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THE COST OF EPI:

A REVIEW OF COST AND COST-EFFECTIVENESS STUDIES

(1979 - 1987)

Resources for Child Health Project

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ABBREVIATIONS

AID	U.S. Agency for International Development
BCG	Bacillus Calmette-Guerin Vaccine
CCCD	Combatting Childhood Communicable Diseases
CDC	U.S. Centers for Disease Control
DPT	Diphtheria-Pertussis-Tetanus Vaccine
EPI	Expanded Program on Immunization
GAG	Global Advisory Group
GDP	Gross Domestic Product
IDB	InterAmerican Development Bank
ISS	Immunization Sustainability Study
ORT	Oral Rehydration Therapy
PAHO	Pan American Health Organization
PHC	Primary Health Care
PPC	Program and Policy Coordination Bureau (A.I.D.)
PVO	Private Voluntary Organization
REACH	Resources for Child Health Project
TAG	Technical Advisory Group
UNICEF	United Nations Childrens Fund
WHO	World Health Organization

FOREWORD

The Resources for Child Health (REACH) Project was initiated by the U.S. Agency for International Development (A.I.D.) to provide technical assistance to developing countries in the areas of immunization and health care financing (HCF). The overall goal of A.I.D. assistance in the health sector is to improve health status in developing countries through support of cost-effective interventions directed at the most needy populations -- poor mothers and children. A.I.D. health assistance is seen primarily as an investment in the development of national self-sufficiency in achieving sustainable improvements in health status as reflected by reductions in infant, child, and maternal mortality and morbidity.

Sustaining improvements in health status requires, in addition to direct program support, support for strengthening the national capacity to generate and manage resources more effectively. The provision of such support is the basis for the A.I.D. effort in health care financing and its implementation is a central focus of the REACH project. REACH health care financing technical assistance focuses on the generation of improvements in resource allocation, efficiency, resource mobilization, and equity in the health sector. The goal of this assistance is to increase the effective level of resources available for health in developing countries by supporting, where appropriate, the implementation of activities to increase the level and direction of government commitment to health, mobilize increased revenues from users of health services and other nongovernmental sources, and improve the efficiency with which available resources are utilized in both the public and the private sectors.

As part of this effort, REACH has conducted several major studies of health financing in Africa, Asia, and Latin America which examine the costs of health services, patterns of utilization, the potential for generating additional resources, and management efficiency in the health sector. In addition, REACH has conducted several workshops to provide training in health care financing to health workers and decision-makers in A.I.D.-assisted countries. REACH has also carried out several multi-country comparative analyses in order to draw lessons learned and share this experience with other countries.

REACH is also one of the principal mechanisms through which A.I.D. plays a major role in the global immunization effort. A.I.D. recognizes the important roles of WHO, UNICEF, and other bilateral donors in supporting governments through the Expanded Program on Immunization (EPI). It supports these efforts by emphasizing policy dialogue, encouraging private sector participation, and searching for more cost-effective delivery systems. In close collaboration with WHO and UNICEF, REACH provides technical assistance to national Expanded Programs on Immunization (EPI) to improve planning, surveillance and evaluation, financial analysis, communications, training, management information systems, and research. The goal of this effort is to decrease mortality and morbidity associated with immunizable diseases through increased coverage and a strengthened capacity to sustain the immunization effort.

While commitment to this goal is implicit in the efforts of both the countries and the donors, its achievement still faces considerable uncertainty. The REACH publication EPI Essentials notes that "...One concern is the recurrent cost of maintaining the EPI at an epidemiologically acceptable level in the future. It is unknown what it costs to sustain coverage levels, particularly in an ever-increasing population, and the long-term financing of the EPI by countries and donors has not yet been discussed seriously."[1] Responding to this area of uncertainty has been a central activity for the REACH project.

This review of costing and cost-effectiveness studies of the EPI is one example of the REACH effort. It draws on the experience of both the EPI and HCF units of the REACH Project and is designed to shed light on the question of the sustainability of immunization efforts noted above. The report summarizes the methods and results of the major costing and cost-effectiveness studies of the EPI. It was initiated to provide an overview of what is currently "known" about the costs of EPI and their relationship to the outcomes of the programs.

This report is part of a broader REACH effort to develop a policy issues framework within which the interrelationship among immunization targets, program strategies, cost, financing, and program results (e.g. coverage levels) can be examined. The goal of the study is to develop an understanding of what constitutes a sustainable level of immunization where sustainability reflects both the costs of achieving a given level of coverage (productivity) and a country's ability to provide it (affordability). This report summarizes the existing cost experience that provides the empirical basis for the productivity side of the analysis.

The report also makes a general contribution to the growing effort to understand and manage more effectively the use of resources for EPI. By compiling this experience and making it more widely available, the REACH project hopes to provide additional support for our shared goal of strengthening the global immunization efforts and the effectiveness with which resources are used to improve health.

The REACH Project invites comments on all of our publications and welcomes the opportunity to continue our collaboration with interested colleagues through the widest possible dissemination and discussion of REACH materials.

Gerald Rosenthal, Ph.D.
Associate Director for Health
Care Financing
The REACH Project
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[1] Cynthia Rawn and Norbert Hirschhorn, EPI Essentials: A Guide for Program Officers. John Snow, Inc., August 1988, p. 142.

EXECUTIVE SUMMARY

This document reviews 28 financial and economic evaluations of the Expanded Program on Immunization (EPI) as part of the Immunization Sustainability Study (ISS) undertaken by the Resources for Child Health Project (REACH) for the Program and Policy Coordination Bureau of the Agency for International Development. The objectives of this review are to assess the quality and consistency of cost and cost-effectiveness studies of the EPI and to determine the extent to which these data provide a basis on which to generalize relationships between program costs and coverage levels in the future.

This document both describes and analyzes the cost and cost-effectiveness literature between 1979 and 1987. Characteristics of each of the financial and economic studies, such as the range of effectiveness measures and the scope of the analysis, are described and compared. The eight country studies (totaling eleven cost-effectiveness ratios for different strategies) selected for further analysis all measure program effectiveness through 30-cluster sample surveys following World Health Organization methodology. These studies therefore identified and calculated program costs in a similar manner.

This overview supports, and in some cases, revises the findings of previous reviews of the literature of cost-effectiveness studies of the EPI (11, 20). The major findings of the REACH review can be summarized as follows:

A. The average cost per fully immunized child (based on eleven estimates) was found to be $13, which is within the specified range of $5-$15 per child presented at the Bellagio Conference in 1984. This figure varies only slightly according to the particular strategy or region under consideration. Routine services through fixed facilities have the lowest cost per fully immunized child (on average $11.74). Immunization campaigns have a higher cost per fully immunized child at $15.62. However, these data do not suggest great differences among different strategies in average cost. Moreover, immunization programs in Africa have lower average costs than those in Asia though the range is also small (between $12.25 to $16.41 for all strategies).

An average figure of $13 per fully immunized child could be used to estimate the cost of an EPI worldwide, regardless of approach used. This average cost per child should be corroborated with data from future studies which use similar methods.

