. In this example, a health planner has the choice between implementing an oral polio vaccine (OPV) or an injectable polio vaccine (IPV) strategy in a population of 500,000. There are 20,000 newborns per year who are eligible to receive three doses of either OPV or IPV. [56] The exchange rate between the local currency and the U.S. dollar is twenty-five to one. The first step is to identify the variable, semi-variable, and fixed costs associated with each health intervention.

Variable costs in this case include the cost of vaccine and supplies. The economic price of one vial of oral polio vaccine is $0.50, and each vial contains 20 doses. By comparison, the unit price of a 10-dose vial of IPV is $2.00. A total of three doses of either vaccine are required for each newborn for full protection against the disease. The district health office has a target of 80% coverage for the first dose, 50% coverage for the second, and 30% coverage for the third, resulting in a total of 32,000 doses of either vaccine to be delivered in one year. Assume that the wastage rate of OPV is 25% and that of IPV is 10% due to differences in the heat stability of the vaccines. This translates into a total of 40,000 OPV doses and 35,200 IPV doses are needed. The vaccine cost is calculated as the total number of vials of vaccine required multiplied by the unit cost per vial of vaccine. The number of vials of vaccine required is equal to the total doses required divided by the number of doses per vial, rounded to the nearest whole number. For OPV, the annual vaccine cost is $1,000, while the cost for IPV is $7,040. [57]

The cost of syringes is the only other variable input for the IPV program (not needed for the OPV strategy). Assume that syringes (with needle) have an import parity price of $0.25 each, and that the total number of syringes used for the IPV program is equal to the number of doses required, or 35,200. Because syringes are used to administer other

[56] There is evidence to suggest that two doses of IPV given at intervals of two months is sufficient to protect against the disease. However, in order to simplify this example, it is assumed that full protection is reached with three doses.

[57] These figures were calculated as follows:

Vaccine requirements:

20,000 newborns x 80% coverage = 16,000 OPV1 or IPV1 doses
20,000 newborns x 50% coverage = 10,000 OPV2 or IPV2 doses
20,000 newborns x 30% coverage = 6,000 OPV3 or IPV3 doses

32,000 OPV or IPV doses

OPV wastage rate (25%) means that 32,000 x 1.25 = 40,000 doses of OPV required
IPV wastage rate (10%) means that 32,000 x 1.10 = 35,200 doses of IPV required

40,000 doses of OPV / 20 doses per vial = 2,000 vials x $0.25 per vial = $1,000
35,200 doses of IPV / 10 doses per vial = 3,520 vials x $2.00 per vial = $7,040

injections, the percent use of syringes for the IPV program must be estimated. A survey in health facilities reveals that 10% of the total syringe use is attributable to IPV injections. The total annual cost of syringes would be $880 {35,200 x $0.25 x 0.10}. These figures represent semi-variable costs.

Suppose that both immunization strategies will be delivered through a system of primary health centers by primary health care workers responsible for providing other basic health services. In this region, 100 health workers earn 400 units of local currency per month in salary and benefits. A survey reveals that workers each spend 10% of their time administering OPV and 15% of their time giving IPV, on average. The difference is due to the added time requirements of preparing and using syringes and needles for IPV injections. The annual personnel cost for the OPV program is {100 workers x 400 x 12 x 0.10} / 25 = $1,920 per year; whereas, the annual personnel cost for the IPV program is $2,880 {(100 x 400 x 12 x 0.15)/25}.

For these immunization strategies, the fixed-specific costs include the cost for refrigeration equipment used to maintain the potency of the vaccines. In this example, assume that an ice-lined refrigerator is required for either vaccine strategy at a cost of 12,000 units of local currency or $480. Because other vaccines beside polio will be stored in the refrigerator, it is necessary to estimate a percent use for the polio program. In the OPV case, three other types of vaccines (BCG, DPT, and measles) are used in the EPI, so that the percent allocation could be 1/4 or 25%. In the IPV case, two other vaccines (BCG and measles) are used in the EPI, so that the percent allocation would be 33% (1/3). Thus, the cost of the refrigerator would be $120 for the OPV strategy and $158.40 for the IPV strategy (total cost multiplied by the percent use).

Each health worker utilizes a hand-held vaccine carrier which costs 125 units of local currency ($5). Immunizations are given twice a week for a percent allocation for both strategies of 2/5 or 40%. Therefore, the cost of the vaccine carriers for OPV and IPV strategies is $5 x 40% x 100 health workers = $200. The total fixed-specific cost in the OPV case is $320 ($200 + $120), and $358.40 ($200 + $158.40) in the IPV strategy.

For these interventions, fixed-general costs include those for transportation and buildings. Since health workers travel by foot, transportation costs are omitted. The average health center is 25 square feet, and the construction cost per square foot is 350 units of local currency. The health worker uses one-quarter (25%) of the center once in each five-day working period (20%) in order to maintain records. There are two health workers per facility for a total of 50 facilities. From Table 5.6, the useful life of a building is estimated to be 25 years, and the discount rate in the study is 3%, for a present worth of annuity factor of 17.4131. The annualized value of the building for both immunization programs is {(50 x 25 x 350 x 0.2 x 0.25) / 25} / 17.4131, which is approximately $50 per year.

The total cost of these hypothetical programs is displayed in Table 5.7. The OPV program is one-third the cost of the IPV strategy ($3,290 versus $11, 208) per year. Personnel costs (semi-variable) account for the greatest proportion of

total cost for the OPV program (58%); whereas, variable costs of vaccines and syringes are the largest share of the IPV program (71%). The distribution of costs by cost category is known as a cost profile and needs to be estimated for the interventions in the analysis in order to identify areas where costs may be reduced. Appendix A.19 can be used to summarize the results of the cost analysis for each intervention under consideration. In order to conserve space, the tables in the Appendix combine fixed-specific and fixed-general costs under both the recurrent and capital cost headings. In the cost analysis, it is recommended that these headings be separated, if fixed-general costs are incorporated into the analysis.

TABLE 5.7
COSTS OF ALTERNATIVE HEALTH INTERVENTIONS FOR POLIOMYELITIS
(Rounded to nearest whole number)

COST COMPONENT	OPV STRATEGY		IPV STRATEGY	
	AMOUNT $	%	AMOUNT $	%
VARIABLE COSTS				
Vaccine	1,000	30	7,040	71
Supplies	0		880	
SEMI-VARIABLE COSTS				
Personnel	1,920	58	2,880	26
FIXED, SPECIFIC COSTS				
Equipment	320	10	358.40	3
FIXED, GENERAL COSTS				
Buildings	50	2	50	<1
TOTAL COST	3,290	100	11,208	100

5.5 An Alternative Method for Calculating Public Health Intervention Costs

Appendix A.20 contains a sample cost analysis for a typical health center in an African setting, which provides antenatal, well-baby, family planning, curative care, and chronic care services. The approach relies on a specification of the number and type of health services to be provided, as well as the demographic and epidemiological profile of the community. In addition, inputs required to provide these services are based on assumptions of acceptable practice standards.

While the emphasis of this approach is on the economic cost of the entire health center, the cost per public health initiative can be ascertained by either allocating total costs on the basis of the proportion of expected visits by diagnosis, or from opinions and assumptions about the time spent by health personnel for individual interventions. The simplicity of this approach may be offset by a lesser degree of accuracy in estimating specific intervention costs. The type of approach used by the cost-effectiveness study team will depend upon the resources, available time, and skills of team members.

5.6 Estimating the Cost of Hospital Care

In order to evaluate the cost-effectiveness of the essential package of clinical services, it is necessary to undertake a cost analysis of hospitals. District, regional, national, or specialty hospitals provide a wide range of services and are organized primarily by functional departments (e.g., pharmacy, maternity, housekeeping, and surgery). Records of expenditures or budgets for individual departments are usually maintained by the hospital, the Ministry of Health, or Social Security Administration, though these do not conform to the economic costs of individual clinical services. While hospital expenditure analysis is warranted when a more thorough evaluation of inputs and costs is not possible due to time constraints or lack of quality information, analysis of hospital expenditures and budgets may not capture fully the value of all resources used in the delivery of services.

There are several approaches which can be used to evaluate costs of specific clinical services, such as delivery, appendectomy, emergency treatment, or cancer therapy. First, the study team can review hospital records of expenditures (or budgets, if expenditure data are not available) by department. Expenditures for individual departments can be allocated to specific clinical interventions on the basis of an allocation rule: the ratio of hospitalizations for a specific condition divided by total hospitalizations for that department within the same one-year time period. For outpatient services, the ratio would be equal to the number of visits by diagnosis divided by total visits per year. These allocation rules assume a linear relationship between resource use and the volume of services provided. If it is thought that resource intensity is not proportional to the number of services delivered, the allocation rules can be modified for specific treatments. For instance, a procedure requiring specialists may be more resource intensive because of labor costs, than a procedure or treatment which can be conducted by an auxiliary or nursing staff.

Once departmental costs are apportioned to each type of clinical service in the study, overhead expenditures need to be allocated to each service using the same type of allocation rule. Overhead expenditures include housekeeping, pharmacy, hospital management, and catering services. [58] The final result will be a cost per bed-day for each type of inpatient service, as well as a cost per outpatient visit. The cost per bed-day can be multiplied by the average length of stay for each diagnosis to determine the total cost of treating or providing a specific hospital service per patient. The annual number of hospitalizations estimated for the population can be multiplied by this figure to calculate the total annual cost of a specific hospital-based intervention:

Total Cost of Clinical Interventions = Cost/Bed-Day (per diagnosis) x Average length of stay (per diagnosis)

[58] See Barnum, H., and Kutzin, J., Public Hospitals in Developing Countries: Resource Use, Cost, and Financing, Johns Hopkins University Press, Baltimore, MD, 1993 for a thorough review. See also Mills, A.J., "The Cost of the District Hospital: A Case Study from Malawi," Policy, Research and External Affairs Working Paper, Population, Health and Nutrition Division, Population and Human Resources Department, World Bank, Washington, D.C., 1991. Barnum, H. Hospital Expenditure in Indonesia, PHN Technical Note, The World Bank, Washington, D.C., 1987.

x Number of hospitalizations per year per diagnosis

Similarly, the cost of outpatient services at regional or national level can be calculated using the following formula:

Total Cost of Outpatient Service = Cost/visit (per diagnosis) x Number of visits per year (per diagnosis)

Alternatively, the cost of hospital services can be estimated through an analysis of types of inputs, similar to the methods described in Sections 5.2 through 5.3. In this approach, resources used to treat or diagnose selected clinical services (e.g., heart disease or leg injury) are identified, prices assigned, and the percent use of that input for the condition estimated. Interviews with health professionals, observation of health care practices, or a combination of these methods can be used to enumerate inputs and percent allocations. Collecting information from a sample of hospitals which represents a typical case mix and the best possible quality of care is recommended. To control for differences in quality, hospitals included in the sample should have a similar length of stay (LOS) per condition. [59] Unless the health intervention under consideration requires treatment, surgery, or the diagnostic services of specialty hospitals, these facilities may be excluded from the analysis because of their unique costs and resource requirements. Categories of inputs used to calculate the cost of a hospital stay include:

[59] For additional discussion of these issues, please refer to Barnum, H., and Kutzin, J., Public Hospitals in Developing Countries: Resource Use, Costs and Financing, Johns Hopkins University Press, Baltimore, 1993.

Personnel: Time spent by specialists, general practitioners, X-ray technicians, etc.;

Pharmaceuticals: Drugs, vaccines, IV fluids, and other pharmaceuticals used;

Supplies: Bandages, disinfectants, laboratory supplies, needles, etc. used;

Vehicle, Equipment, & Building Maintenance and Operation: Resources used to maintain and operate diagnostic, medical and surgical equipment, vehicles, and physical plant;

Annual Value of Equipment: X-ray machines, beds, surgical equipment, life-support equipment, operating tables, examination equipment, etc.;

Annual Value of Vehicles: Resources used for transporting patients to and from the hospital, particularly for emergency cases; and,

Annual Value of Buildings: Amount of space used to deliver in-patient care and outpatient services.

Cost categories such as per diem and promotion are omitted from hospital cost analysis since these activities are not part of the usual delivery of clinical services. Unit costs of hospital inputs can be obtained from hospital administration records or the finance office. The pharmacy is a good source of information on the unit price of pharmaceuticals. Finally, the Ministry of Health or Social Security Administration may maintain an inventory of supplies purchased and distributed to hospitals.

The third approach for estimating the annual operating cost of hospitals is based on pre-established practice standards, as well as the epidemiologic and demographic profile of a community, region, or country. [60] Appendix A.21 contains estimates and parameters used to calculate the annual cost of a district hospital which provides both inpatient and outpatient services, referrals, and laboratory services in an African setting. The advantage of this approach is that is it relatively simple and economic costs, rather than expenditures form the basis of the analysis. However, the problem of allocating costs to different clinical services remains because the emphasis of this method is on calculating total operating costs of hospitals. One strategy may be to disaggregate hospital costs by type of clinical service according to the allocation rules based on volume of service described previously.

[60] This methodology is derived from the Africa Technical Department, Human Resources and Poverty Division, A Framework and Indicative Cost Analysis for Better Health in Africa, The World Bank, Washington, D.C., May 1993.

Finally, in order to reduce the time required for hospital cost analysis, efforts can be made to estimate the total value of all resources used for one type of service (e.g., abdominal surgery), and to use this as a **base case** for calculating the cost of other similar types of clinical services. For example, if the amount of time spent in cardiac surgery is twice that for abdominal surgery, the total base cost could be multiplied by 2 (two) to estimate the cost of cardiac surgery.

It is recommended that hospital-based intervention costs be calculated using the second methodology described in this section, which involves enumeration of inputs and assignment of market prices and allocation rules. The study team needs to carefully document which approach for costing clinical services is used in the analysis.

5.7 Projecting the Future Costs of Health Interventions

Some of the interventions included in the analysis will require several years to implement. This section examines how the cost-effectiveness study team can predict and evaluate future levels of inputs, changes in input prices, and differences in allocation of joint inputs over time for multi-year health interventions.

5.7.1 Projecting Inputs for Health Interventions

Estimates of current requirements for resources must be adjusted to reflect expansion of coverage and phasing of certain inputs. Additional health personnel, equipment, vehicles, or facilities may be required to respond to increasing population size or differences in the epidemiologic profile. There are three approaches to projecting the inputs of health programs into the future. The first requires an analysis of inputs necessary for achieving target coverage levels, based on estimates of resource intensity (i.e., number of beds required or number of nursing to medical personnel). Another approach is to base future input levels on experiences of other programs within the same region. Finally, a simple "mark-up" approach above current levels of inputs may be used, although technical innovation and quality changes are not accounted for explicitly in this method. Appendix A.22 is designed to facilitate estimation of additional input requirements for a five-year period, though the time frame may be extended for longer range planning.