B. The contributions of national governments to immunization programs (approximately 50% of total program cost) are lower than reported earlier. For routine services through fixed facilities, the proportion of government contribution is greatest at 55% of total; this proportion diminishes to 40% for campaign strategies. In addition, government contributions to the EPI tend to be in the form of salaries for health workers, building depreciation costs, and in some instances, transport costs. The bulk of EPI costs (particularly those which require foreign exchange, such as vaccines, syringes, cold chain equipment, vehicles, and even local training costs) are being borne by international organizations and outside donor agencies. The study found that countries with lower GNP per capita make less of a relative contribution to the EPI from government resources.

C. As expected, the larger the population reached by the EPI, the larger the total program cost, although it appears that average cost declines with increasing coverage rates. This relationship supports earlier theories of Creese and has implications for the ability of highly populated countries (Nigeria and Indonesia, for instance) to finance a national EPI at high coverage levels. The results from the Mauritania study, showing a cost-effectiveness ratio for the national campaign nearly half that of the campaigns in Cameroon and Senegal, support this finding as well because the Mauritania campaign covered a smaller target population that lived in urban areas.

D. Sustaining immunization programs and strategies using only government resources will be difficult in some countries, particularly when government health expenditures are already low. WHO/EPI concluded at the Bellagio Conference in 1984 that the implementation of the EPI cannot occur without the continued high commitment of international donor organizations. For most national governments, securing significant resources for preventive programs will require either a reallocation of resources from curative to preventive programs or to the health sector from other sectors, improved efficiency of service delivery and/or financing of immunization by individuals.

E. At the present time, insufficient empirical data exist that can be used to determine the cost of an EPI at higher coverage levels. Cost-effectiveness studies have not been undertaken at repeated intervals to measure the incremental coverage gains and link them to changes in costs. Future studies should be designed which measure the relationships between costs and coverage levels over time so that estimates can be made about the cost of reaching higher coverage levels and/or eradicating disease in the future.

F. This review confirms earlier observations of previous summaries (Creese, Haaga, and Parker) on the varied quality and lack of consistent methodology for cost-effectiveness studies. A cost-effectiveness study protocol should be developed which would standardize basic costing and effectiveness terminology and methods, and, as well, address the needs of program managers and policy makers. The study protocol would help managers evaluate the distribution and use of EPI resources in order to improve effectiveness and efficiency of service delivery. The study strategy should also take into account issues relevant to policy makers, such as the cost of reaching higher coverage rates or eradicating disease.

G. The process of undertaking this review has revealed that there has not been enough dissemination of study findings from one country to another or documentation of use of study results in-country. Evidence suggests that studies are conducted on an ad hoc basis, without building upon previous experience in the region or even in the same country.

I. PURPOSE OF THIS REVIEW

Prepared as part of the Immunization Sustainability Study (ISS) undertaken by the Resources for Child Health Project (REACH) for the Program and Policy Coordination Bureau of the Agency for International Development, this document reviews 28 economic and financial studies of the Expanded Program on Immunization (EPI). The overall goal of the Immunization Sustainability Study is to assess the level of resources required to maintain immunization coverage levels or to achieve future targets, and to judge to what extent these resource requirements can be financed by countries within their domestic economic resources. To accomplish this goal, a policy framework has been developed which compares Expanded Program on Immunization (EPI) outcomes with program inputs and links inputs to macro-economic indicators for specific countries for which there are sufficient data.

This document describes and analyzes the costing, cost-benefit and cost-effectiveness literature to assess the quality and consistency of cost and effectiveness data on EPI and to determine whether these data provide a sufficient basis on which to generalize relationships between program costs and coverage levels in the future. It is anticipated that this review will establish guidelines for further analysis of how resources used for EPI translate into coverage gains.

A review of the cost literature can facilitate addressing some of the following questions:

1) What will it cost to maintain immunization coverage, and could this cost be financed by governments, given current economic capacity?

2) What will it cost to reach higher levels of coverage, and could this cost be financed by governments, given future economic capacity?

3) In which countries should we expect donor contributions to be the major source of financing for EPI activities and for how long into the future?

4) In which countries can we expect that high coverage levels and reduced childhood mortality and morbidity can be achieved and within what time period?

5) What would the implications be for cost, coverage and affordability of changing EPI technologies and strategies (i.e., changing to eradication of disease)?

6) What would the implications be for cost, coverage and affordability of improving the economic conditions of countries?

This document is organized into five sections. Section I states the purpose of the review. Section II provides a brief historical perspective about the importance of cost analysis for the EPI and donor agency perspectives on the policy issues of the program. Section III reviews and compares the results of the 28 studies, which are described further in Appendix D. Section IV describes the policy implications of the findings of the review, and Section V provides recommendations for future studies.

II. PERSPECTIVES ON COSTING OF EPI

Discussion of the costs and cost-effectiveness of immunization programs has taken place among the international donor community since the early 1980s (11, 20, 27, 36). EPI has been described repeatedly in earlier studies as one of the most "cost-effective" means of reducing childhood mortality since the unit cost per dose of vaccines were (and still are) relatively low compared to the enormous costs of treating

disease on an inpatient hospital basis. It was believed that it cost approximately $5 to $15 to immunize a child fully, and that immunization programs should be affordable to most countries (36).

This viewpoint was supported by the fact that the recurrent costs of tertiary care facilities far surpassed the cost of operating the EPI in almost all developing countries. Therefore, if diseases could be prevented by immunization, resources to provide inpatient hospital care could be saved or reallocated to strengthen the delivery of EPI services in the long-run. This type of argument led to increased commitments on the part of the donor community for financing the start-up and early operating costs of immunization programs in order to increase coverage. The following section reviews the main historical viewpoints on the costs and affordability of the EPI for each of the major donors.

A. BELLAGIO CONFERENCE, 1984

The Bellagio Conference in 1984 was a momentous occasion that brought key policy makers from major donor organizations and national governments together to discuss their role in protecting children by strengthening and supporting the Expanded Program on Immunization. The outcome of the meeting was a "plan to immunize all of the world's children as an impetus to primary health care..." (preface, 36).

In his discussion of vaccine preventable diseases of children, Dr. R.H. Henderson, Director of the EPI in Geneva made a convincing argument for the affordability of immunization:

> Immunization is one of the most cost-effective measures to reduce childhood mortality. This in itself provides a powerful justification to provide the necessary financial resources. Furthermore, the resources required are not large. WHO estimates that it costs US$ 5.00 to $15.00 to fully immunize a child, and as infants generally comprise 4% of the population, a national immunization program could be fully implemented for an investment of approximately US$ 0.20-0.60 per capita. Some 80% of these costs will be borne by the developing country itself, as they largely represent the salaries of staff and operating costs. The items most readily supplied by the international community, comprising vaccines, vaccination supplies, cold chain equipment, vehicles and training, account for 20% or less of the costs.
>
> Even if modest, however, such costs do pose problems. Although immunization services for children and mothers are affordable within the national resources of all but a handful of the world's poorest countries, most national health budgets are typically consumed by the operating expenses of hospitals and the purchase of drugs which benefit only a small proportion of the total population. It has proved difficult to increase the support available for immunization and other preventive services by decreasing the current investments in curative services. Rather, increases have been sought by increasing the proportion of newly available resources allocated to prevention... (pps. 10-11).

Dr. Henderson also states that variations in total program costs are due to national strategies and conditions, but that all studies "indicate that immunization costs are expensive during the development period of the program, as they cover fixed costs while delivering services to a relatively small percent of the infant population. It will usually require five to ten years before most countries are able to attain immunization coverage levels in the range of 60%-80% when the services then tend to be more cost-efficient" (p. 34).

These statements were based upon a review of available EPI costing studies undertaken by WHO in 1984. The following table summarizes the results of available studies at that time (see Haaga, 1982, for a listing of the studies).

TABLE 1

Estimated distribution of costs for fully immunized children in the developing world

Category of cost	% of total cost	% of total costs from national sources	% of total costs from external sources
Recurrent:			
Vaccines	14	9	5
Vaccine supplies	8	6	2
Salaries	45	43	2
Training	5	3	2
Cold chain and transport: operating cost	11	8	3
Nonrecurrent:			
Cold chain and transport: capital cost	17	10	7
TOTAL	100	79	21

Based on a review of available studies, 1984.
Source: Bellagio Conference Proceedings, Rockefeller Foundation, 1984.

Dr. William Foege, Centers for Disease Control, in his presentation on "Protecting the World's Children: Strategies for Attaining the Goal," makes the observation that the "paucity of existing data on the actual expenditures of immunization programs in developing countries makes it difficult to determine the precise total cost of the proposed immunization initiative." He contends that there is "a wide range of immunization program sizes, vaccine packages, delivery system settings with different input requirements, years of operation, service contacts and financial

accounting systems, which preclude direct comparisons. In addition, ... studies are based on short-term data, which inhibits identification of both economies and diseconomies of scale." (p. 100, Bellagio Conference Summary)

Dr. Foege presented data from a World Bank projection of the total cost of fully vaccinating infants and women at varying coverage levels for both routine and accelerated strategies. This projection estimates that on an annual basis, external funding for the routine EPI will be approximately $226 million. These projections were based on the assumption that donor assistance would not exceed 80% of the total cost of immunizing women and children (pps. 110-114).

On the basis of these figures, Foege suggested that external assistance should be provided for from five to 20 years, with countries gradually replacing external assistance with national support. In addition, an argument was made that early research should focus on "acquiring a better understanding of costs and identification of potentially greater efficiencies of limited resource use." (p. 103)

Therefore, an agenda was established during the Bellagio Conference in 1984 to investigate further the relationships between investments in the EPI and improvements in child health, as well as to assess the long-run affordability of immunization programs to national governments. This agenda called for additional efforts in planning the financial sustainability of national EPIs.

B. DONOR PERSPECTIVES

1. World Health Organization

The World Health Organization has played a major role in the development of costing methodologies and cost analysis for the EPI. In 1979, the EPI costing guidelines (45) were developed in order to facilitate cost analysis, as well as to improve the consistency of cost and cost-effectiveness information. The guidelines provide general rules about cost calculations and the allocation of joint costs among immunizations and other services provided in health facilities. Costs are classified as either capital or recurrent costs. Capital costs include those of buildings, vehicles and equipment (cold chain) and other associated costs, including spare parts. Recurrent costs include salaries and benefits, transport, vaccines, training and miscellaneous costs.

The method recommends allocating personnel costs by the proportion of time spent per health worker to administer vaccinations. Vaccine costs are constructed from the number of vials of vaccine used in the health facility multiplied by the unit price per vial. Transport costs are based on the numbers of kilometers driven for the EPI. Other costs are to be reconstructed based on facility records. Capital costs are allocated to the program based on their initial purchase price or replacement value. This figure is multiplied by a proportion of use for the program (presumably determined through interviews) and divided by a present worth of annuity factor that is based on the useful life of the capital asset and the current official interest rate (discount rate) in the country.

The EPI costing guidelines were extensively field-tested in three Asian countries (Thailand, the Philippines, and Indonesia) and used to evaluate alternative strategies in Colombia and Brazil. The guidelines were developed as a training tool and were strongly oriented toward managerial applications.

Recently, the WHO developed a standardized computer cost analysis program (EPICost) for program managers to improve the efficiency and effectiveness of the EPI. This spreadsheet is currently being field-tested. WHO is also encouraging more cost analysis of individual county programs, as well as a review of previous studies in order to examine two other issues. The first is whether previous estimates of cost per fully immunized child and the proportion of national resources devoted to immunization strategies remain more or less correct. The second, based on a review of a number of countries, is how programs can be planned in the future to minimize dependence on external resources.

2. Pan American Health Organization

In 1985 as part of a larger initiative to strengthen and accelerate the EPI in the Americas, the Pan American Health Organization committed itself to the eradication of polio virus from the Region by 1990 (43). Several organizations besides PAHO support this effort, including AID, UNICEF, the IDB and Rotary International, bringing the total five-year donor contribution to $85 million (1987-91).

In order to assure an optimal utilization of resources and to avoid duplication of effort, an Interagency Coordinating Committee (ICC) was formed at the regional level to oversee progress on a biannual basis (43).

A matrix for programming and tracking EPI budgets at the country level was developed in 1987 in order to monitor five year budgets for the EPI and eradication efforts. This budget matrix analyzes recurrent and capital costs for the following categories: biologicals, cold chain, training, social communications, operational costs, supervision, epidemiological surveillance, and research and evaluation. For each, an expected output and time frame is determined. At the country level, the MOH/EPI meets with ICC agencies to negotiate and determine the budget, a "Plan of Action" for each category, and the source of financing, i.e. national or external (by agency).

PAHO's preliminary analysis for 19 countries shows that over $450 million was committed to the Plans of Action, 85% financed by government resources. The proportion of external funds ranges from 4% in Brazil to 48% in Bolivia. Overall, nearly 90% of recurrent costs will be funded by national resources (43).

The Financial Analysis Framework will be evaluated in the near future to determine whether it has allowed countries to monitor expenditures and variances between budget and expenditures. To date, no other agency has adapted a framework such as PAHO's.

3. UNICEF

By 1988, worldwide immunization coverage reported for the third doses of DPT and polio has surpassed the 50 percent level in both developing and developed countries (2) and regional differences in coverage have decreased considerably (WHO, GAG 1988). UNICEF has been a major force behind the acceleration of the EPI as part of its global effort to achieve Universal Childhood Immunization (UCI). Since 1984, approximately 60 countries have undertaken national campaigns, periodic pulses and intensification of routine activities among other strategies. Annual funding for UCI approached $90 million in 1988 (personal communication; UNICEF).

The range of acceleration experiences around the world has been reported to the Global Advisory Group (WHO) in 1987 and 1988 by UNICEF. The major contributions of accelerated strategies have been 1) enhanced immunization coverage within a short period of time; 2) increased social awareness and mobilization of the population for immunization services; 3) stronger political commitment to the program; and 4) strengthened infrastructure (e.g., equipment and retrained personnel) for immunization services.

On the other hand, UNICEF has been criticized for its approach toward acceleration efforts, and weak technical support in planning some campaigns. Accelerations have sometimes been launched at the expense of other health programs in the short run and, in some cases, EPI activities have declined following mass campaign efforts. The experiences reviewed suggest a greater need for planning and promoting integration and

sustainability of the program. The costs of campaigns have been larger in some cases than routine program costs, raising questions about the economic justification of this strategy.