5.7.2 Projecting Unit Prices [61]

Unit prices will change over time due to the effects of inflation and price fluctuations. Future market prices can be predicted from an average of historical prices collected over a period of several years. The longer the time horizon, the more accurate this figure will be because large fluctuations in prices will be smoothed out. In addition, inflation must be controlled in the analysis. [62]

The consumer price index (CPI) is the value of a market basket of goods from one year to the next. These data can be collected on a yearly basis from any volume of International Financial Statistics published by the International Monetary Fund, line 64. For locally manufactured products, the domestic CPI figures are appropriate to use; for imported goods, CPI figures from the United States can be used. The relative consumer price is calculated by dividing the price index value in each year by the value for the base year (1988, in this example). Notice that in Table 5.8, the relative price for 1988 is standardized at a base price of 1.0, and prices in 1992 are generally 1.375 times those of 1988 in this example. The third column in the table contains estimates of the unit cost per gallon of fuel (market price) in a hypothetical country. In the last column, **current prices** are converted into 1988 terms (**constant price**) by dividing the figures in column 3 by those in column 2, or the actual market price divided by the relative consumer price. The next step is to determine the average annual price increase over this period. Subtract the current price in 1988 from that in 1992 (212.6 - 154.7 = 57.9), and divide this figure by the 1992 price to calculate the overall price increase during this period (approximately 30%). The average annual price increase (percent) is used to project unit prices of health inputs. The cost in year *n* is equal to the base cost in year 0 x (1 + percent increase)^n. To project the cost of a gallon of fuel in 1995, multiply the constant price in 1992 by the inflation factor: 8.73 x $(1.3)^3$ = 19.

[61] Refer to Ward and Deren, 1991; Gittinger, 1982; and Over, 1991 for further details concerning price projections.

[62] This example was based on information found in Gonzales, M.C., and Shepard, D.S., 1982.

The study team also can adjust for future foreign exchange fluctuations when predicting the unit prices of inputs. For example, if inflation is rising by 10% per year, but the value of local currency is expected to decline relative to U.S. currency by 6% per year, then the original price must be multiplied by $1 + (\text{inflation} - \text{value of local currency})^{n}$. In this case, the base price would be multiplied by 1.04 to reflect changes in the price of inputs in the next time period expressed as U.S. dollars. This type of calculation is referred to as adjustment for price contingencies. [63] Appendix A.23 may be used to record future unit costs of inputs.

TABLE 5.8
EXAMPLE OF INFLATION ADJUSTMENT TO UNIT PRICES

YEAR	PRICE INDEX (1)	RELATIVE CONSUMER PRICE (2)	UNIT COST OF FUEL (3)	1988 CONSTANT PRICES (4)
1988	154.7	1.000	3.50	3.50
1989	167.9	1.085	4.00	3.69
1990	177.5	1.147	7.00	6.10
1991	193.3	1.250	8.00	6.40
1992	212.6	1.375	12.00	8.73

5.7.3 Allocation of Joint Inputs Over Time

The percent allocation of joint costs will change over time, depending upon the range of activities provided in health facilities. Unfortunately, there is a paucity of information on the use of inputs over time. The best approach is to focus on key health intervention elements which are shared among health activities, such as equipment and vehicle use. Percent use for multi-year interventions can be estimated using Appendixes A.24 and A.25.

This chapter previously described techniques for determining the proportion of time spent on activities by health workers. The percent of time required in the future for health activities must be linked to original estimates, projected coverage levels, type of strategy employed, and level of technical expertise. If the original estimate included some degree of slack, then the share of total time spent on a particular health activity will not necessarily increase in the short run. On the other hand, if health workers have little free time, it may be necessary to hire additional workers, rather than overburden

[63] See the ANE Bureau Guidance for Costing of Health Service Delivery Projects, Resources for Child Health Project, Arlington, VA, 1990.

current staff with additional health care priorities.

The difficulty arises when the proportion of total time spent by health workers under current staffing patterns exceeds 100% for multi-year health interventions under consideration. Appendix A.24 can be used to determine if the projected time requirements of health personnel will be in excess of existing staffing levels. The total amount of time spent on different health activities is added together and compared with the number of full-time staff equivalents. The number of staff needed is the difference between the total available staff and full-time equivalent staff. If time estimates are greater than availability of staff, then either the amount of time on activities needs to be reduced; or the total number of staff in a particular category needs to be increased. Any changes in the quantities of personnel (or other inputs) need to be reflected in Appendix A.22. Another option is to substitute different types of personnel. For instance, activities assigned to nursing staff might be performed by assistant nurses or other staff. A similar process can be used to predict growing demands on use of vehicles and equipment.

5.7.4 Analysis of the Future Costs of Health Interventions

The study team can use the same formulas outlined in Section 5.3 for calculating the cost of multi-year health interventions. These costs can be summarized by using the table in Appendix A.26. The total cost for each year of the project needs to be discounted back to the pre-project year. This can be accomplished by using the present value which incorporates a 3% discount rate and the number of years in the future the project occurs. For instance, the total cost in Year 1 of the project needs to be discounted back to the pre-project year by multiplying the total cost by 0.9709 or the present value for a 3% discount rate, one year in the future. The process is repeated for each year, using the appropriate present value. The total multi-year intervention project cost is the sum of all of the discounted costs for each year.

5.8 Determining the Cost and Effectiveness of Clusters of Health Interventions

Analysis of individual interventions does not adequately address the option of integrating health services into clusters of related services, which have been thought to be more cost-effective than implementing a wide range of single, vertical health programs. Because many resources are shared in the delivery of specific health interventions, and because some interventions have indirect benefits for other health conditions, it is also somewhat arbitrary to distinguish and compare the cost-effectiveness individual programs. Integration of health programs is thought to result in **economies of scope**: fewer resources are required to implement integrated programs than individual interventions because of shared inputs.

Table 5.9 presents one way of organizing the range of health interventions into larger disease control programs

which depend on similar modalities of service delivery and have multiple health benefits. [64] Primary Health Care (PHC) encompasses five out of six of these broad categories. A regional immunization program for adults and children which provides ten vaccines listed in Table 5.9 would have a positive impact on vaccine-preventable diseases, as well as other health problems, such as acute respiratory infection, diarrheal disease, maternal health, and cancer (hepatic). Providing a wider range of immunization services through the EPI would help reduce the incremental cost of each intervention. In addition, if a local government decides to focus efforts on nutrition and breastfeeding strategies, the table suggests that twelve different disease categories may be directly or indirectly affected. A program to ensure universal access to potable water and sanitation facilities can impact a range of diseases, such as parasitic diseases and viral infections. Similarly, hospital-based services could be expanded to include preventive services typically reserved for rural and peri-urban health centers.

The cost-effectiveness study team needs to determine criteria for integrating services, such as feasibility, type of health personnel involved, or locality. The cost-effectiveness of these options can be compared with the results from the individual disease control interventions to see whether integrated services are more or less cost-effective than the sum of individual disease control efforts.

5.8.1 Estimating the Effectiveness of Clusters of Health Interventions

While many health professionals believe integration of health services will result in substantial savings in the health sector and are more cost-effective than single interventions, there is little research to support this claim. Changing the service mix also has implications for the effectiveness of services. Little information exists on the overall impact of integrated services on health status. Effectiveness of the entire package of services may be greater than any single component because of a synergy of interaction. On the other hand, implementing the entire package may divert resources such as personnel time away from some services, rendering them less effective. The net effect will be difficult to predict, and is an important research question for resource allocation and health planning.

One method for estimating program effectiveness is to use a range of effectiveness measures for individual components. For example, water and sanitation services are 30% effective in reducing the incidence of diarrheal disease, and nearly 70% effective in reducing the disease burden of selected helminthic infections. [65] In addition, the effectiveness

[64] Organization is based on a review of preventive and case management strategies discussed in Jamison, D.T., Mosley, W.H., Measham, A.R., and Bobadilla, J.L., eds., forthcoming.

[65] See Appendix A.10.

of a key component of the health package could serve as a representative measure for the impact of a cluster of health services. However, the estimated health impact of individual interventions may be over-stated: the same deaths may be prevented with a diarrheal disease control program or with a vaccination program. Combining these two activities would not necessarily improve health impact since the target population is the same for both.

TABLE 5.9
COMBINATION OF INDIVIDUAL DISEASE CONTROL PROGRAMS

INTEGRATED PROGRAMS	TARGET POPULATION	DISEASE GROUPS	ADDITIONAL BENEFITS FOR OTHER DISEASE GROUPS
Immunization	Infants Women Children	Tetanus BCG Poliomyelitis Diphtheria Pertussis Influenzae Pneumonia Measles Rotavirus Cholera Hepatitis B	Tuberculosis and Leprosy Acute Lower Respiratory Infection ARI ARI ARI, Diarrheal Disease Diarrheal Disease Diarrheal Disease Cancer, Maternal Mortality
Nutrition and Breastfeeding	All	ARI Diarrheal Disease Micronutrient Disorders Tuberculosis Cancer Cardiovascular Disease Leprosy Fertility and Perinatal Mortality Oral Health Cataract Onchocerciasis and Helminth Infections	Maternal Health
Water and Sanitation	All	Onchocerciasis and Helminth Infections Poliomyelitis Diarrheal Disease Schistosomiasis Tetanus Oral Health Leprosy Malaria	Cancers
Family Planning	Adults	HIV Infection Sexually Transmitted Diseases Perinatal and Maternal Mortality Fertility Reduction	Opportunistic Infections Tuberculosis
Vector Control	All	Malaria Onchocerciasis and Helminth Infections	
Substance Abuse/ Smoking Cessation	Adults Adolescents	Injury Oral Health Cardiovascular Disease Cancer Chronic Obstructive Pulmonary Disease Maternal and Perinatal Mortality	Leprosy

5.8.2 Calculating the Costs of Clusters of Health Interventions

It will be important in the future to conduct studies which examine the cost and cost-effectiveness of combining services. Adding components onto an existing health service is one option for combining services. Examples include distributing vitamin A with childhood immunizations; training traditional birth attendants to work with maternal and child health care workers; and adding an AIDS education component into family planning services. Combining interventions will result in additional use of labor, supplies, equipment, and drugs. Estimating the cost of combined programs involves identifying new inputs, evaluating prices for those inputs, and an assessing the effect of the new service on previous patterns of personnel time and other shared inputs. The methods presented for the cost analysis earlier in this chapter can be adapted for this type of evaluation. Appendix A.27 contains an example using an African health center in which rehabilitation of severely malnourished children is provided in addition to existing services.

Another approach is to maximize the benefits of the health infrastructure and to implement as many activities in a hospital or health center as possible. This option may require additional hiring and training of health staff, purchases of equipment and supplies, or complete development of new activities, such as emergency care. The method outlined previously on identification of required inputs and estimation of unit costs and percent use can be followed.

Table 5.10 provides a simple, hypothetical example of evaluating the costs of including an AIDS education component into a family planning program implemented in a health center. This table suggests that a combined AIDS education and family planning program ($11,940) costs less than the sum of the two individual programs ($10,000 + $2,960). Health worker time allocated to family planning was assumed to increase from 25% to 30% in the combined program, although the AIDS education program alone occupied 20% of time in this example. These hypothetical calculations suggest that there may be ample "slack" time available, or that activities are similar enough to preclude substantial additional time commitments.

While not explicitly incorporated into the cost analysis, it may be useful to disaggregate total economic costs of health interventions according to the different implementing and financing agencies to determine the distribution of economic contributions. For instance, when health interventions are funded by donor organizations, examining the resources which the government uses to deliver these health services is important, to assess whether the public sector could absorb a greater share of the economic cost of the program.

TABLE 5.10
EFFECT OF COMBINING AN AIDS EDUCATION PROGRAM WITH FAMILY PLANNING

COST CATEGORY	FAMILY PLANNING	AIDS EDUCATION (incremental cost)	COMBINED PROGRAM
Variable (Marginal):			
Contraceptives	$ 1,300	$500	$ 1,500
Semi-Variable:			
Personnel [66]	$ 1,200	$ 960	$ 1,440
Fuel	$ 500	nil	$ 500
Fixed, specific:			
Vehicles	$ 1,000	nil	$ 1,000
Media	$ 5,000	$ 1,500	$ 6,500
Fixed, general:			
Health Center	$ 1,000	nil	$ 1,000
TOTAL COST	$ 10,000	$ 2,960	11,940

[66] Personnel costs were calculated assuming 100 health workers, each spending 25% of total working time on family planning; 20% of time on AIDS education; and 30% of time combined. The monthly salary was 100 local currency units, and the exchange rate was 25 local currency units per dollar. Personnel costs were rounded in this example, and the other figures are illustrative.

CHAPTER 6:

EVALUATING THE COST-EFFECTIVENESS OF HEALTH INTERVENTIONS

6.1 Evaluating the Cost-effectiveness of Health Interventions

The cost-effectiveness of health interventions can be assessed in two ways. First, the total cost can be divided by the number of discounted healthy life years or DALYs gained to estimate the average cost per DALY. Interventions with the lowest average cost are presumed to be the most cost-effective strategies. However, comparisons among alternative interventions operating at different points on their average cost curves may lead to erroneous conclusions about the merits of one program over another at a given level of scale.

An approach for estimating average costs of health interventions is to estimate the total cost of the same program in similar facilities operating at different levels of scale. In this way, an average cost curve for one specific intervention could be generated (albeit roughly). The most efficient providers of services, and the one in which future interventions can be based in terms of level of inputs, will exhibit the lowest average cost per unit of output. From field studies, most health facilities operate on the increasing returns portion of their average cost curve, implying that the capacity to provide efficient services has not been exhausted, and expanding output would be more efficient.

Part of the problem with comparing the average cost per healthy life gained is that each intervention results in a varying amount of total health benefit, so that one is comparing the costs of achieving different health outcomes, which defeats the purpose of cost-effectiveness analysis. In order to overcome this situation, decisions to invest in one particular health intervention or another need to be based on the cost of one additional healthy life year or DALY gained, or the marginal cost per DALY. [67] The slope of the total cost curve is the marginal cost of that intervention. Yet, in most cases, the total cost of an intervention will be measured for only a given level of output (point estimate), so that the total cost curve is not known. Box 6.1 provides an example of how a total cost curve was derived for a sample of health facilities in Indonesia. For this methodology, variable costs calculated using the approaches described in Chapter 5 will approximate marginal costs. This is because variable costs change with each additional patient contact, which is essentially the definition of marginal costs. Comparisons at the margin provide a better indication of the value of each additional life or DALY saved through alternative health strategies.