To address these issues while supporting the goals of UCI, UNICEF has actively participated in and financed economic and financial evaluations of national programs and campaigns. In addition, efforts are underway to train UNICEF staff and consultants in methods for cost analysis for planning and monitoring EPI activities.

The role of economic and financial evaluation of EPI has been a concern for UNICEF since 1984. Some of the limitations of existing cost-effectiveness studies are presented in a memorandum written jointly by UNICEF with the World Bank. This document states that...

> existing evidence is not sufficient to allow generalization about the future costs of the EPI, on either a country-specific or wider basis, with a high degree of confidence. (27)

This inability to generalize or project future EPI costs was due to several factors, including the 1) variation in measuring program effectiveness (i.e., different target populations); 2) variation in immunization strategies; 3) the nonuniformity of accounting frameworks used; and 4) variation in the prices of inputs.

In a subsequent memorandum from the same source, it was stressed that the World Health Organization's EPI costing guidelines (44) should be reviewed and refined in light of the current experience in the field with cost-effectiveness studies. This memo proposes some new directions for cost analysis of immunization programs, including determining the

incremental costs of the EPI, defining better outcome measures, assessing costs of immunization to beneficiaries, and developing a repository of costing information so that each new study could build upon previous ones.

These documents have contributed to discussions about the gaps and problems in the application of economic and financial evaluations to EPI. Although some improvements have been made in the methods of analysis and refinement of outcome measures, the new directions outlined above remain largely unimplemented.

In a recent article (1987), "Increasing the Usefulness of Cost-effectiveness Analysis in Immunization Program Management," D. Parker underscores the fact that little use has been made of the results of costing evaluations of the EPI and proposes three themes or directions for UNICEF in this domain (29). These ideas (paraphrased below) are based on the UNICEF experience with cost and cost-effectiveness analysis of the EPI.

The first theme focuses on the development of costing frameworks and their use and application in the field. Through negotiations with EPI managers, donors and evaluators, better and more responsive methods could be designed. More regular feedback of study results may improve their utility for program management and planning as well. Second, a set of costing indicators should be developed which would assist in the interpretation of cost-effectiveness analyses. Such indicators include the choice of costing categories and the measures chosen to evaluate program effectiveness.

Finally, the relationship between policy questions and the results of cost-effectiveness studies needs to be better articulated. Several recommendations for priority issues include efficiencies in delivery of immunization services, estimating costs of alternative strategies, and gaining a better understanding of program costs at different scales of operation, "by combining cost estimates into a broader picture of cost functions."

4. Agency for International Development

Over the past few years, AID has increased its commitment to and financing for immunization in the context of the Agency's Child Survival emphasis. AID pledged its support for a global effort for universal immunization by 1990, and Agency funding for immunization services increased from approximately $30 million in 1985 to $51 million in 1988 (internal document). Funding for 1989 and 1990 will remain at about the same level. In addition, the Agency provides funds to other international donor organizations, such as the Pan American Health Organization, Rotary International and UNICEF, to support their efforts toward global eradication of polio and universal childhood immunization by 1990. Contributions to these agencies are included in the annual figures reported above.

AID supports EPI through bilateral child survival projects, projects with private voluntary organizations and two large projects in Africa and worldwide: Childhood Communicable Diseases (CCCD) Project and the

Resources for Child Health (REACH) Project. The Agency stresses integration of primary health services over vertical, campaign strategies and generally follows WHO technical guidelines.

The CCCD Project focuses on prevention of childhood diseases in nine African countries through immunization, on reduction of infant and child mortality and morbidity from diarrheal diseases through administration of ORT, and prevention of malaria through prophylaxis and early detection and treatment of clinical cases. In addition, USAID supports national immunization programs by financing Technical Advisors for Child Survival (TACS) in USAID-assisted countries.

The REACH Project was designed to support the Agency's goal of reducing childhood morbidity and mortality through immunization and works in USAID-assisted countries to strengthen EPI. Of particular emphasis is improving surveillance and monitoring of the EPI; evaluation, including cost-effectiveness analysis and coverage surveys; research on social acceptability of immunization; and control of tetanus.

AID's Asia/Near East Bureau has sponsored the development of a standardized costing framework and methodology for planning, monitoring and evaluating AID health projects. The ANE Bureau Guidance for Costing Health Service Delivery Projects (1) was produced by REACH and has been distributed widely to enhance uniformity in cost analysis for health projects including EPI.

Concurrent with the increased efforts in child survival and particularly in immunization, AID concern with the issue of sustainability of health and child survival efforts has increased. Sustainability of

child survival services depends upon their costs and the combination of public and private resources available to finance these efforts in the long-run. The Bureau for Program and Policy Coordination (AID) requested the REACH Project to examine the resource requirements of Universal Childhood Immunization (UCI) or reaching high coverage targets, and to determine the most cost-effective program mixes to achieve desired coverage targets. The Immunization Sustainability Study was designed to address these questions.

In addition, the Bureau for Science and Technology, Office of Health (S&T/Health) is interested in evaluating the costs of accelerated immunization programs and the implications of these strategies for program sustainability. S&T/Health has sponsored several cost and cost-effectiveness studies of alternative immunization strategies through the REACH Project.

The REACH Project has undertaken field studies of the cost-effectiveness of alternative strategies for the EPI in Mauritania, Cameroon, Senegal, Turkey, and the Philippines. Studies in Haiti, Sudan and India have begun in 1989. As part of REACH's ongoing field work, efforts have been made to synthesize the results of previous studies and to outline directions for future research.

The limitations of previous studies and future directions were outlined in a document entitled "Cost-effectiveness of Immunization Programs: Issues and Future Directions," presented at the 1987 REACH Technical Advisory Group Meeting (9). A summary of this document was presented at an international conference organized by the International

Center for the Child (Centre International de l'Enfance) in Paris on "Economic and Financial Evaluation of Immunization Programs" in December 1987.

As described previously by Parker and others (11, 20), the ability to generalize from previous studies has been hampered by the wide variation in methods used to calculate both the costs and the effectiveness of EPI. Specifically, studies have used various economic or financial data to determine cost; different cost categories and elements; and inconsistent time frames for analysis. Most of the variation in costing methodology arises from the variety of approaches used to allocate joint or shared costs among EPI and other health programs (17, 18, and 26). In addition, few studies have evaluated the private sector effectively or examined the cost-effectiveness of individual antigens (e.g., tetanus or measles). Finally, the ability to generalize from cost-effectiveness evaluations was limited by the inability of point estimates to describe relationships between program costs and outcomes adequately.

The REACH analysis recommended the following directions for cost and cost-effectiveness analysis:

1. At the policy level, consensus should be reached on research priorities for economic and financial evaluation of EPI which consider the needs of program managers, donor organizations and evaluators.

2. EPI managers at all levels should become familiar with the methods of cost evaluation and methods that can be more easily adapted to field conditions need to be developed.

3. Once the methods are improved, more effort should be made to ensure that the results from cost-effectiveness studies are used by program managers and policy decision-makers.