[67] Refer to Mooney, G., and Creese, A., "Priority Setting for Health Service Efficiency: The Role of Measurement of Burden of Illness," in Jamison, D.T., Mosley, W.H., Measham, A.R., and Bobadilla, J.L., eds., Disease Control Priorities in Developing Countries, Oxford University Press, New York, forthcoming.

BOX 6.1: CASE STUDY OF HEALTH FACILITIES IN INDONESIA [1]

In two rural subdistricts in Indonesia, a small sample of public facilities was used to evaluate the cost of providing family planning, curative care, and maternal and child health care. A simplified cost function was developed to estimate fixed and variable costs per contact, which consisted of the cost of drugs and supplies per contact. The average fixed and average variable costs were calculated for the sample of facilities. These averages were then used to extrapolate the total cost curve over a wide range of output levels. The study found increasing returns to scale for both health centers and subcenters for both MCH and curative care. The figures below illustrate the study findings.

[1] Berman, P., "Cost efficiency in primary health care: studies of health facilities in Indonesia," Health Policy and Planning, volume 4, Number 4, pp. 316-322, 1989.

Appendix A.30 can be used to calculate and compare the cost-effectiveness of health interventions, measured as both average and marginal cost per discounted healthy life year or DALY gained. Part of the appendix is reproduced below in Table 6.1, in which the cost-effectiveness of the two polio vaccine strategies is derived. The hypothetical family planning and AIDS education interventions are included for comparison as well. This table suggests that the OPV immunization strategy is more cost-effective than the IPV strategy, which is the least cost-effective of all of the interventions in terms of marginal cost per DALY. This example does not provide as wide a range of cost-effectiveness estimates as found in the study of the Global Burden of Disease. [68] Appendix A.33 shows the range of public health and clinical services which can be provided for a value up to the GNP per capita in low- and middle- income countries. Box 6.2 below reviews some of the factors which influence the variability of cost-effectiveness ratios.

[68] World Development Report, World Bank, 1993.

TABLE 6.1
ILLUSTRATION OF COST-EFFECTIVENESS ANALYSIS

PROGRAM	Number DALY Gained	Total Cost	Marginal Cost	Average Cost/ DALY	Marginal Cost/ DALY
OPV Immunization Program	744	$3,290	$1,000	$4.42	$1.34
IPV Immunization Program	903	$11,208	$7,920	$12.41	$8.77
Family Planning Program	200	$10,000	$1,300	$50	$6.50
AIDS Education Program	100	$2,960	$500	$29.60	$5.00

Once cost-effectiveness ratios are calculated for each intervention, they can be ranked from the most, to the least cost-effective (largest ratios), using the format provided in Appendix A.31. Since health care priorities may not be based on economic criteria alone, this appendix allows for a qualitative evaluation (e.g., high, medium, and low) of the acceptability of the intervention to the population; the affordability of services; and the feasibility of implementation. After ranking health interventions according to the marginal cost/DALY gained, they can be grouped into sets of services according to a range of cost-effectiveness values (see Appendix A.32). These groupings will determine the cost-effective package of essential health care services for a region or country.

The decision rule which needs to be employed for selecting the essential package of health services is based on a social determination of the value of an additional healthy life year or marginal cost per DALY gained. Interventions which have cost-effectiveness ratios equal to or less than this threshold value can be included in the essential package to be funded by government resources. The most cost-effective intervention is financed and implemented first, followed by the next most cost-effective intervention until government resources are completely utilized. This will result in a mixture of health services and strategies for reducing the burden of disease. The threshold level can be determined through a consensus of experts. One recommendation is that the threshold value of an additional DALY gained can be equal to the annual value of individual consumption, or the GNP per capita. [69]

[69] The value of GNP per capita should reflect consumption only and not investment.

BOX 6.2: Factors Influencing the Cost-effectiveness of Interventions [1]

Several factors pertaining to the choice of interventions will have consequences for the **cost-effectiveness** of alternative disease control programs. [1] First, health services, for both preventive and curative care, can be provided through different strategies. The *type of strategy* selected will have an effect on the cost-effectiveness of interventions because of different levels of resources used, access of the population, and effectiveness of the technology. For instance, an MCH outreach program may be more cost-effective than one based in a hospital. Screening for diabetes prevention using mobile services could be less cost-effective than one based in urban areas. A program which is implemented in the private sector may utilize different types of inputs than one conducted through public health services, and the public/private mix of services will have an impact on the cost-effectiveness of those interventions.

Second, the *volume of services* affects the cost-effectiveness of alternative interventions and is related to the notion of **economies of scale**. The cost of starting a program is high as a result of capital investments in equipment, training, and initial stocks of drugs. In the initial stages of implementation, coverage of the population with the new program is usually low, and therefore, the cost per person covered is greater on average. As the program develops over time, these initial investment costs are spread over larger numbers of patients and average cost declines. At some point, new investments must be made to reach the last segment of the target population, and average costs are predicted to rise again. This phenomenon gives rise to the familiar U-shaped average cost curve.

The volume of services is related to both the level of demand for those services by the population and the ability of the health system to supply those services. For instance, mass laparoscopy camps may be the least costly strategy for a family planning program. However, if women are fearful or unwilling to participate in this type of service, coverage will be low and the strategy will not be as cost-effective as predicted. High quality health care which is provided in the most culturally and socially appropriate manner will result in higher demand and coverage for these services, thereby increasing the cost-effectiveness of programs. The level of demand must be considered relative to the incidence and case fatality rates of disease. In areas of high endemicity, less than universal coverage, access, and compliance by the population may render the intervention ineffective and less cost-effective overall.

Finally, the *level of institutional support*, including roads, communication networks, and physical infrastructure in the health sector, will have an impact on the effectiveness of disease control programs. For example, an ARI control program implemented in a rural area with insufficient roads will not be as cost-effective as the same program conducted in urban areas. Moreover, the effectiveness of the decentralized program may be higher than a program which is highly centralized and in which information and decisions take longer to reach health care providers. Small, pilot programs may be highly cost-effective because of effective management, leadership, motivation of the community, and adequate logistics systems. Expanding the pilot project into a regional or national program is likely to reduce its cost-effectiveness, as leadership and management are diluted and systems become more complex.

[1] For a more thorough review of these factors, see Chapter 1, Table 4 in Jamison, D.T, Mosley, W.H., Measham, A.R., and Bobadilla, J.L., eds., forthcoming; and, Hammer, J.S., "The Economics of Malaria Control," The World Bank Research Observer, Volume 8, Number 1, pp. 1-22, January 1993.

In sum, the most cost-effective health interventions, represented by the marginal cost per healthy life year or DALY gained, are derived from the set of interventions which have values less than or equal to the social marginal value of an additional DALY gained, or the GNP/capita. The most cost-effective interventions are implemented first to the fullest extent, followed by other interventions in descending order of cost-effectiveness, until government resources are exhausted. This process is illustrated in the following section.

6.2 Affordability Analysis and Selection of Health Priorities

Affordability of health programs relates to the ability of governments, donor organizations, private companies, and individuals to cover the costs of health services. Affordability is ascertained by evaluating the difference between the total cost of priority health interventions and the resources available from all sources to finance these programs. While interventions may be cost-effective, they may not be affordable when implemented fully by the Ministry of Health or other financing agency. The following example attempts to illustrate this point. Suppose the government has $25,000 available to invest in the health sector on an annual basis, and a cost-effectiveness analysis reveals the following results:

TABLE 6.2:
ANALYSIS OF AFFORDABILITY OF HEALTH INTERVENTIONS [70]

Intervention	Measles Immunization	Malaria Control	Cancer Therapy	Total	
				$	DALYs Lost or Saved
Marginal Cost/DALY Gained	$25	$50	$100		
Number of DALYs Lost per Year	100 (10%)	30 (3%)	900 (87%)		1,030
Total Cost to Save all DALYs	$2,500	$1,500	$90,000	$94,000	1,030
Decision Rules: 1) Disease with Greatest DALY Losses			$25,000	$25,000	250
2) On a Proportional Basis of DALYs Lost	$2,500	$750	$21,750	$25,000	332.50
3) According to Most Cost-effective	$2,500	$1,500	$21,000	$25,000	340

Three decision rules are applied to this example. First, resources are allocated toward that intervention which experiences the greatest lost of DALYs (i.e., cancer at 900 DALYs per year). At $100 per DALY gained, the intervention of cancer therapy can save 250 DALYs for a budget of $25,000. In this case, no other intervention will be funded. A second decision rule is to fund interventions according to proportional disease burden (i.e., the number of DALYs lost per intervention/total number of DALYs lost). In this case, 87% of the resources ($21,750) will be allocated to cancer therapy, followed by 10% ($2,500) devoted to measles immunization; and 3% ($750 for malaria control programs. This option results in a total of 332.50 DALYs saved, which is larger than the first case. Finally, the third decision rule aims to implement the most cost-effective interventions in descending order until government resources are exhausted (the strategy recommended in this manual). In this case, the measles immunization program and the malaria control strategy are fully funded and save

[70] The author owes this type of example to Hammer, J.S., 1993.

100 DALYs and 30 DALYs, respectively. The remaining budget of $21,000 is used to fund cancer therapy, resulting in 210 healthy life years DALYs gained. The outcome of the third approach results in the greatest number of DALYs saved, or 340 per year.

If it is not possible to fully implement all cost-effective health interventions having ratios below a threshold value because of resource constraints, several options are available to program managers and policy makers:

1) **Eliminate redundant interventions**: Suppose that both the OPV and IPV strategies had cost-effectiveness ratios below a certain threshold value for the marginal cost/DALY. Policy makers could remove the least cost-effective strategy of the two (the IPV strategy) in order to free up additional resources to be allocated to other types of health programs. The drawback of this approach is that it is possible that certain population groups may benefit from one strategy over another, and withdrawing strategies from the list may reduce services to these groups.

2) **Alter the scale of production**: Another alternative is to reduce the level of scale of the cost-effective health interventions in order to reduce the total cost of health programs. For instance, suppose that the measles immunization option was based on universal coverage rates. Reducing the coverage level is likely to diminish the total and marginal costs of the intervention, as well as its effectiveness. The drawback to altering the scale of production is that implementing a smaller program may have a significantly reduced health impact, particularly in cases where there are spill-over benefits from one individual to another (e.g., such as in herd immunity).

3) **Target the health intervention:** Cost-effective health interventions could be targeted so that the DALYs lost (or gained) are ascribed to population groups most in need. For instance, one may find that the burden of disease is uneven between males and females for a specific disease, such as STDs. Targeting the intervention to females would reduce the total number of DALYs gained and thereby liberate additional resources for funding other health interventions.

4) **Phase the health intervention:** Instead of saving DALYs for each health intervention in one year, one could re-estimate the cost-effectiveness of phased programs, which achieve benefits over a longer time horizon.

5) **Cost recovery:** This option can help expand the total amount of resources available in the public sector by allowing some interventions to generate revenues by charging fees for services. These revenues can be used to recover the operating costs of specific programs, releasing additional funds for other services.

6.3 Calculating the Cost-effectiveness of Clusters of Health Interventions

The cost-effectiveness of clusters of health interventions is determined by examining the marginal cost associated with the combined effort, and the resulting gain in the number of DALYs. In Table 6.3, the marginal cost per DALY of the combined program is clearly less than both the marginal cost of the family planning intervention and AIDS education. In addition, the combined program results in a greater number of DALYs gained than any of the other options. Therefore, in this context, the combined program should be launched prior to funding and implementation of other alternatives.

TABLE 6.3
EXAMPLE OF A COST-EFFECTIVENESS COMPARISON
OF INTEGRATED HEALTH INTERVENTIONS

INDICATOR	VALUE

Annual Cost of Family Planning Services	$10,000
Annual Cost of AIDS Education	$2,960
Marginal Cost of Family Planning Services	$1,300
Marginal Cost of AIDS Education	$ 500
Number of DALY Gained from Family Planning Services	200
Number of DALY Gained from AIDS Education	100
Expected DALY Gained from Combined Program	600
Incremental DALY Gained from Combined Program (above those gained from family planning services)	400 (600 - 200)
Average Cost/DALY, Family Planning Services	$50 ($10,000 / 200)
Marginal Cost/DALY, Family Planning Services	$13 ($1,300 / 100)
Average Cost/DALY, AIDS Education	$29.60 ($2,960 / 100)
Marginal Cost/DALY, AIDS Education	$5 ($500 / 100)
Average Cost/DALY, Combined Program	$19.90 ($11,940 / 600)
Marginal Cost/DALY, Combined Program	$3.75 ($1,500 / 400)

6.4 Sensitivity Analysis

During the cost-effectiveness analysis, many assumptions regarding epidemiological parameters, effectiveness of interventions, and resource requirements are made. Documenting assumptions will facilitate sensitivity testing and provide evidence for additional analyses when the original assumptions are challenged. A sensitivity analysis determines how "sensitive" the final results are to key assumptions. Table 6.4 illustrates a sensitivity analysis for the OPV example using three alternative scenarios, resulting from changes in the 1) discount rate; 2) allocation rule used to estimate personnel time; and, 3) estimates of effectiveness of the intervention.

Changing the discount rate from 3% to 15% decreases the number of discounted healthy life years gained to 201. [71] As a result, the average cost per DALY increases to $16.37 and the marginal cost per DALY rises to $4.98, or four times the original figures. Therefore, the cost-effectiveness results are **sensitive** to the choice of discount rate. It will be important in the analysis to choose the initial discount rate carefully, following the guidelines outlined in Chapter 4 of this manual.

Increasing the amount of time spent by personnel on the immunization program, from 10% to 20% (scenario 2), increases the total cost of the OPV program to $5,210. The cost-effectiveness ratio (average cost) is double that for the original case, although the marginal cost/DALY remains the same. Personnel time assumptions do not appear to affect the analysis very much in this case.

A final test consists of reducing the coverage level of OPV to 50% from the original 80%, which causes total program effectiveness to decline to 32%. This has two effects. First, the total and variable cost of the intervention declines as the number of doses required to attain a lower coverage level is reduced. [72] Second, the number of discounted healthy life years or DALYs gained falls to 546. The average cost/DALY remains nearly the same as the base case; while the marginal cost per DALY declines from $1.34 to $0.54. Thus, changes in the coverage rate influence the effectiveness and the cost-effectiveness of health interventions, although the final cost-effectiveness figures are within the same order of magnitude as the original values.

[71] Please refer to Table 4.5 for the origin of these figures.

[72] In this example, it was assumed that OPV1 coverage was 50%, OPV2 coverage was 30%, and OPV3 coverage was 15%.

TABLE 6.4:
ILLUSTRATION OF A SENSITIVITY ANALYSIS
(using the OPV example)

INDICATOR	DALYs Gained	Total Cost	Marginal Cost	Average Cost/DALY	Marginal Cost/DALY
Base Case	744	$3,290	$1,000	$4.42	$1.34
15% Discount Rate	201	$3,290	$1,000	$16.37	$4.98
Increase in % Personnel Time for OPV (10% to 20%)	744	$5,210	$1,000	$7.00	$1.34
Reduction in Coverage to 50%	546	$2,587	$297	$4.73	$0.54

In conclusion, these calculations demonstrate the need for testing key assumptions made in the analysis. [73] The difficulty arises in interpreting the results of the cost-effectiveness analysis in light of the findings of the sensitivity analysis. As we have seen in the example, changes in the discount rate and program effectiveness do affect the results, and most probably the rankings of different interventions. However, changes in the relative orders of magnitude are the most important to consider. If the orders of magnitude of the cost-effectiveness ratios change during the course of a sensitivity analysis, this is cause to re-examine the original assumptions used in the analysis. The study team is encouraged to calculate a range of cost-effectiveness estimates for each intervention according to variations in assumptions. Careful documentation of assumptions and verification of estimates are important for the cost-effectiveness analysis.

6.5 Research Priorities

Additional information is needed on both the costs and benefits of health interventions in order for governments to make wiser investments in health care services. Research priorities in the future include: 1) methods for estimating resource at different levels of scale; 2) approaches for evaluating the cost-effectiveness of clusters of health interventions; 3) data on the impact of interventions on health through monitoring and surveillance of disease patterns. It is hoped that by utilizing the methods outlined in this manual, data bases of higher quality information will become available and integrated into the health planning process or used for program management.

GOOD LUCK!!!

[73] In these examples, assumptions are tested singly, but they may work in combination.

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GLOSSARY

Incidence Rates: Incidence rates measure the number of new cases of a disease per 1,000 population within a year and reflect the probability of developing the disease in a specific time period.

Case Fatality Rates: A case-fatality rate is defined as the number of individuals dying from a specific disease after diagnosis compared to the number of individuals with the disease, and represents the risk of dying during a specific time period. Case fatality figures are not rates but proportions.

Public Health Interventions: These include childhood immunizations provided through the Expanded Programme on Immunization (including vitamin A supplementation and hepatitis B vaccination); school-based health services; information services for family planning and nutrition; programs to reduce tobacco and alcohol consumption; information to improve the household environment; and AIDS prevention.

Essential Clinical Package: This includes maternal and prenatal care; family planning; chemotherapy for tuberculosis control; control of sexually transmitted diseases; and case management of serious childhood diseases, such as diarrheal disease, acute respiratory infections, measles, malaria, and acute malnutrition.

Essential Package of Health Services: The combination of the public health and the essential clinical package of health interventions.

Effectiveness: Effectiveness refers to the impact of a health intervention on the burden of disease in a community, and is a function of the coverage rate of an intervention, patient and provider compliance, technical efficacy and other factors.

Efficacy: Efficacy is the rate at which a medical technology or pharmaceutical cures or prevents a disease, usually at the level of the individual. These figures are often derived from clinical trials and pilot studies. Due to a lack of information on community effectiveness, efficacy rates have been used as proxies for effectiveness measures.

Intervention: A disease control strategy or program. A cluster of interventions is similar to an integrated health program.

Economic costs: The opportunity cost of using resources in one program rather than in their next best alternative use. Economic cost is the "payment required to keep that input in its present employment, or ... the remuneration the input would receive in its best alternative employment." (Nicholson, W., 1989)

Financial Costs: Financial costs refer to actual expenditures or outlays made for a specific health intervention.

Short & Long-run Costs: Short-run costs are those in which capital inputs are fixed over the entire range of output. Long-run costs are those for which all inputs are variable over the output range. Most evaluations of health programs examine short-run costs because they focus on the current level and

configuration of inputs, such as calculating the total cost of hospital services, given a total of 200 beds. By contrast, long-run hospital costs would reflect potential variation in the total number of beds at different levels of output. For convenience, short-run costs can be defined as those which occur within a time period of less than one year, and long run costs to a period greater than one year.

Recurrent & Capital Costs: Recurrent costs are those which are essential for program operations and which occur frequently within a year. Evaluation of recurrent costs can be useful when planning the ongoing financing of projects. Too often, health facilities are constructed without considering the long-term operating costs which are borne by the government. Capital costs include purchases of equipment and materials which may last longer than one year.

Variable Costs: Variable costs vary directly with each patient contact, such as the cost of drugs, vaccines, and supplies.

Semi-variable costs: Costs of a specific health intervention which vary in a non-linear manner as the number of patient contacts increases or decreases.

Fixed Costs: Fixed costs refer to those costs which do not vary in the short-run, and which are usually related to physical plant and equipment.

Fixed-specific costs: Costs associated with the specific health intervention which do not vary with the number of patient contacts in the short run. For instance, initial training costs, and costs of equipment purchased specifically for a health intervention would be included in this category.

Fixed-general costs: Costs associated with the general health system which do not vary with the number of patient contacts in the short run. Examples of these types of costs include construction costs of health facilities, routine administrative and overhead costs of the Ministry of Health, and overhead costs of hospital services.

Cost-effectiveness: The ratio of intervention costs to effectiveness.

Efficiency: Technical efficiency refers to the greatest level of output which can be achieved utilizing a specific combination of inputs and a level of technology. Allocating efficiency involves the least costly combination of inputs, given a level of technology, to produce a level of output.

Export Parity Price: The export parity price (or f.o.b., freight-on-board price) reflects the market price charged for the input, as well as all costs to load a commodity on a ship or airplane, marketing and transportation costs in the country of origin, export taxes, and charges associated with exportation.

Import Parity Price:	The parity price at the point of importation (c.i.f., or cost, insurance, and freight) is equal to the f.o.b. price, freight charges to the point of importation, and insurance and unloading charges.
Marginal Value Product:	The value of the additional output obtained by employing one additional unit of labor. Under perfect competition, marginal value product is equal to the wage rate.
Marginal Physical Product:	The additional output produced by employing one additional unit of labor.
Consumer Price Index:	The consumer price index (CPI) is the value of a market basket of goods from one year to the next.

APPENDIXES

APPENDIX A.1a
EPIDEMIOLOGICAL ESTIMATES USED BY THE GHANA HEALTH ASSESSMENT TEAM (1981)

DISEASE CATEGORY	CFR (%)	A_o (years)	A_d (years)	D_{od} (%)	Q (%)	D (%)	t (days)	I/1,000
Cholera	7.3	15	15	0	0	0	14	0.05
Typhoid	7.3	20	20	0	0	0	60	4.0
Gastroenteritis	1.0	2	2	0	0	0	14	70.0
Tuberculosis	35.0	20	25	25	0	0	200	2.0
Diphtheria	7.0	3	3	0	0	0	30	0.01
Pertussis	1.0	1	1	0	0	0	30	21.0
Meningitis	20.0	10	10	0	0	0	30	1.25
Poliomyelitis	5.0	3	3	0	95	25	0	0.22
Measles	3.0	2	2	0	0	0	21	39.0
Malaria	2.3	1	1	0	07.7	2	0	40.0
Venereal Disease	0.01	20	30	1.25	0	0	35	1.7
Leprosy	25.0	20	30	50	75	25	0	0.5
Chicken Pox	0.02	4	4	0	0	0	14	22.0
Schistosomiasis	4.0	5	30	4	96	1	0	7.0
Common Cold	0.0	15	-	0	0	0	0.6	1000.0
Guinea Worm	0.0	7	-	0	0	0	45	2.4
Yaws	0.0	4	-	0	1	30	90	6.0
Onchocerciasis	0.0	5	-	0	5	70	0	2.8
Trachoma	0.0	3	-	0	5	86	45	1.6
Hepatitis	3.0	20	20	0	0	0	60	8.87
Trypanosomiasis	19.0	15	17	50	13.5	30	90	0.05
Tetanus: Neonatal Non-neonatal	80.0 35.0	0 15	0 15	0 0	0 0	0 0	0 30	0.5 0.75
Malignant Neoplasms: Child Adult	75.0 80.0	6 50	7 52	75 75	0 0	0 0	180 180	0.03 0.65
Diabetes	50.0	40	55	30	50	25	0	0.05
Severe Malnutrition	60.0	2	2	0	0	0	180	1.5
Sickle Cell Disease	80.0	0	5	50	20	30	0	1.25
Hookworm Anemia	0.1	4	5	50	5	6	0	19.0
Rheumatic Heart Disease	75.0	25	32	50	25	30	0	0.3
Hypertension	75.0	40	50	50	25	25	0	0.75
Influenza	0.1	20	20	0	0	0	21	50.0

Pneumonia: Child Adult	40.0 10.0	2 30	2 30	0 0	0 0	0 0	30 30	2.4 7.0
Peptic Ulcer	2.0	25	35	20	98	5	0	3.88
Other GI Disorders	10.0	25	25	0	0	0	60	2.8
Intestinal Obstruction	10.0	30	40	20	20	10	0	4.0
Cirrhosis	80.0	30	35	50	20	25	0	0.65
Chronic Renal Disease	85.0	30	35	75	15	25	0	0.31
Complications of Pregnancy	6.5	20	20	0	5	25	21	4.8
Birth Diseases: Prematurity Pneumonia Birth injury Congenital Other	10.2 50.0 50.0 15.0 50.0	0 0 0 0 0	0 0 0 0 0	0 0 0 0 0	0 0 50 80 0	0 0 20 25 0	0 0 0 0 0	9.6 0.46 1.6 0.96 0.54
Skin Infections	0.0	4	-	0	0	0	6	470.0
Psychiatric Disorders	5.0	15	35	50	95	30	0	0.66
Other Eye Diseases	0.0	60	-	0	100	50	0	0.05
Dental Disease	0.0	10	-	0	10	15	30	2.8
Gynecological Disorders	1.0	25	40	10	20	25	20	1.0
ENT Diseases	0.3	12	25	20	4	25	30	0.56
Accidents	10.0	15	15	0	5	25	30	7.7
Cerebrovascular Disease	35.0	50	50	0	35	75	120	2.3
Congenital Heart Disease	80.0	0	10	50	20	30	0	0.07
Other Heart Disease	75.0	35	45	50	25	30	0	0.37

NOTE: CFR = case fatality rate; HIV = human immunodeficiency virus; ENT = ear-nose-and throat; GI = gastrointestinal.

SOURCE: Ghana Health Assessment Project Team, "A Quantitative Method of Assessing the Health Impact of Different Diseases in Less Developed Countries," International Journal of Epidemiology, Volume 10, Number 1, pp. 73-80; 1981.

APPENDIX A.1b: SELECTED EPIDEMIOLOGIC ESTIMATES FROM DISEASE CONTROL PRIORITIES IN DEVELOPING COUNTRIES [74]

DISEASE TYPE	INCIDENCE RATE(S)	CASE FATALITY RATES	MORTALITY RATES	OTHER INDICATORS
Diarrheal Disease	**Incidence Rates measured as the Number of Episodes/Child/Year:** LAC Region: 0.8 - 10.4 (median 4.9) SSA Region: 1.6 - 9.9 (4.4) MENA Region: 2.1 - 10.8 (2.7) Asia/Pacific: 1.1 - 5.7 (2.6) All Regions: 0.8 - 10.8 (3.5)	By age group: < 5 years: 2/1,000 5-14 years: 0.4/1,000 15-59 years: 0.3/1,000 + 60 years: 0.5/1,000	6.5 - 13.6/1,000	
Tuberculosis	**Incidence of Smear Positive Samples per 100,000 population:** SSA: 117 MENA: 54 Asia: 79 South America: 54 Central America: 54 Total: 79	**Measured as a percent:** SSA: 39 - 47 MENA: 26 - 29 Asia: 32 - 37 South America: 28 - 32 Central America: 38 - 45 All: 33 - 38%	**Death Rates per 100,000:** Sub Saharan Africa: 116 MENA: 34 Asia: 62 South America: 37 Central America: 52 All: 65	**Risk of Disease (percent):** SSA: 1.5 - 2.5 MENA: 0.5 - 1.5 Asia: 1 - 2 South/Central America: 0.5 - 1.5
Acute Respiratory Infections	37/1000 (nourished population) - 457.8/1000 (severely malnourished population); Between 10 - 20% of children in developing countries	From pertussis: 15% From measles: 2 - 34%	Approximately 4 million deaths/year; 75% of deaths due to pneumonia Measles deaths account for 1.5 - 2 million	**Relative Risk:** 2.5 times greater among LBW; 2 times greater with Vitamin A deficiency
Poliomyelitis	250,000 new cases per year; 10/1000 school age children (ranging from 0.25 to 43)	0.15%		**Prevalence:** 3 - 5/1000
Tetanus		85% NNT; 40-50% non-NNT	**NNT Mortality Rates/1000 live births:** Africa: 2-51 MENA: 7 - 91 SEA: 5 - 93 West Pacific: 8 - 16	**Duration (days):** NNT = 19 non-NNT = 14

[74] Jamison, D.T., Mosley, W.H., Measham, A.R., and Bobadilla, J.L., eds. Disease Control Priorities in Developing Countries, Oxford University Press, forthcoming.