4. More attention should be paid by researchers to involving local experts in data analysis.

5. The relationship between the results of these studies and the broader issues of program sustainability needs to be further defined. Financial sustainability of the program should be a topic addressed by these studies.

In conclusion, there is a growing recognition that current knowledge in costing and cost-effectiveness of immunization strategies needs to be reviewed and new lessons drawn from past experiences. This is the primary objective of this review document.

III. COST-EFFECTIVENESS OF THE EPI

Several methodologies can be used to evaluate the economic and social effects of health investments in order to improve the allocation of scarce health resources. Cost-benefit analysis measures both costs and benefits in quantitative or monetary terms. It usually has been used to analyze specific disease control programs and to compare alternative strategies, such as prevention versus treatment, of a childhood disease.

An alternative construct is cost-effectiveness analysis. Like cost-benefit analysis, cost-effectiveness analysis is a tool for comparing costs and outcomes of health programs. However, cost-effectiveness analysis has a major advantage over cost-benefit analysis in that it relates qualitative measures of effects to quantitative measures of resource inputs. This methodology is useful when the objective of the analysis is to determine the most appropriate strategy for obtaining a set of agreed-upon outcomes (17). For immunization programs, cost-effectiveness analysis should result in determining the least-cost

strategy for reaching a specific level of coverage. The term "cost" means the total value of all resources used (physical, human and financial) to deliver immunization services.

These studies should also provide useful management information for EPI staff, such as the resource intensity of certain EPI components (e.g., training, transportation, evaluation) and their contribution to the outcome measure of children fully immunized. For example, if an EPI is spending a large proportion of total cost on training (20%) but the health workers are administering vaccines at the incorrect ages or intervals between doses, then the resources allocated to training may not be used most effectively and different training strategies should be explored to rectify the situation. Similarly, if transportation and fuel costs are high but the number of children vaccinated during outreach sessions is low, there may be inefficiencies in the use of resources and better management and planning of outreach activities may make the service more effective.

This tool remains underutilized. Although the data collected and analyzed for cost-effectiveness studies should provide a wealth of information for program management, the use of study results for decision-making about resource allocation among alternative strategies and improved program efficiency remains to be documented.

A. REVIEW OF STUDIES

This section describes and analyzes the results from 28 costing, cost-effectiveness and cost-benefit analyses of immunization programs found in the literature and/or undertaken recently. Short summaries of the objectives and results of each study are contained in Appendix D.

In order to compare the costs and outcomes of different studies undertaken in different years, all costs were valued in constant 1987 U.S. dollars. The method used to estimate 1987 equivalents was based on figures of the Consumer Price Index (CPI) for the United States for the year in which the study was conducted (11). Most of the studies evaluated costs in both local currency (for salaries and locally produced items) and foreign currency (for equipment, vaccines, vehicles and other items requiring foreign exchange). Although using the CPI for the United States might result in an overvaluing of the local current component and an undervaluing of the foreign exchange component, it is unclear how sensitive the estimates are to the accuracy of the 1987 figures. This method is used as a best estimate of current values of earlier studies.

Appendix A presents the cost-effectiveness ratios for studies which contained sufficient data for further analysis, as well as other more detailed cost figures. Appendix B explains the methods for calculating current 1987 U.S. values.

Enough cost information measured by roughly similar methods now exists for different strategies to be able to draw some tentative conclusions. When appropriate, conclusions from earlier reviews (11, 20, 25) will be

compared with new information in order to determine how much our knowledge and understanding of the relationships between costs and coverage has increased.

1. Description of the Studies

The 28 studies included in this review were conducted between 1971 and early 1988. Table 2 illustrates the results from this descriptive review. Eight of the studies were performed in Asia/Near East countries; 15 in African countries and five Latin American and Caribbean countries. Several countries (the Republic of Turkey, the Philippines, Indonesia, the People's Republic of the Congo, and the Republic of Cameroon) have been the site of multiple costing studies, although in no case were costs and outcomes measured in the same manner in each study.

a. Strategy

Some of these studies evaluated different immunization strategies or approaches for delivering immunizations to children. Ten studies focused on national immunization campaigns, 22 evaluated routine services provided through fixed facilities, and five examined some form of mobile or outreach services. Eight studies compared different delivery strategies, and only one compared all three principal strategies: fixed centers, mobile teams, and a national campaign (5).

b. Scope

The studies varied in terms of the scope of the analysis. Various studies collected data at the central, regional, district or facility levels. Eight studies based costs and effectiveness measures on a sample of health facilities, thirteen estimated national costs and coverage figures, and six examined programs at the regional, district or provincial level. Of the facility-based studies, the sample size ranged from six in Indonesia (12) to 24 in Malawi (33). None of these samples were selected on a completely random basis: most were included in the studies because they were believed to be representative of the types of strategies or the range of coverage experience in a particular country. For example, in the Philippines, the facilities were selected to represent different local population sizes (catchment areas). In Turkey, different types of health facilities (e.g., district health center, urban health center, rural health center, district MCH center) were selected to represent the range of types of service delivery sites.

c. Age groups

The age groups for which immunization services were targeted varied considerably among these studies, reflecting the changing and varying immunization policy in different countries. Eleven studies focused on children less than one year of age; five used data from cluster sample surveys of children between the ages of 12 and 23 months (these data allow an estimate of the impact on the vaccination status of the cohort of children less than one year of age by the previous years' activities); four studies focused specifically on children less than five years of age; three

were studies of tetanus toxoid vaccination for women of reproductive age; and four studies used different age groups between 0 and five years (i.e. coverage of children less than three years).

d. Time frame for analysis

The time frame for analysis ranged from discrete rounds of a national immunization campaign (of one day or one week) to a year. This variation confounded efforts to compare results without annualizing them.

e. Measurement of costs

Classification of cost elements and methods of cost analysis have been inconsistent from one study to the next, although in 17 of the studies the authors claimed to have followed or adapted the WHO/EPI costing guidelines (44). Only five studies followed this methodology exactly. These guidelines were developed as a training tool to improve the uniformity of methods and to generate greater understanding of the implications of these studies in the field.

Variations in the application of the guidelines (1979) have arisen for several reasons. Primarily, the delivery of EPI services and the evaluation of EPI progress has evolved and improved over time. For instance, new strategies (accelerations) have been used to deliver services more rapidly than through routine fixed facility approaches. There have been recent developments in vaccine, syringe, and cold chain technologies which influence service delivery and have implications for the type and frequency of resources used for the EPI. Further, the techniques for evaluating and analyzing immunization coverage have also evolved. The