HIV and STDs: Gonorrhea Ophthalmia neo. Chlamydia Syphilis HIV	0.45 - 25% (avg= 7.3 in women, 10.8 in men) 3.5% of live births 5 - 50% (9.5% in women, 12.4% in men) 0.25 - 25% (5.8% in both on average) 0.5 - 1.8%; 10-40% at risk	~100%	< 20% ~100%	**Risk of Transmission:** 30-40% in males; 50-80% in females < 30% ~100% thru IV drug use; 25-50% mother to child; 0.1 - 5% thru intercourse
Hepatitis B			25% of carriers die from cirrhosis or liver cancer	Perinatal transmission rate: 70-90% 350 million infected carriers worldwide (2-50% prevalence)
Leprosy	1-3/1000			**Prevalence:** 11.5 million cases (males > females); A_o = 10-20 years; 30-50 years (bimodal) A_d = 29 years; 39 years Degree of disablement (D) = 40% Permanently disabled (Q) = 30%
Onchocerciasis	3-11/1000 in hyperendemic areas; 1.7 - 2/1000 in mesoendemic areas			**Blindness rate per 1000:** 30 - 130 **Prevalence per 1000:** 7 - 9 A_o = 39 years
Helminthic Infections (Ascaris)		1.4/100,000	< 1/100,000	**Prevalence:** 25% Permanently disabled (Q) = 0.14%
Maternal and Perinatal Diseases		**Maternal Mortality Ratio per 100,000 live births:** SSA: 640 Asia: 420 LAC: 270 World: 250-1,660 (390) **Perinatal Mortality Rate per 1000:** 40-60		
Micronutrient Deficiency Disorders: Vitamin A	250-500,000 children go blind/year	50-80% of blind		A_o = 6 months, peaking at 2-4 years **Prevalence (percent):** Africa: 1.6 - 11 Asia: 1 - 20 MENA: 0.57 LAC: 0.81

Cancers:	**New cases/year x 1000:** Stomach: 336 Esophagus: 254 Lung: 206 Liver: 192 Cervix: 370 Colon/Rectum: 183 Mouth/Pharynx: 272 Breast: 224 Lymphoma: 122 Leukemia: 106		**Deaths per year x 1000:** Stomach: 280 Esophagus: 231 Lung: 187 Liver: 174 Cervix: 154 Colon/Rectum: 108 Mouth/Pharynx: 101 Breast: 97 Lymphoma: 81 Leukemia: 81	**Age at death (male/female):** Stomach: 64/62 Esophagus: 65/65 Lung: 63/66 Liver: 56/57 Cervix: 61 Colon/Rectum: 61/60 Breast: 57 Leukemia: 32/34 All: 59/58
Cardiovascular Diseases: Infarction Stroke		20% 30% (60-85% hemorrhagic)	65-310/100,000 for IHD; 26-245/100,000 for CHD	Degree of disability: 20-30%

NOTES: Not possible to include data on all parameters for each disease category in tabular form. Readers are encouraged to review individual chapters in Disease Control Priorities in Developing Countries for further details.

SSA = Sub Saharan Africa

MENA = Middle East and North Africa

Group 1 Diseases: Communicable, Maternal, and Perinatal Diseases

A. Infectious and Parasitic
    1. Tuberculosis
    2. Sexually Transmitted Diseases excluding HIV
        a) Syphilis
        b) Chlamydia
        c) Gonorrhea
        d) Pelvic Inflammatory Disease
    3. HIV
    4. Diarrhoeal Diseases
        a) Acute Watery
        b) Persistent
        c) Dysentery
    5. Childhood Cluster
        a) Pertussis
        b) Poliomyelitis
        c) Diphtheria
        d) Measles
        e) Tetanus
    6. Meningitis
    7. Hepatitis
    8. Malaria
    9. Tropical Cluster
        a) Trypanosomiasis
        b) Chagas' Disease
        c) Schistosomiasis
        d) Leishmaniasis
        e) Lymphatic Filariasis
        f) Onchocerciasis
    10. Leprosy
    11. Trachoma
    12. Intestinal Helminths
        a) Ascaris
        b) Trichuris
        c) Hookworm
B. Respiratory Infections
    1. Acute Lower Respiratory Infection
    2. Acute Upper Respiratory Infection

[75] Adapted from the Global Burden of Disease and the World Development Report

2. Sepsis
3. Eclampsia
4. Hypertension
5. Obstructed Labor
6. Abortion

D. Perinatal Conditions

Group II Diseases: Noncommunicable Diseases

A. Malignant Neoplasms
1. Mouth and Oropharynx
2. Esophagus
3. Stomach
4. Colon/Rectum
5. Liver
6. Pancreas
7. Trachea/Bronchus/Lung
8. Melanoma and Other Skin
9. Breast
10. Cervix
11. Corpus Uteri
12. Ovary
13. Prostate
14. Bladder
15. Lymphoma
16. Leukemia

B. Other Neoplasm
C. Diabetes Mellitus
D. Nutritional/Endocrine
1. Protein-Energy Malnutrition
2. Iodine Deficiency
3. Vitamin A Deficiency
4. Anemias

E. Neuro-Psychiatric
1. MAD
2. BAD
3. Psychoses
4. Epilepsy
5. Alcohol Dependence
6. Alzheimer's Disease

F. Sense Organ
    1. Glaucoma-related Blindness
    2. Cataract-related Blindness

G. Cardiovascular Diseases
    1. Rheumatic Heart Disease
    2. Ischemic Heart Disease
    3. Cerebrovascular Disease
H. Chronic Respiratory Diseases
    1. COPD
    2. Asthma
I. Diseases of the Digestive System
    1. Peptic Ulcer Disease
    2. Cirrhosis of the Liver
J. Diseases of the Genito-Urinary System
    1. Nephritis/Nephrosis
    2. Benign Prostatic Hypertrophy
K. Skin Disease
L. Diseases of the Musculo-Skeletal System
    1. Rheumatoid Arthritis
    2. Osteoarthritis
M. Congenital Abnormalities
N. Oral Health
    1. Dental Caries
    2. Periodontal Disease
    3. Eduentulism

Group III Diseases: Injuries

A. Unintentional
    1. Motor Vehicle Accidents
    2. Poisonings
    3. Falls
    4. Fires
    5. Drowning
    6. Occupational
B. Intentional
    1. Self-inflicted
    2. Homicide and Violence
    3. War

APPENDIX A.3
TABLE FOR RECORDING ASSUMPTIONS USED IN CALCULATING THE NUMBER OF HEALTHY LIFE YEARS OR DALYs LOST DUE TO DISEASE

Disease: ICD Number:	Best Value		Upper Bound		Lower Bound	
	Males	Females	Males	Females	Males	Females
Case Fatality Rate (%)						
Average Age at Onset (A_o)						
Average Age at Death (A_d): Premature mortality Mortality following disability						
Life Expectancy at Onset E(A_o)						
Life Expectancy at Death E(A_d) Premature mortality Mortality following disability						
% Disability Before Death (D_{od})						
% Permanently Disabled (Q)						
% Degree of Disablement (D): Temporary disability prior to death Permanent disability						
Duration of Acute Illness (t)						
Incidence/1,000 Population						
Total Population (in 000's)						

NOTES:

APPENDIX A.4
FORM FOR CALCULATING THE NUMBER OF HEALTHY LIFE YEARS OR DALYs LOST FOR INDIVIDUAL DISEASES
(by gender) [76]

Type of Health Outcome	Number of Healthy Years of Life or DALYs Lost per Person		Number of Individuals in Each Category per 1,000 Population		Number of Healthy Years of Life or DALYs Lost per 1,000 Population		Percent Distribution Among Health Outcomes	
	Males	Females	Males	Females	Males	Females	Males	Females
Immediate Death (A)								
Death Following Disability (B1)								
Disability Before Death (B2)								
Permanent Disability (C)								
Acute Illness (D)								
Subtotal								

76 Note that this table could be modified to include age groups as well.

APPENDIX A.5
TABLE FOR SUMMARIZING HEALTHY LIFE YEARS OR DALYs LOST BY DISEASE CATEGORY, AGE, AND GENDER

DISEASE	NUMBER OF HEALTHY LIFE YEARS OR DALYS LOST										
	TOTAL	FEMALE	MALE	0-4 YEARS	5-14 YEARS	15-29 YEARS	30-44 YEARS	45-59 YEARS	60-69 YEARS	+ 70 YEARS	NOTES
Group I Diseases A. B. C. D. Subtotal											
Group II Diseases A. B. C. D. E. F. G. H. I. J. K. L. M. N. Subtotal											
Group III Diseases A. B. Subtotal											
Grand Total											

APPENDIX A.6: DISTRIBUTION OF THE GLOBAL BURDEN OF DISEASE IN 1990 BY GENDER, CAUSE, AND TYPE OF LOSS (millions of DALYs) [77]

Gender	Outcome	Disease Category		
		Communicable/Perinatal/Maternal	Noncommunicable	Injuries
Male	Premature Death Disability	255 47	152 146	70 39
Female	Premature Death Disability	240 74	135 142	33 20

[77] World Development Report, Table 1.1, World Bank, Washington, D.C., 1993.

APPENDIX A.7: DISTRIBUTION OF GLOBAL DALY LOSSES BY CAUSE AND GEOGRAPHIC REGION, 1990 (percent) [78]

Category of Disease	Geographic Region of the World								
	World	SSA	India	China	OAI	LAC	MEC	FSE	EME
Population (millions)		510	850	1134	683	444	502	346	798
Category I: Communicable Diseases	45.5	70.1	50.5	25.3	48.7	42.5	50.9	8.6	10.9
Category II: Noncommunicable Diseases	42.5	20.2	40.2	58.0	40.0	42.6	36.1	74.8	77.4
Category III: Injuries	12.0	9.7	9.1	16.7	11.3	14.9	13.0	16.6	11.7
Total DALYs (millions)	1,353	282	292	201	177	103	144	58	95
Equivalent Infant Deaths, millions	44.4	9.2	9.6	6.6	5.8	3.4	4.7	1.9	3.1
DALYs/1,000 Population (millions)	257	553	344	178	260	233	286	168	119

NOTES: SSA = Sub-Saharan Africa; OAI = Other Asia and Islands; LAC = Latin America and the Caribbean; MEC = Middle Eastern Crescent; FSE = Formerly Socialist Economies; and, EME = Established Market Economies.

78 World Development Report, Box 1.3, Washington, D.C., 1993.

APPENDIX A.8: SAMPLE CHARACTERISTICS OF A WELL-FUNCTIONING DISTRICT HOSPITAL AND HEALTH CENTER [79]

District Hospital	Health Center
Outpatient Care: Regular outpatient care is limited to emergencies and referred patients who are all seen by a physician. Referrals come from health center clinics. In addition, there would be a small outpatient clinic run by a nurse where patients from outside the district can be attended as well as patients who refuse to go to a health center. This clinic would carry a high consultation fee so as to discourage patients from direct attendance at the hospital. **In-patient Care:** In-patient care for 5,000 admissions (average length of stay of six days) and 2,000 deliveries per year (average length of stay of three days). Admissions are to the following wards: pediatrics, medicine, surgery and orthopedics, and gynecology and obstetrics. For serious cases, one ward would provide higher staff/patient ratios and 24-hour nursing care. **Range of Interventions:** There would be two operating theaters that would perform a reasonable range of interventions covering: traumatology, laparotomy, bowel resection, splenectomy, caesarean section, cranioembriotomy, appendectomy, hernia repair, extra-uterine pregnancy, sterilization, intestinal obstruction, aspiration and drainage of pio-pneumothorax. **Laboratory Services:** Services would include blood microscopy, direct examination of cerebro-spinal fluid (CSF), urine, faeces and vaginal smears, Venereal Disease Research Laboratory (VDRL) and HIV serology and blood grouping. The hospital would produce its own intravenous (IV) fluids and perform blood transfusions. One important task is the quality control of the microscopy done at the health center (primarily acid-fast bacteria (AFB) stains for the detection of tuberculosis) and radiography and fluoroscopy of extremities, skull, chest, stomach and bowel. **Total Bed Days = 36,000; Occupancy Rate = 70%.**	**Ante-Natal Services:** The health center would provide pre-delivery, delivery, and post-delivery care; tetanus vaccination, prophylaxis for malaria, and vitamin supplements. **Well-Baby Services:** The center would offer immunizations through the Expanded Program on Immunization (EPI), growth monitoring, and micronutrient supplementation. **Family Planning:** Health workers would provide advice, information, education, and communication concerning family planning; as well as supply contraceptives for men and women. **Curative Care Services:** This center would serve as the entry point in the health care system for basic trauma care, malaria treatment, treatment and testing of sexually transmitted diseases (STDs); diarrheal disease treatment with ORS; treatment and management of opportunistic infections resulting from AIDS; and other infectious disease treatment. Health workers will refer patients to the district hospital in cases of serious illness. **Chronic Care Services:** The health center will provide services to treat and manage tuberculosis and opportunistic infections caused by AIDS and other STDS. In addition, handicapped support will also be provided. **Population Served: = 10,000; Health Centers per District = 15**

[79] The text is taken almost completely from the following document: The World Bank, Africa Technical Department, Human Resources and Poverty Division, A Framework and Indicative Cost Analysis for Better Health in Africa, Technical Working Paper Number 8, pps. 13-15, May 1993.

DISEASE GROUP	FOCUS	HOSPITAL-BASED	HEALTH CENTER BASED	MOBILE TEAM OUTREACH	SCHOOL-BASED	COMMUNITY-BASED	NATIONAL PROGRAMS, INSTITUTES, OR POLICIES
POLIOMYELITIS	Prevention	Immunization	Immunization	Immunization	Immunization	Immunization	
	Case mgmt	Rehab/Surgery	Rehab			Rehab/Detection	Rehab Institute
ARI	Prevention	Immunization	Immunization Vitamin A Nutrition	Immunization Vitamin A	Nutrition		
	Case mgmt	Tx of pneumonia	Tx of pneumonia				Indoor air pollution control
DIARRHEAL DISEASE	Prevention	Immunization	Immunization	Immunization	Health Ed	Water/Sanitation Breastfeeding	
	Case mgmt	ORS/IV fluids Antibiotics	ORS Antibiotics	ORS Antibiotics			
MICRONUTRIENT DEFICIENCY	Prevention	Supplement	Supplement	Supplement	Supplement	Fortification Supplement Nutrition	
	Case mgmt	Treatment	Treatment				
TUBERCULOSIS	Prevention	Immunization	Immunization	Immunization		Screening Case Finding	TB Institutes
	Case mgmt	Drug therapy	Drug therapy	Drug therapy			
TETANUS	Prevention	Immunization Safe births ANC/MCH	Immunization Safe births ANC/MCH	Immunization ANC/MCH	Immunization	Immunization campaign Injury control Safe births	
	Case mgmt	Treatment	Treatment	Treatment			
INJURY	Prevention				Health Ed	Education Surveillance	Driver's Education Legislation
	Case mgmt	Emergency Care Occupational Therapy	First Aid	First Aid			Substance Abuse Occupational Health Rehabilitation
ORAL HEALTH	Prevention				Health Ed	Fluorination Nutrition	Oral Health Program
	Case mgmt	Surgery Prophylaxis	Prophylaxis	Prophylaxis			
MATERNAL/ PERINATAL HEALTH	Prevention	MCH/ANC Safe births	MCH/ANC Safe births	MCH/ANC		Screening Family Planning	Training of TBAs
	Case mgmt	Emergency Care	Referral	Referral			
LEPROSY	Prevention					Water/Sanitation	
	Case mgmt	Surgery Diagnostics Drug therapy	Diagnostics Drug therapy	Diagnostics Drug therapy	Health Ed		Rehabilitation
CATARACT	Prevention					Nutrition Supplement	UV Exposure Control
	Case Mgmt	Surgery				Surgical camps Sunglasses	

CANCER	Prevention	Immunization MCH Screening	Immunization MCH	Immunization MCH		Screening Nutrition Immunization	Substance Abuse Tobacco Legislation Occupational Exposure Vector control
	Case mgmt	Surgery Radiation/Chemo therapy Diagnostics	Referral	Referral			
ONCHOCERCIASIS	Prevention					Surveillance Water system	Vector Control
	Case mgmt	Diagnosis Surgery Drug therapy	Diagnosis Drug therapy	Diagnosis Drug therapy		Mass surgery	
HELMINTH INFECTIONS	Prevention					Water/Sanitation Screening	Vector control
	Case mgmt	Chemotherapy	Chemotherapy	Chemotherapy		Chemotherapy	
COPD	Prevention		Immunization Vitamin A	Immunization Vitamin A		Nutrition	Anti-smoking Occupational Health
	Case mgmt	Diagnosis Drug therapy	Drug therapy	Drug therapy			Rehabilitation
HIV/STDs	Prevention	Family Planning Safe delivery Eye Prophylaxis	Family Planning Safe delivery Eye Prophylaxis	Family Planning	Health Ed	Screening Safe delivery	Monitoring & Surveillance
							Blood Bank Quality Control Counseling
	Case mgmt	Drug therapy Diagnosis Patient care	Drug therapy Diagnosis	Drug therapy Diagnosis			
MALARIA	Prevention	Prophylaxis Immunization	Prophylaxis Immunization	Prophylaxis Immunization	Prophylaxis Immunization	Immunization Screening	Vector Control
	Case mgmt	Chemotherapy	Chemotherapy	Chemotherapy	Diagnosis		
		Hospital care	Referral	Referral			
		Diagnosis	Diagnosis	Diagnosis			
MEASLES	Prevention	Immunization	Immunization	Immunization		Campaigns	
	Case mgmt	Treatment	Treatment	Referral			

NOTES:
Immunization strategies for prevention of ARI include pertussis, pneumonia, influenza, and measles immunization.
Immunization strategies for prevention of diarrheal disease include measles, cholera, and rotavirus vaccines. Nutrition strategies include breastfeeding.
Tx = Treatment
Dx= Diagnostic facilities
Mgmt = management
ANC = antenatal care
Ed = education

Disease Group	Interventions	Effectiveness/Impact
Acute Respiratory Infection	Pertussis Immunization	50% - 90% vaccine efficacy
	Pneumococcal Immunization	50% - 80% vaccine efficacy; 50% mortality reduction
	Measles Immunization	90% to 96% vaccine efficacy
	H. influenzae Immunization	0% - 90% vaccine efficacy
	Nutrition Supplementation	unknown
	Vitamin A Supplementation	unknown
	Case Management	11.5% - 40%
Diarrheal Disease	Rotavirus Immunization	80% vaccine efficacy; 3% mortality reduction
	Cholera Immunization	70% vaccine efficacy; 2.8% mortality reduction
	Measles Immunization	90% - 95% vaccine efficacy
	Breastfeeding	8-27% < 6 months; 1-9% < 5 years
	Water and Sanitation	30%
	Personal Hygiene	14% - 48% incidence reduction
	Oral Rehydration Salts	70%
	Chemotherapy	limited
Tetanus	Tetanus Toxoid and DPT Immunization	91% - 95% vaccine efficacy
	Hospital Delivery	85%
	Trained TBA	33%
	Case Management	up to 10%
	Injury Control	unknown
Poliomyelitis	Oral Polio Vaccine	79% - 85% vaccine efficacy
	Injectable Polio Vaccine (DPTP)	90% - 96% vaccine efficacy
	Improved Sanitation	unknown
	Rehabilitation	unknown
Tuberculosis	BCG Immunization at birth	40% - 70% vaccine efficacy
	Chemoprophylaxis	less than 100% depending upon compliance rates
	Case Detection: smears	90% sensitivity
	Case Detection: X-ray	87% sensitivity
	Treatment: standard course	less than 30%
	Treatment: short course	less than 60%

	Use of Seat Belts	45% Mortality reduction; 40% - 70% injury reduction
	Taxation on alcohol	less than 75% reduction in deaths for a 50% tax
	Legislation	79% reduction in car accidents in Brazil
	Use of helmets	72% reduction in fatalities; 20% reduction in injuries
	Adequate emergency facilities and referral	33% reduction in deaths
	Education	unknown
Hepatitis B	Hepatitis B Immunization	75% - 95% vaccine efficacy
	Food/Alcohol	0.1% - 70% reduction in cancers related to diet
	Reduction Occupational Exposure	less than 10%
	Smoking Cessation	high
Onchocerciasis	Vector control: insecticides	85%
	Improved Hygiene	unknown
	Nodulectomy	66.7%
	Chemotherapy: ivermectin	unknown
Helminthic Infections	Chemotherapy: prazinquanel for Schistosomiasis	58% - 85%
	Chemotherapy: ivermectin for Nematode infection benzimidiols for Nematode infection	75% 75%
	Chemotherapy for Ascaris	100%
	Chemotherapy for Hookworm	20%
	Vector control: water filtering	30% for dracunculiasis
	Hygiene and Sanitation	29% for Ascaris 78% for Guinea Worm 4% for Hookworm 77% for Schistosomiasis
Maternal and Perinatal Health Problems	Training of birth attendants	less than 65% maternal mortality reduction; 30% - 40% reduction in perinatal mortality over a ten-year period
	Nutrition Supplementation	unknown
	Family Planning Services	see below
Leprosy	BCG Immunization	30% to 80% vaccine efficacy
	Treatment with dapsone	50%
	Treatment with rifampicin	50%
	Treatment with daily prednisolone	75%
	Sanitation/Hygiene/Socioeconomic development	unknown
	Rehabilitation	unknown

	Health education	unknown
	Screening of pregnant women for STDs	unknown
	Chemotherapy for STDs (except HIV)	approximately 100%
	Chemotherapy for AIDS	prolongs life for 2 years
	Improved blood supply	approximately 100% effective in preventing transmission
	AIDS patient care	unknown
Measles	Measles Immunization	90% - 95% vaccine efficacy
	Improved hygiene and sanitation	unknown
Family Planning	Birth Control methods	Abortion = 100% Tubal ligation = 99% Vasectomy = 99% Injectable progestin = 99% Birth control pills = 97% - 99% IUD = 96% Condom = 90% Diaphragm = 87% Breastfeeding for 6 months = 98%
	Birth Spacing	60% ?
Micronutrient Deficiency	Supplementation	75%
	Fortification	75%
	Breastfeeding	unknown
	Nutrition Education	unknown
Cataract	Mass surgery	85% - 92%
	Sunglasses	Blocks 86% - 94% of UV light
	Nutrition Supplementation	unknown
Oral Health	Fluorination of water	unknown
	Education	unknown
	Nutrition	unknown
	Tooth brushing	34% reduction in dental caries

NOTES: Vaccine efficacy figures represent those attained under ideal conditions. Coverage rates are likely to influence total health impact.
Unknown effectiveness measures refer to cases where there is an absence of quantitative information, though qualitatively, relationships between the intervention and health benefits are assumed to exist.

SOURCES: Jamison, D.T., Mosley, W.H., Measham, A.R., and Bobadilla, J.L., eds. Disease Control Priorities in Developing Countries, Oxford University Press, New York, forthcoming. Esrey, S.A., Potash, J., Roberts, L., and Shiff, C., Health Benefits from Improvements in Water Supply and Sanitation: Survey and Analysis of the Literature on Selected Diseases, Technical Report Number 6, Water and Sanitation for Health (WASH) Project, Arlington, VA, 1991.

APPENDIX A.11
FORM FOR ESTIMATING THE EFFECTIVENESS OF HEALTH INTERVENTIONS

INTERVENTION	Intervention 1:	Intervention 2:	Intervention 3:	Intervention 4:	Intervention 5:
Original incidence rate/1,000 **(I)**					
Percent efficacy **(a)**					
Percent coverage **(b)**					
Percent change in incidence rate **(a x b) = (c)**					
Revised incidence rate **{I x (1-c)}**					
Original CFR **(CFR)**					
Percent compliance rate **(e)**					
Percent change in CFR **(a x d) = (e)**					
Revised CFR **{CFR x (1-e)}**					
Original values for other parameters (D or D_{od})					
Percent change in D or D_{od}					
Revised values for D or D_{od}					
NOTES:					

APPENDIX A.12: FORM FOR CALCULATING THE

NUMBER OF HEALTHY LIFE YEARS or DALYs LOST

HEALTHY LIFE YEARS OR DALYs LOST/1,000 FROM:						
Health Outcome	Original Values of Healthy Life Years Lost		Life Years Lost from an Intervention		Life Years Lost from an Intervention	
	Male	Female	Male	Female	Male	Female
A						
B1						
B2						
C						
D						
Subtotal						

YEARS OF HEALTHY LIFE OR DALYs LOST IN THE POPULATION OF 500,000:						
Health Outcome	Original Values of Healthy Life Years Lost		Life Years Lost from an Intervention		Life Years Lost from an Intervention	
	Male	Female	Male	Female	Male	Female
A						
B1						
B2						
C						
D						
Subtotal						

YEARS

OR DALYs GAINED FROM HEALTH INTERVENTIONS

HEALTHY LIFE YEARS OR DALYs GAINED/1,000 FOR:				
Health Outcome	Life Years Gained from an Intervention		Life Years Gained from an Intervention	
	Male	Female	Male	Female
A				
B1				
B2				
C				
D				
Total				
YEARS OF HEALTHY LIFE OR DALYs GAINED IN THE POPULATION FROM:				
Health Outcome	Life Years Gained from an Intervention		Life Years Gained from an Intervention	
	Male	Female	Male	Female
A				
B1				
B2				
C				
D				
Total				

PRESENT VALUE: What 1 Case in Year t Would Be in the Present

YEAR	3%	5%	10%	15%
1	0.9709	0.9524	0.9091	0.8696
2	0.9426	0.9070	0.8264	0.7561
3	0.9151	0.8638	0.7513	0.6575
4	0.8885	0.8227	0.6830	0.5718
5	0.8626	0.7835	0.6209	0.4972
6	0.8375	0.7462	0.5645	0.4323
7	0.8131	0.7107	0.5132	0.3759
8	0.7894	0.6768	0.4665	0.3269
9	0.7664	0.6446	0.4241	0.2843
10	0.7441	0.6139	0.3855	0.2472
11	0.7224	0.5847	0.3505	0.2149
12	0.7014	0.5568	0.3186	0.1869
13	0.6810	0.5303	0.2897	0.1625
14	0.6611	0.5051	0.2633	0.1413
15	0.6419	0.4810	0.2394	0.1229
16	0.6232	0.4581	0.2176	0.1069
17	0.6050	0.4363	0.1978	0.0929
18	0.5874	0.4155	0.1799	0.0808
19	0.5703	0.3957	0.1635	0.0703
20	0.5537	0.3769	0.1486	0.0611
21	0.5375	0.3589	0.1351	0.0531
22	0.5219	0.3418	0.1228	0.0462
23	0.5067	0.3256	0.1117	0.0402
24	0.4919	0.3101	0.1015	0.0349
25	0.4776	0.2953	0.0923	0.0304
26	0.4637	0.2812	0.0839	0.0264
27	0.4502	0.2678	0.0763	0.0230
28	0.4371	0.2551	0.0693	0.0200
29	0.4243	0.2429	0.0630	0.0174
30	0.4120	0.2314	0.0573	0.0151
31	0.4000	0.2204	0.0521	0.0131
32	0.3883	0.2099	0.0474	0.0114
33	0.3770	0.1999	0.0431	0.0099
34	0.3660	0.1904	0.0391	0.0086
35	0.3554	0.1813	0.0356	0.0075
36	0.3450	0.1727	0.0323	0.0065
37	0.3350	0.1644	0.0294	0.0057
38	0.3252	0.1566	0.0267	0.0049
39	0.3158	0.1491	0.0243	0.0043
40	0.3066	0.1420	0.0221	0.0037

PRESENT WORTH OF ANNUITY FACTOR: What 1 Case Every Year from Time t to the Present Would Be

YEAR	3%	5%	10%	15%
1	0.9709	0.9524	0.9091	0.8696
2	1.9135	1.8594	1.7355	1.6257
3	2.8286	2.7232	2.4869	2.2832
4	3.7171	3.5460	3.1699	2.8550
5	4.5797	4.3295	3.7908	3.3522
6	5.4172	5.0757	4.3553	3.7845
7	6.2303	5.7864	4.8684	4.1604
8	7.0197	6.4632	5.3349	4.4873
9	7.7861	7.1078	5.7590	4.7716
10	8.5302	7.7217	6.1446	5.0188
11	9.2526	8.3064	6.4951	5.2337
12	9.9540	8.8633	6.8137	5.4206
13	10.6350	9.3936	7.1034	5.5831
14	11.2961	9.8986	7.3667	5.7245
15	11.9379	10.3797	7.6061	5.8474
16	12.5611	10.8378	7.8237	5.9542
17	13.1661	11.2741	8.0216	6.0472
18	13.7535	11.6896	8.2014	6.1280
19	14.3238	12.0853	8.3649	6.1982
20	14.8775	12.4622	8.5136	6.2593
21	15.4150	12.8212	8.6487	6.3125
22	15.9369	13.1630	8.7715	6.3587
23	16.4436	13.4886	8.8832	6.3988
24	16.9355	13.7986	8.9847	6.4338
25	17.4131	14.0939	9.0770	6.4641
26	17.8768	14.3752	9.1609	6.4906
27	18.3270	14.6430	9.2372	6.5135
28	18.7641	14.8981	9.3066	6.5335
29	19.1885	15.1411	9.3696	6.5509
30	19.6004	15.3725	9.4269	6.5660
31	20.0004	15.5928	9.4790	6.5791
32	20.3888	15.8027	9.5264	6.5905
33	20.7658	16.0025	9.5694	6.6005
34	21.1318	16.1929	9.6086	6.6091
35	21.4872	16.3742	9.6442	6.6166
36	21.8323	16.5469	9.6765	6.6231
37	22.1672	16.7113	9.7059	6.6288
38	22.4925	16.8679	9.7327	6.6338
39	22.8082	17.0170	9.7570	6.6380
40	23.1148	17.1591	9.7791	6.6418