TABLE 2
SUMMARY OF COST-EFFECTIVENESS STUDIES OF THE EPI

NO.	COUNTRY	STRATEGY(IES)	SCOPE	CURRENT $$[a]	COVERAGE AGE GROUP	DOSES[b]	FVC[c]	ANTIGEN[d]	TT	DEATHS/ CASES AVERTED[e]
	ANE BUREAU									
1.	Turkey (Brenzel)	Routine	National Facil=16	1987	12-23 mos. 9 provinces	yes yes	yes no	no no	no no	no no
2.	Turkey (Fairbank)	Campaign	National	1986	0-5 years	yes	no	no	no	no
3.	Thailand (Creese)	Routine	Facil=8	1979	0-1 year	no	yes	no	no	no
4.	Philippines (Creese)	Routine	Facil=9	1979	0-1 year	no	yes	no	no	no
5.	Philippines (Turner)	Routine and Outreach	National	1988-1992	0-1 year	no	yes	no	no	yes
6.	Indonesia (Creese)	Routine	Facil=6	1979	0-1 year	no	yes	no	no	no
7.	Indonesia (Barnum)	Routine	1 province (Java)	1978	0-1 year school	no	yes	DPT/BCG yes	yes (DT)	yes
8.	Indonesia (Berman)	Routine Campaign	2 districts Aceh Lomdan	1987	Women 15-44 TT2 15-44	TT2 TT2	no no	no no	yes yes	yes yes
	AFR BUREAU									
9.	Zambia (Ponnighus)	Routine	District	1975	7-30 mos.	no	no	measles	no	yes
10.	Uganda (Cameron)	Routine	National	1986	0-1 years	--	--	---	--	---
11.	The Gambia (Robertson)	Routine	Facil= 13	1980	15-27 mos.	yes	yes	yes (all)	yes	yes
12.	Tanzania (Feilden)	Routine Mobile clinics	National	1987	0-1 year	no	yes	no	no	no
13.	Swaziland (Robertson)	Routine	Facil=17	1984						
14.	Senegal (Brenzel)	Campaign	National	1986	12-23 mos.	yes	yes	no	no	yes
15.	Mauritania (Brenzel, Claquin)	Campaign Mobile teams Routine	National National National	1985 1985 1985	18-36 mos.	no no no	yes yes yes	no no no	no no no	no no no

TABLE 2 (cont'd)
SUMMARY OF COST-EFFECTIVENESS STUDIES OF THE EPI

NO.	COUNTRY	STRATEGY(IES)	SCOPE	CURRENT $$[a]	COVERAGE AGE GROUP	DOSES[b]	FVC[c]	ANTIGEN[d]	TT	DEATHS/ CASES AVERTED[e]
16.	Malawi (Robertson)	Routine	Facil=18	1984						
17.	Kenya					no	yes	no		
18.	Cote d'Ivoire (Shepard)	Routine	3 zones	1978	0-1 year	no	no	yes (measles)	no	yes
19.	Congo (Dabis)	Fixed centers	National Hospital	1985	12-23 mos.	no	yes	yes measles	no	yes
20.	Congo (Qualls)	Routine Mobile Teams	National Facil=3	1985	none	no	--	---	--	---
21.	Cameroon (Brenzel)	Campaign Routine	National National	1986 1986	12-23 mos. 0-5 years	yes yes	yes yes	no no	yes yes	no no
22.	Cameroon (Makinen)	Campaign	National + Hospital	1971-1976	6-36 mos.	no	yes	yes measles	no	yes
23.	Burkina Faso (de Champeaux)	Routine Mobile teams (mixed)	Regional	1987	0-2 years	no	yes	no	yes	no
	LAC BUREAU									
24.	Honduras (Hartman)	Pulse campaigns	National	1983	0-1 year	yes	no	yes	no	yes
25.	Haiti	Routine	Region	1971	0-1 year	no	no	(OPV no	yes	yes
26.	Ecuador (Shepard)	Campaign Routine	Nat.+ Fac=22 Nat.+ Fac	1985 1985	12-23 mos. 0-5 years	yes yes	yes yes	no no	no yes	no no
27.	Colombia (Creese)	Campaign Routine	Facil= 10 National	1984 1984	infants infants	yes yes	yes yes	no no	no no	no no
28.	Brazil (Creese)	Routine and campaigns	16 municipalities	1982	0-1 year	no	no	measles, polio	no	yes

[a] Year in which cost data were reported.
[b] Study measured cost per dose for the EPI.
[c] Study measured cost per fully immunized or fully vaccinated child (same meaning).
[d] Study measured cost per antigen (i.e., cost per child vaccinated against measles).
[e] Deaths/cases averted refers to whether the study evaluated these specific effectiveness measures.

The 30-cluster sample technique (22) has become a standard method for estimating coverage and existing software programs (COSAS and EPIInfo) are being refined to facilitate analysis of program performance.

All of these improvements in the program have implications for the sophistication and level of specificity required for cost and cost-effectiveness evaluations. Some of the current weaknesses in the original (1979) guidelines are as follows: First, the classification and identification of cost elements do not sufficiently characterize all of the inputs into the EPI, especially for acceleration and mobile strategies. A costing framework should be organized to assist in the evaluation of all inputs into an immunization program or strategy. However, the WHO/EPI guidelines focus on the cost of providing services in fixed facilities and do not describe the costs of the entire program or of different strategies at a national, regional or district level. Costs for supervision, management and administration, vaccination and medical supplies, program evaluation, technical assistance, mass media strategies and cold chain maintenance are not included in the framework.

Second, evaluators have used cost information collected at the facility level in different ways. The WHO guidelines propose that a sample of health facilities serve as a basis for all cost calculations and that these facilities be considered the unit of analysis. It would be useful if the facilities were representative of different coverage levels and population sizes in order to assess the effect of scale in the cost estimates. The WHO guidelines recommended comparing cost-effectiveness ratios of the health facilities and identifying the reasons for discrepancies in costs or outcomes to evaluate the efficiency and effectiveness of delivery of immunization services in the health system.

Some studies have used the facility-based approach to calculate national program costs (33, 34, 35 and 36) by first determining the average cost per dose administered in the sample and then multiplying by the number of doses administered nationwide. Another variation on the facility-based approach is to use the facility sample as a basis for establishing the proportions for allocating joint costs, and applying them to national preventive program figures (5, 6, 7, 8, 16 and 38). The comparability of study results has been limited by the variation in study methods.

Third, evaluators have not been consistent in the sources of input price figures and economic indicators. The unit prices used to estimate costs, especially the cost of labor, significantly affect the total cost figure for the health facility. No studies included in this review used shadow prices for determining the salary component of total cost, and the studies are inconsistent in terms of including benefits, such as housing and insurance, in wage figures.

The total cost figure is sensitive to the particular discount rate which is selected for determining the annual value of equipment and other material goods (17). While the WHO guidelines address this issue and provide a table for calculating annualized values, more guidance should be given for undertaking sensitivity testing.

f. Measurement of effectiveness

The identification of the effectiveness measure differed in these studies as well, largely as a result of the availability of good techniques of program outcomes. Traditionally, four principal types of effectiveness measures have been used for cost analysis: 1) the number of doses administered for a particular strategy and age group; 2) the number of

children fully immunized for the range of vaccines provided in a particular EPI; 3) the number of cases prevented through immunization; and 4) the number of deaths averted as a result of immunization against specific diseases. Other measures of EPI outcomes which have been used include years of life added and increases in productivity to society as a result of prevented mortality or morbidity.

1) Doses

Each effectiveness indicator measures some aspect of the program. For example, the number of doses administered provides some indication of the level of contact with the population. However, reported figures from health centers and other health facilities may not be the most reliable estimates of EPI performance because of incentives or pressure to reach coverage targets. Out of 28 studies, twelve calculated the cost per dose.