44	0.2724	0.1169	0.0151	0.0021		44	24.2543	17.6628	9.8491	6.6524
45	0.2644	0.1113	0.0137	0.0019		45	24.5187	17.7741	9.8628	6.6543
46	0.2567	0.1060	0.0125	0.0016		46	24.7754	17.8801	9.8753	6.6559
47	0.2493	0.1009	0.0113	0.0014		47	25.0247	17.9810	9.8866	6.6573
48	0.2420	0.0961	0.0103	0.0012		48	25.2667	18.0772	9.8969	6.6585
49	0.2350	0.0916	0.0094	0.0011		49	25.5017	18.1687	9.9063	6.6596
50	0.2281	0.0872	0.0085	0.0009		50	25.7298	18.2559	9.9148	6.6605
51	0.2215	0.0831	0.0077	0.0008		51	25.9512	18.3390	9.9226	6.6613
52	0.2150	0.0791	0.0070	0.0007		52	26.1662	18.4181	9.9296	6.6620
53	0.2088	0.0753	0.0064	0.0006		53	26.3750	18.4934	9.9360	6.6626
54	0.2027	0.0717	0.0058	0.0005		54	26.5777	18.5651	9.9418	6.6631
55	0.1968	0.0683	0.0053	0.0005		55	26.7744	18.6335	9.9471	6.6636
56	0.1910	0.0651	0.0048	0.0004		56	26.9655	18.6985	9.9519	6.6640
57	0.1855	0.0620	0.0044	0.0003		57	27.1509	18.7605	9.9563	6.6644
58	0.1801	0.0590	0.0040	0.0003		58	27.3310	18.8195	9.9603	6.6647
59	0.1748	0.0562	0.0036	0.0003		59	27.5058	18.8758	9.9639	6.6649
60	0.1697	0.0535	0.0033	0.0002		60	27.6756	18.9293	9.9672	6.6651
61	0.1648	0.0510	0.0030	0.0002		61	27.8404	18.9803	9.9701	6.6653
62	0.1600	0.0486	0.0027	0.0002		62	28.0003	19.0288	9.9729	6.6655
63	0.1553	0.0462	0.0025	0.0001		63	28.1557	19.0751	9.9753	6.6657
64	0.1508	0.0440	0.0022	0.0001		64	28.3065	19.1191	9.9776	6.6658
65	0.1464	0.0419	0.0020	0.0001		65	28.4529	19.1611	9.9796	6.6659
66	0.1421	0.0399	0.0019	0.0001		66	28.5950	19.2010	9.9815	6.6660
67	0.1380	0.0380	0.0017	0.0001		67	28.7330	19.2391	9.9831	6.6661
68	0.1340	0.0362	0.0015	0.0001		68	28.8670	19.2753	9.9847	6.6662
69	0.1301	0.0345	0.0014	0.0001		69	28.9971	19.3098	9.9861	6.6662
70	0.1263	0.0329	0.0013	0.0001		70	29.1234	19.3427	9.9873	6.6663
71	0.1226	0.0313	0.0012	0.0000		71	29.2460	19.3740	9.9885	6.6663
72	0.1190	0.0298	0.0010	0.0000		72	29.3651	19.4038	9.9895	6.6664
73	0.1156	0.0284	0.0010	0.0000		73	29.4807	19.4322	9.9905	6.6664
74	0.1122	0.0270	0.0009	0.0000		74	29.5929	19.4592	9.9914	6.6665
75	0.1089	0.0258	0.0008	0.0000		75	29.7018	19.4850	9.9921	6.6665
76	0.1058	0.0245	0.0007	0.0000		76	29.8076	19.5095	9.9929	6.6665
77	0.1027	0.0234	0.0006	0.0000		77	29.9103	19.5329	9.9935	6.6665
78	0.0997	0.0222	0.0006	0.0000		78	30.0100	19.5551	9.9941	6.6665
79	0.0968	0.0212	0.0005	0.0000		79	30.1068	19.5763	9.9946	6.6666
80	0.0940	0.0202	0.0005	0.0000		80	30.2008	19.5965	9.9951	6.6666

Formula Used to Calculate the PV: $1 / (1 + r)^n$

Formula Used to Calculate the PWAF: $[t_1 - t_n \times q]/(1 - q)$, where $q = 1/(1=r)$

APPENDIX A.15:
FORM FOR CALCULATING THE NUMBER OF DISCOUNTED HEALTHY LIFE YEARS OR DALYs GAINED FROM HEALTH INTERVENTIONS (by gender)

DISEASE CATEGORY	DALYs Gained/1,000		DALYs Gained/Case		PWAF	Discounted DALYs Gained/1,000		Discounted DALYs Gained	
	Males	Females	Males	Females		Males	Females	Males	Females
Group I Diseases: A. B. C. D. Subtotal									
Group II Diseases: A. B. C. D. E. F. G. H. I. J. K. L. M. N. Subtotal									
Group III Diseases: A. B. Subtotal									
Grand Total									

NOTES: This table could be modified to include age intervals. DALYs also refers to the number of healthy life years gained. The last column is the total value in the population.

TYPE OF COST	COST CATEGORY	DESCRIPTION OF QUANTITIES OF INPUTS	SOURCE OF INFORMATION
VARIABLE	Pharmaceuticals	Quantity and type of drugs, vaccines and contraceptives	Inventory records, facility surveys
	Supplies	Amount of needles, syringes, laboratory supplies, reagents, birthing kits, stationary, insecticides	Inventory records, facility surveys
SEMI-VARIABLE	Personnel	Number and type of health and auxiliary personnel involved in the health program	Facility surveys Expert opinion
	Per Diem/Supervision	Frequency of supervisory visits requiring per diem	Ministry of Health records Facility survey
	Vehicle Operation & Maintenance	Frequency and type of repairs, amount of fuel and oil to be used	Ministry of Health motor pool Facility survey
RECURRENT: FIXED-SPECIFIC & FIXED-GENERAL	Equipment Operation & Maintenance	Frequency and type of repairs; amount of fuel required for operation	Ministry of Health records Facility survey
	Promotion	Amount and type of resources required to reproduce promotional materials, as printed matter or broadcasts	Ministry of Communication Expert opinion
	Training	Amount and type of resources required to reproduce training materials and hold training sessions	Ministry of Health records Donor organizations
	Administration/ Management	Number and type of administrative personnel	Ministry of Health records Interview
CAPITAL: FIXED-SPECIFIC & FIXED GENERAL	Vehicle	Amount and type of vehicles used in the program, including automobiles, ambulances, airplanes, boats, bicycles, motorcycles	Ministry of Health records Facility survey Donor organization records
	Equipment	Amount and type of equipment, including operating tables, laboratory equipment, X-ray machines, cold chain and audio-visual equipment, computers	Ministry of Health records Facility survey Donor organization records
	Building	Amount and type of facilities which need to be constructed for the intervention	Ministry of Public Works Expert opinion Donor organizations
	Promotion	Amount and type of resources used to produce and develop original promotional materials	Ministry of Communication Expert opinion
	Training	Amount and type of resources used to produce and develop original training materials	Ministry of Health records Donor organizations

VARIABLE	Pharmaceuticals	Cost per bottle, vial or per unit, including freight and internal transportation costs, and cost of wastage	Inventory records, donor organization records, market survey
	Supplies	Cost per unit (box, carton, bottle) of supply	Inventory records, donor organization records, market survey
SEMI-VARIABLE	Personnel	Gross annual salary and fringe benefits, such as housing, transportation, allowances, medical coverage	Ministry of Health records Interview
	Per Diem & Supervision	Cost of daily stipend	Ministry of Health records Donor organizations
	Vehicle Operation & Maintenance	Cost of repairs, fuel and oil (per liter or per gallon	Market survey Ministry of Health motor pool Ministry of Transportation
RECURRENT: FIXED-SPECIFIC & FIXED-GENERAL	Equipment Operation & Maintenance	Cost of repairs and fuel for operation	Ministry of Health records Market survey
	Promotion	Cost of minute or second of broadcast time, cost of renting equipment	Ministry of Communication Private broadcasting corporation
	Training	Cost of reproducing training materials and operating training sessions	Ministry of Health records Donor organizations
	Administration/ Management	Gross salaries and benefits of administrative personnel	Ministry of Health records Interview
CAPITAL: FIXED-SPECIFIC & FIXED-GENERAL	Vehicle	Purchase price of vehicle, including freight and customs duties	Market survey Donor organization records
	Equipment	Purchase price of equipment, including freight and customs duties	Market survey Donor organization records
	Building	Construction cost (including fees)	Ministry of Public Works Ministry of Health Market survey
	Promotion	Cost of producing initial promotional materials	Ministry of Health records
	Training	Cost of producing training materials, including hiring of trainers, transportation	Ministry of Health records Donor organizations

APPENDIX A.18
SAMPLE TABLES FOR COST CALCULATIONS

TYPE OF PERSONNEL	QUANTITY REQUIRED	SALARY & BENEFITS/MO.	% TIME	COST/MO.	TOTAL COST	NOTES
HEALTH PERSONNEL						
a)						
b)						
c)						
d)						
e)						
f)						
Subtotal						
AUXILIARY PERSONNEL						
a)						
b)						
c)						
d)						
e)						
f)						
Subtotal						
ADMINISTRATIVE PERSONNEL						
a)						
b)						
c)						
Subtotal						
TOTAL COST OF PERSONNEL						
FORMULA: Number x Percent Time x Gross Monthly Salary and Benefits x 12						

TYPE	QUANTITY REQUIRED	UNIT OF MEASURE	POPULATION COVERED	UNIT COST	PERCENT USE	TOTAL COST
PHARMACEUTICALS						
a)						
b)						
c)						
d)						
e)						
Subtotal						
VACCINES						
a)						
b)						
c)						
d)						
e)						
Subtotal						
CONTRACEPTIVES						
a)						
b)						
c)						
d)						
e)						
Subtotal						
TOTAL COST OF PHARMACEUTICALS						

FORMULAS:
Pharmaceuticals cost = Quantity used/person/yr x Episodes/person/yr X Population covered x Unit cost x Percent use
Vaccine cost = (Number of doses utilized/yr + Number of doses wasted/yr)/Number of doses/vial x Unit cost/vial
Contraceptives cost = Amount used/person/yr x Persons covered x Unit price

NOTE: Unit prices need to represent f.o.b. or c.i.f prices.

TYPE OF SUPPLY	QUANTITY REQUIRED	UNIT OF MEASURE	POPULATION COVERED	UNIT COST	PERCENT USE	TOTAL COST
a)						
b)						
c)						
d)						
e)						
f)						
g)						
h)						
i)						
j)						
k)						
l)						
m)						
TOTAL COST OF SUPPLIES						
FORMULA: Quantity required/person/year x Population covered x Unit cost x Percent Use						

APPENDIX D: WORKSHEET FOR ESTIMATING THE COST OF PER DIEM					YEAR	
TYPE OF PERSONNEL	FREQUENCY OF SUPERVISION	LENGTH OF STAY (days)	PERCENT USE	PER DIEM AMOUNT	TOTAL COST	NOTES
a)						
b)						
c)						
d)						
e)						
f)						
TOTAL COST OF PER DIEM						
FORMULA: Frequency of supervision/month x 12 x Duration x Per Diem Amount x Percent Use for Health Intervention						

APPENDIX E: WORKSHEET FOR ESTIMATING VEHICLE OPERATING COSTS						YEAR
Type of Vehicle	Vehicle 1	Vehicle 2	Vehicle 3	Vehicle 4	Vehicle 5	Vehicle 6
FUEL COSTS						
Frequency of travel per month						
Distance per roundtrip						
Cost/unit of fuel						
Distance traveled/unit of fuel						
Subtotal fuel cost						
REPAIR COSTS						
Frequency of repair per month						
Cost of average repair						
Subtotal repair cost						
MAINTENANCE COSTS						
Frequency of maintenance per month						
Cost of maintenance						
Subtotal maintenance cost						
Subtotal Vehicle Operation						
Percent Use of Vehicle						
TOTAL VEHICLE OPERATION & MAINTENANCE COST						

Fuel cost = {[Number of roundtrips/month x 12 x Distance per roundtrip x unit cost of fuel] / Distance traveled per unit of fuel} x Percent Use
Repair cost = Frequency of repairs/month x 12 x Average cost per repair x Percent use
Maintenance cost = Frequency of maintenance activities/month x 12 x Average cost of maintenance activity x Percent use

APPENDIX F: WORKSHEET FOR ESTIMATING EQUIPMENT OPERATING COSTS						YEAR
TYPE OF EQUIPMENT	Equipment 1	Equipment 2	Equipment 3	Equipment 4	Equipment 5	Equipment 6
REPAIR COSTS						
Frequency of repair						
Cost of average repair						
Subtotal repair cost						
MAINTENANCE COSTS						
Frequency of maintenance						
Cost of maintenance						
Subtotal maintenance cost						
Subtotal Equipment Operation Costs						
Percent Use of Equipment						
TOTAL EQUIPMENT OPERATION & MAINTENANCE COST						
FORMULAS: Repair Cost = Frequency of Repairs/month x 12 x Average cost of repair x Percent use Maintenance Cost = Frequency of maintenance activities/month x 12 x Average cost of maintenance activities x Percent use						

APPENDIX G: WORKSHEET FOR ESTIMATING RECURRENT PROMOTION COSTS						YEAR
TYPE OF BROADCAST	DURATION OF BROADCAST (mins or secs)	FREQUENCY OF BROADCAST/MONTH	COST/UNIT OF TIME	PERCENT USE	TOTAL COST	NOTES
a)						
b)						
c)						
d)						
e)						
f)						
g)						
Subtotal Broadcast Costs						
TYPE OF PRINTED MATTER	VOLUME OF MATERIAL	FREQUENCY OF REPRODUCTION	UNIT COST OF REPRODUCTION	PERCENT USE	TOTAL COST	NOTES
a)						
b)						
c)						
d)						
Subtotal Printed Matter						
TOTAL RECURRENT PROMOTION COSTS						

FORMULAS:
Broadcast Cost = Duration of Broadcast x Frequency of Broadcast/month x 12 x Unit cost/time x Percent use
Materials Cost = Volume of materials (number of pages, booklets, etc.) x Frequency of reproduction/year x Unit cost x Percent