2) Children fully immunized

Because EPI requires repeated vaccinations for full protection against polio, diphtheria, pertussis and tetanus, the number of fully immunized children (those receiving all eight required doses) is considered to be one of the best measures of the ability of the EPI to provide sustained and complete services to a population over a period of time. It is well-documented, however, that the number of fully immunized children is less than those receiving the third dose of DPT or measles vaccination because full immunization represents the joint probability of receiving all doses. As such, the number of fully immunized children under-represents the full activity of a program by omitting partial immunization (those

children receiving fewer than eight doses) from the output measure. Therefore, the cost to partially immunize is allocated to those who are fully immunized.

For cost-effectiveness analysis, the methods to calculate the number of fully vaccinated children have varied, hampering comparison of various program outcomes. For example, some country EPIs use vaccines or schedules different from the WHO standards: one dose of BCG (Bacillus Calmette-Guerin, for tuberculosis), one dose of measles, three doses of DPT (diphtheria, pertussis, and tetanus) and three (or four) doses of OPV (oral polio virus). Further, the method of determining the number of children fully immunized differs among the studies considered here. Some studies divide the total number of doses administered by the number of required vaccines. This would tend to underestimate the effectiveness of an immunization program and overestimate the cost-effectiveness ratio. It has been demonstrated that the average number of doses required for full immunization exceeds the required number of doses (33, 34), because children lose their immunization cards and are re-vaccinated, or because health workers needlessly give additional vaccinations when they think that the interval between doses (e.g., DPT1 and DPT2) has been too long. One study demonstrated that full vaccination actually required 14 doses, compared to the eight doses theoretically required (33).

The most reliable estimates children fully immunized come from coverage surveys. Several studies reviewed (5, 7, 8, 16, 35, and 37) based the cost per fully immunized child on results of surveys that used the WHO cluster sample method (22). Four studies used the WHO Coverage Survey Analysis Software (COSAS) to analyze coverage data. This provides additional information on the age interval between doses, the number of children correctly immunized (based on schedules and doses), and the

percent of missed immunization opportunities. Only in one case were the actual numbers of fully immunized children reported through a routine system and during a campaign (5).

As a result, not all cost-effectiveness studies which report cost per fully vaccinated child have the same meaning. Therefore, comparisons must be made with caution. Of the 28 studies included in this review, 22 report cost per fully immunized child, though the target age group varies, as does the number and type of vaccines required for full immunization.

3) Health status measures

The measurement of cost per dose and cost per fully immunized child does not translate the benefits of immunization into values that reflect the impact on morbidity or mortality. For this reason, studies have used data on incidence, case fatality and vaccine efficacy to attempt to calculate the cost per case averted, cost per death averted, and cost per years of life added. Of the studies reviewed, thirteen report the cost per death averted and similar program benefits.

The major drawback of these estimates is that they are based on linear assumptions about a fixed relationship between disease incidence, case-fatality rates and vaccine efficacy and rarely take into account the effect of population dynamics on disease transmission. There are several factors that affect the attribution of immediate health benefits to investments in immunization programs: the time-lag of effects of immunization on disease incidence, the nature of disease cycles (i.e., measles incidence tends to follow a four-year cycle in rural areas), and the competing health risks present in a child's environment.

Because of the circulation of wild virus and patterns of disease transmission due to migration or population density, among other factors, reduction in disease burden because of immunization will not be immediately realized in the population as a whole, although individuals are theoretically protected. Further, DPT and polio require multiple doses in order to confer full protection against disease, so there is a time-lag before a population is fully protected. Because peak incidence of some diseases follows a cyclical pattern, immunization in one year may not have much affect on disease incidence over a longer period of time nor influence the magnitude in epidemic years. Calculations of years of life added or death averted also ignore the competing health risks that are present in a child's environment: a child might be protected against polio but still retains the risks of dying of malnutrition, diarrheal disease, or by accident.

Calculations of numbers of deaths or cases prevented in the studies reviewed are based on figures that are now believed to be inaccurate and unreliable. In some cases, evaluators use figures of disease incidence or case fatality rates from neighboring countries. Vaccine efficacy rates do not reflect "field efficacy" but are quoted from manufacturers' reports. Where cold chain failures occur, there is a high probability that the vaccine that is being injected into children is not as potent as vaccine in the laboratory.

Thus, most calculations of impact of immunizations on disease incidence or mortality rates are overestimates based on optimistic assumptions. Efforts should be made to undertake longitudinal, coherent studies that incorporate actual measures of disease incidence and mortality rates.

4) Partial immunization

Some studies have attempted to segregate total program costs to determine the cost of fully immunizing a child with specific antigens, such as polio or tetanus (3, 35 and 41). The advantage of this effectiveness measure over the number of fully immunized children is that it takes into account immunization activities that do not necessarily result in a child receiving the full complement of antigens but receiving sufficient doses to be partially protected against particular diseases.

However, the methods used to allocate total cost to a particular antigen have relied on proportional distributions (based on the number of doses per antigen over total doses) that do not accurately reflect the resource intensity of different vaccines. A homogeneous distribution of total program costs among the different antigens will be affected by differences in the time required for injection (BCG must be reconstituted, for example); the training level required to administer the vaccine (oral polio can be given by non-trained vaccinators); the need for additional social motivation (for repeat visits for DPT and polio or to counter beliefs about tetanus vaccination during pregnancy); and disease control and eradication priorities (WHO adopted a policy of polio eradication in 1988) and the Declaration of Talloires (1988) proposes the control of measles and tetanus by the year 2000. Development of methods that would allow more careful allocation of program costs for specific antigens will be important in the next ten years because of global efforts against specific diseases such as polio, measles and tetanus.

In conclusion, measurement of EPI and health outcomes of the program has been the weakest aspect of cost-effectiveness studies. Recent advances in and attention to monitoring of immunization activities and disease surveillance are important steps in the betterment of evaluation methods and widespread use of computerized coverage surveys and analysis packages in calculating cost-effectiveness ratios is recommended. However, more work remains to be done in the development of a more useful indicator of program effectiveness.

2. Comparison of Cost-Effectiveness Study Results

Appendix A contains data on 19 cost-effectiveness studies that reported figures of cost per fully immunized child. Because these studies employed different methods of calculating both costs and outcomes, they cannot be directly compared nor can conclusions be drawn about the relationships between costs and coverage. Only 11 estimates (eight studies) out of the total sample of 19 studies using cost per fully immunized child were based on methods similar for direct comparison. The main criteria for further analysis included:

1) Use of coverage survey data for estimating number of fully immunized children (or other reliable method);

2) Similar classification of cost elements;

3) Use of similar methods for calculating costs.

The studies were also similar in the sources of cost information and in the unit price estimates for equipment, though wages and benefits were not adjusted for shadow prices across the estimates. All but one of the studies (Mauritania) used coverage survey data on all of the six EPI-preventable diseases as the basis for estimates of the number of fully immunized children. The Mauritanian data were based on actual reported

figures of the number of children fully immunized, through the routine surveillance system which was believed to be accurate enough to be included here.

a. Cost per fully immunized child

Table 4 compares the eleven cost-effectiveness ratios (including technical assistance costs) and ranks them from the most cost-effective to the least cost-effective program. According to this table, Tanzania has the lowest figure of $6.53 per fully immunized child, while Cameroon has the highest ($19.48). The arithmetic average for all eleven estimates was approximately $13.00 per fully immunized child. When technical assistance costs were factored into total cost figures, the average cost per fully immunized child increased to $15.00.