TYPE OF TRAINING	NUMBER OF PARTICIPANTS	DURATION OF TRAINING (days)	PER DIEM AMOUNT	PERCENT USE	TOTAL COST
a)					
b)					
c)					
d)					
e)					
Subtotal					

TYPE OF TRAINING	NUMBER OF TRAINERS	DURATION OF TRAINING	GROSS SALARY AND BENEFITS	PERCENT USE	TOTAL COST
a)					
b)					
c)					
d)					
e)					
Subtotal Trainer Cost					

TYPE OF MATERIALS	VOLUME OF MATERIALS	FREQUENCY OF REPRODUCTION PER YEAR	UNIT COST OF REPRODUCTION	PERCENT USE	TOTAL COST
a)					
b)					
c)					
d)					
Subtotal Material Costs					

TOTAL TRAINING COSTS	

FORMULAS:
Training Costs = Number of participants x Duration of training x Per Diem x Percent Use
Trainer Costs = Number of trainers x Gross salary/month x (Duration/Working days a month) x Percent Use
Materials Costs = Volume of materials x Frequency of reproduction per year x Unit cost x Percent use

TYPE OF VEHICLE	NUMBER	UNIT COST	PERCENT USE	USEFUL LIFE	PWAF	TOTAL COST	NOTES
VEHICLES							
a)							
b)							
c)							
d)							
e)							
Subtotal Vehicles Cost							
EQUIPMENT							
a)							
b)							
c)							
d)							
e)							
Subtotal Equipment Cost							
BUILDINGS							
a)							
b)							
c)							
d)							
Subtotal Building Cost							
TOTAL VEHICLE, EQUIPMENT AND BUILDING							
FORMULAS: (Number x Unit cost x Percent use) / Present Worth of Annuity Factor							

TYPE OF TRAINING	NUMBER OF PARTICIPANTS	DURATION OF TRAINING	PER DIEM AMOUNT	PERCENT USE	TOTAL COST	PWAF	ANNUAL COST
a)							
b)							
c)							
d)							
e)							
Subtotal Training Per Diem Costs							

TYPE OF TRAINING	NUMBER OF TRAINERS	DURATION OF TRAINING	GROSS SALARY AND BENEFITS	PERCENT USE	TOTAL COST	PWAF	ANNUAL COST
a)							
b)							
c)							
d)							
e)							
Subtotal Trainer Cost							

TYPE OF MATERIAL	PERCENT USE	DEVELOPMENT COSTS		TOTAL COST	PWAF	ANNUAL COST
a)						
b)						
c)						
d)						
Subtotal Material Costs						

SUBTOTAL TRAINING COSTS							

FORMULAS:
Training Annual Cost = {Number of participants x Duration x Per Diem x Percent Use} / PWAF
Trainer Annual Cost = {Number of trainers x Salary/month x (Duration/Working days a month) x Percent use}/PWAF
Materials Annual Cost = {Development cost/materials x Percent use} / PWAF

TYPE OF MATERIAL	PRODUCTION COST	PERCENT USE	SUBTOTAL	USEFUL LIFE	PRESENT WORTH OF ANNUITY FACTOR	TOTAL COST
a)						
b)						
c)						
d)						
e)						
f)						
g)						
h)						
i)						
j)						
k)						
l)						
Subtotal						

FORMULAS:
Promotion Capital Costs = {Production cost x Percent use} / PWAF

TYPE OF COST	COST CATEGORY	TOTAL COST	PERCENT	NOTES
RECURRENT COSTS				
Variable	Pharmaceuticals			
	Supplies			
	Subtotal			
Semi-Variable	Personnel			
	Per Diem/Supervision			
	Vehicle Operation & Maintenance			
	Subtotal			
Fixed-Specific or Fixed-General	Equipment Operation & Maintenance			
	Promotion			
	Training			
	Administration & Management			
	Subtotal			
Subtotal Recurrent Costs				
CAPITAL COSTS				
Fixed-Specific or Fixed-General	Vehicle			
	Equipment			
	Building			
	Promotion			
	Training			
	Subtotal			
TOTAL COST OF THE HEALTH INTERVENTION				
MARGINAL COST OF THE HEALTH INTERVENTION				

[80] World Bank, Africa Technical Department, Human Resources and Poverty Division, A

[81] World Bank, Africa Technical Department, Human Resources and Poverty Division, A

APPENDIX A.22: PROJECTED QUANTITIES AND TYPES OF INPUTS FOR MULTI-YEAR HEALTH INTERVENTIONS

RECURRENT COST	CATEGORY	YEAR __	YEAR __	YEAR __	YEAR __	YEAR __	NOTES
Variable	Pharmaceuticals						
	a)						
	b)						
	c)						
	d)						
	Supplies						
	a)						
	b)						
	c)						
	d)						
Semi-variable	Personnel						
	a)						
	b)						
	c)						
	d)						
	Per Diem /Supervision						
	a)						
	b)						
	c)						
	Vehicle Operation and Maintenance						
	a)						
	b)						
	c)						

APPENDIX A.21 (cont'd): PROJECTED QUANTITIES AND TYPES OF INPUTS FOR MULTI-YEAR HEALTH INTERVENTIONS

TYPE OF COST	CATEGORY	YEAR __	YEAR __	YEAR __	YEAR __	YEAR __	NOTES
Fixed-Specific or Fixed-General	Equipment Operation and Maintenance						
	a)						
	b)						
	Promotion						
	a)						
	b)						
	Training						
	a)						
	b)						
CAPITAL							
Fixed-Specific or Fixed-General	Vehicles						
	a)						
	b)						
	Equipment						
	a)						
	b)						
	Buildings						
	a)						
	b)						
	Promotion						
	a)						
	b)						
	Training						
	a)						
	b)						

APPENDIX A.23: PROJECTED UNIT COSTS OF INPUTS FOR MULTI-YEAR HEALTH INTERVENTIONS

RECURRENT COST	CATEGORY	YEAR __	YEAR __	YEAR __	YEAR __	YEAR __	NOTES
Variable	Pharmaceuticals						
	a)						
	b)						
	c)						
	d)						
	Supplies						
	a)						
	b)						
	c)						
	d)						
Semi-variable	Personnel						
	a)						
	b)						
	c)						
	d)						
	Per Diem & Supervision						
	a)						
	b)						
	c)						
	Vehicle Operation & Maintenance						
	a)						
	b)						
	c)						

APPENDIX A.23 (cont'd): PROJECTED UNIT COSTS OF INPUTS FOR MULTI-YEAR HEALTH INTERVENTIONS

TYPE OF COST	CATEGORY	YEAR __	YEAR __	YEAR __	YEAR __	YEAR __	NOTES
Fixed-Specific or Fixed-General	Equipment Operation & Maintenance						
	a)						
	b)						
	Promotion						
	a)						
	b)						
	Training						
	a)						
	b)						
CAPITAL							
Fixed-Specific or Fixed-General	Vehicles						
	a)						
	b)						
	Equipment						
	a)						
	b)						
	Buildings						
	a)						
	b)						
	Promotion						
	a)						
	b)						
	Training						
	a)						
	b)						

	EPI	MCH	Family Planning	Injury	Total Time Required	Full Time Equivalents	Number of Staff	Staff Needed
HEALTH STAFF								
a)								
b)								
c)								
d)								
e)								
f)								
AUXILIARY PERSONNEL								
a)								
b)								
c)								
d)								
e)								
f)								
ADMINISTRATIVE PERSONNEL								
a)								
b)								
c)								

APPENDIX A.25: PROJECTED PERCENT USE OF INPUTS FOR MULTI-YEAR HEALTH INTERVENTIONS

RECURRENT COST	CATEGORY	YEAR __	YEAR __	YEAR __	YEAR __	YEAR __	NOTES
Variable	Pharmaceuticals						
	a)						
	b)						
	c)						
	Supplies						
	a)						
	b)						
	c)						
Semi-variable	Personnel						
	a)						
	b)						
	c)						
	Per Diem /Supervision						
	a)						
	b)						
	Vehicle Operation & Maintenance						
	a)						
	b)						
	c)						

APPENDIX A.25 (cont'd): PROJECTED PERCENT USE OF INPUTS FOR MULTI-YEAR HEALTH INTERVENTIONS

TYPE OF COST	CATEGORY	YEAR __	YEAR __	YEAR __	YEAR __	YEAR __	NOTES
Fixed-Specific or Fixed-General	Equipment Operation & Maintenance						
	a)						
	b)						
	Promotion						
	a)						
	b)						
	Training						
	a)						
	b)						
CAPITAL							
Fixed-Specific and Fixed-General	Vehicles						
	a)						
	b)						
	Equipment						
	a)						
	b)						
	Buildings						
	a)						
	b)						
	Promotion						
	a)						
	Training						
	a)						

Variable	Pharmaceuticals						
	a)						
	b)						
	c)						
	d)						
	Supplies						
	a)						
	b)						
	c)						
	d)						
Semi-variable	Personnel						
	a)						
	b)						
	c)						
	d)						
	Per Diem /Supervision						
	a)						
	b)						
	c)						
	Vehicle Operation & Maintenance						
	a)						
	b)						

Fixed-Specific and Fixed-General	Equipment Operation & Maintenance						
	a)						
	b)						
	Promotion						
	a)						
	b)						
	Training						
	a)						
	b)						
CAPITAL							
Fixed-Specific and Fixed-General	Vehicles						
	a)						
	b)						
	Equipment						
	a)						
	b)						
	Buildings						
	a)						
	b)						
	Promotion						
	a)						
	b)						
	Training						
	a)						
	b)						
TOTAL COST							
PRESENT VALUE							
DISCOUNTED TOTAL COST							
DISCOUNTED MARGINAL COST							

[82] World Bank, Africa Technical Department, Human Resources and Poverty Division, A

MULTI-YEAR HEALTH INTERVENTIONS

INDICATOR	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5
Original Incidence Rate/1,000					
Efficacy (%)					
Coverage (%)					
Percent change in incidence rate					
Revised incidence rate					
Original CFR					
Compliance rate					
Percent change in CFR					
Revised CFR					
Original values of D or D_{od}					
Percent change in D or D_{od}					
Revised values of D or D_{od}					
NOTES:					

APPENDIX A.29: DISCOUNTED HEALTHY LIFE YEARS OR DALYs GAINED \ FOR MULTI-YEAR INTERVENTIONS

HEALTH INTERVENTION	YEAR 1		YEAR 2		YEAR 3		YEAR 4		YEAR 5		TOTAL	
	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE	MALE	FEMALE
Disease Category I: A. B. C. D. Subtotal												
Disease Category II: A. B. C. D. E. F. G. H. I. J. K. L. M. N. Subtotal												
Disease Category III: A. B. Subtotal												
Grand Total												

APPENDIX A.30: FRAMEWORK FOR COMPARING THE AVERAGE AND MARGINAL COST-EFFECTIVENESS OF ALTERNATIVE HEALTH INTERVENTIONS

HEALTH INTERVENTION	DISCOUNTED NUMBER DALYs GAINED	TOTAL ANNUAL COST	MARGINAL COST	AVERAGE COST/DALY	MARGINAL COST/DALY	NOTES
a)						
b)						
c)						
d)						
e)						
f)						
g)						
h)						
i)						
j)						
k)						
l)						
m)						

NOTE: This table could be modified to include age intervals, or to accommodate results from multi-years projects.

APPENDIX A.31: RANKING OF HEALTH INTERVENTIONS ON BASIS OF THE MARGINAL COST PER DALY

HEALTH INTERVENTION	MARGINAL COST/ DALY GAINED	AVERAGE COST/ DALY GAINED	ACCEPTABILITY	AFFORDABILITY	LOGISTIC FEASIBILITY	NOTES
a)						
b)						
c)						
d)						
e)						
f)						
g)						
h)						
i)						
j)						
k)						
l)						
m)						
n)						

NOTES: The columns marked acceptability, affordability, and logistic feasibility can be completed by estimating whether each of these parameters are high, medium, or low for the region or country.

APPENDIX A.32: ORGANIZATION OF HEALTH SERVICES
ACCORDING TO RANGES OF COST-EFFECTIVENESS FIGURES

Cost/DALY or Healthy Life Year Saved	Interventions	Notes/Discussion
< $10/DALY		
$10 - $25/DALY		
$25 - $50/DALY		
$50 - $100/DALY		
$100 - $250/DALY		
$250 - $500/DALY		
$500 - $1000/DALY		
> $1000/DALY		

APPENDIX A.33
COST PER DALY FOR THE ESSENTIAL PACKAGE OF HEALTH SERVICES [83]

ESSENTIAL PACKAGE OF HEALTH SERVICES	COST/DALY ($)	COST/CAPITA ($)
Low Income, GNP/capita of $350		
Public Health Services:		
Expanded Program on Immunization (EPI-plus)	12 - 17	0.5
School health program	20 - 25	0.3
Other public health programs	na	1.4
Tobacco and alcohol control	35 - 50	0.3
AIDS prevention program	3 - 5	1.7
Total		4.2
Essential clinical Package:		
Short-course chemotherapy for tuberculosis	3 - 5	0.6
Management of the sick child	30 - 50	1.6
Prenatal and delivery care	30 - 50	3.8
Family planning	20 - 30	0.9
Treatment of STDs	1 - 3	0.2
Limited tertiary care	200 - 350	0.7
Total		7.8
Total Cost of the Essential Package of Health Services		12.0
Middle Income, GNP/capita of $2,500		
Public Health Services:		
Expanded Program on Immunization (EPI-plus)	23 - 28	0.7
School health program	32 - 37	0.5
Other public health programs	na	2.7
Tobacco and alcohol control	45 - 55	0.5
AIDS prevention program	12 - 17	1.9
Total		6.3
Essential clinical Package:		
Short-course chemotherapy for tuberculosis	5 - 7	0.2
Management of the sick child	50 - 100	1.0
Prenatal and delivery care	60 - 110	6.8
Family planning	100 - 150	2.0
Treatment of STDs	10 - 15	0.2
Limited tertiary care	400 - 600	1.8
Total		12.0
Total Cost of the Essential Package of Health Services		18.3

[83] World Development Report, World Bank, Tables 4.7 and 5.3, 1993.

APPENDIX A.34:
WORKSHEET FOR CONDUCTING A SENSITIVITY ANALYSIS

INDICATOR	DALY GAINED	TOTAL COST	MARGINAL COST	AVERAGE COST/DALY	MARGINAL COST/DALY
Base Case					
Scenario 1:					
Scenario 2:					
Scenario 3:					
Scenario 4:					
Scenario 5:					
Scenario 6:					
Scenario 7:					