The variations in the figures in Table 4 are most likely due to differences in technologies and strategies used in different regions of the world. These data are further divided and analyzed in Table 5 by strategy and in Table 6 by strategy and region. From Table 5, differences in the average cost per fully immunized child as a result of alternative strategies emerge. Fixed facility strategies are the most cost-effective at $11.74 per fully vaccinated child, followed by mobile teams at $12.90 per fully immunized child. In this comparison, campaigns have a higher cost-effectiveness ratio, with an average cost per child of $15.62. However, the differences among strategies (less than $4.00 per child) is less than expected from variations in technology and in the organization and delivery of services. It should be kept in mind that these figures exclude technical assistance costs and that there are only two observations for mobile teams and three for campaigns in this analysis.

TABLE 3
Elements Included in Cost-effectiveness Studies

Elements	Study 1	2	3	4	5	6	7	8	9	10	11
Personnel											
Salaries	X	X	X	X	X	X	X	X	X	X	X
Benefits	X	X	X	X	X	X	X	X	X	X	X
Vaccines	X	X	X	X	X	X	X	X	X	X	X
Wastage	X	X	X	X	X	X	X	X	X	X	
Transportation	X	X	X	X	X	X	X	X	X	X	X
Supplies	X	X	X	X	X	X	X	X	X	X	X
Communication		X	X			X	X	X	X	X	
Management/ Supervision	X	X	X	X	X	X	X	X	X	X	
Vehicles	X	X	X	X	X	X	X	X	X	X	X
Equipment	X	X	X	X	X	X	X	X	X	X	X
Buildings	X	X	X	X	X	X	X	X	X	X	X
Technical Assist.		X	X	X	X	X		X	X	X	X
Other	X	X	X	X	X	X	X	X	X	X	X
Coverage survey	X			X	X	X	X	X		X	X
Target age group	<1 year	<5 year	<5 year	12-23 mos.		<1 year	12-23 mos.	<5 year	12-23 mos.	12-23 mos.	12-23 mos.

Estimates: 1=Tanzania routine, 2= Mauritania routine, 3=Mauritania campaign, 4= Burkina Faso routine, 5= Burkina Faso mobile, 6= Philippines routine, 7= Turkey routine, 8=Mauritania mobile, 9=Cameroon campaign, 10=Senegal campaign, 11= The Gambia routine.

TABLE 4

Comparison of Cost-Effectiveness Studies of the EPI Using Similar Methods
(excluding technical assistance costs)

COUNTRY	STRATEGY	COST 1987 USD	NO. FIC	COST/FIC
Tanzania	Facility	$4,571,000	700,000	$6.53
Mauritania	Facility	$88,698	12,297	$7.21
Burkina Faso	Facility	$44,058	5,977	$7.37
Mauritania	Campaign	$207,652	25,507	$8.14
Burkina Faso	Mobile	$27,239	2,325	$11.72
Philippines	Facility	$17,036,583	1,233,147	$13.82
Mauritania	Mobile	$290,313	20,604	$14.09
The Gambia	Facility	$442,222	26,791	$16.51
Turkey	Facility	$15,265,676	803,568	$19.00
Senegal	Campaign	$4,905,427	255,000	$19.24
Cameroon	Campaign	$3,678,669	188,864	$19.48
Average (n=11)				$13.01
Standard Deviation				$4.89
Median				$13.82

FIC = Fully Immunized Child

Tanzania figures from "Joint Review Report on EPI in Tanzania," Ministry of Health -- Danida Review Team (September 1987), R. Feilden.

Mauritania figures from Brenzel, L., "Cost-Effectiveness of Alternative Immunization Strategies in the Islamic Republic of Mauritania," UNICEF, 1986.

Burkina Faso data from de Champeaux, Antoine, "Evaluation du Programme Elargi de vaccination, Province de la Sissile," OCCGE, 1987. Mobile and facility data based on proportions of total coverage attributable to each strategy (see p. 57, 28% and 72% respectively), as well as disaggregation of total cost by strategy. U.S. dollar equivalents based on an exchange rate of 400 U.S. dollars per CFA in 1987.

Philippines figures from Turner, Pamela, 1987.

Turkey figures from Brenzel, L., 1988.

Cameroon data from Brenzel, L. 1987.

Senegal data from Brenzel, L., et. al., 1987.

Data for The Gambia based on Robertson, Robert, 1984. Cost per child represents 1987 equivalent of $14.00 (average of facility costs). Total number fully immunized calculated from total cost and average cost per child.

TABLE 5

Comparison of Cost-effectiveness Studies of the EPI by Strategy
(excluding technical assitance costs)

COUNTRY	STRATEGY	COST U.S. $	NO. FIC	COST/FIC
Tanzania	Facility	$4,571,000	700,000	$6.53
Mauritania	Facility	$88,698	12,297	$7.21
Burkina Faso	Facility	$44,058	5,977	$7.37
Philippines	Facility	$17,036,583	1,233,147	$13.82
The Gambia	Facility	$442,222	26,791	$16.51
Turkey	Facility	$15,265,676	803,568	$19.00
Average (n=6)		$6,241,373	463,630	$11.74
Standard Deviation		$7,195,566	477,417	$4.94
Mauritania	Campaign	$207,652	25,507	$8.14
Cameroon	Campaign	$4,905,427	255,000	$19.24
Senegal	Campaign	$3,678,669	188,864	$19.48
Average (n=3)		$2,920,311	156,457	$15.62
Standard Deviation		$1,989,472	96,452	$5.29
Burkina Faso	Mobile	$27,239	2,325	$11.72
Mauritania	Mobile	$290,313	20,604	$14.09
Average (n=2)		$158,476	11,465	$12.90
Standard Deviation		$131,537	9,140	$1.19

Source: Table 4

Table 6 segregates the data by strategy and region. These data reveal an unexpected finding: on average, **the African programs through fixed facilities are nearly thirty percent more cost-effective per fully immunized child ($9.41) than the Asian programs evaluated ($16.41).** This finding may be due to the larger population sizes and higher coverage levels in the Asian programs. There do not appear to be large differences overall among the ratios for different strategies, from $11.74 (facility based) to $15.62 (campaigns) per fully immunized child. However, the total number of children fully immunized is 40 times that for routine services in fixed facilities than for mobile teams.

These results somewhat modify previous conceptions of the average cost per fully immunized child per strategy. The analysis supports the initial figures estimated by WHO for the Bellagio Conference of between $5 and $15 per child ($5.47 and $16.41, respectively in current 1987 dollars), though the average of $13.00 per child, regardless of strategy, lies at the high end of the range.

Although there are very few comparable observations for this analysis, and no comparable observations from Latin American countries, these data suggest more of a uniformity for cost-effectiveness ratios across regions and strategies than perhaps previously believed. When the analysis includes technical assistance costs, there are no significant differences again between African or Asian programs through fixed facilities.

TABLE 6

Comparison of the Cost Per Fully Immunized Child (in $1987 U.S.)

STRATEGY	ALL STUDIES	ASIAN PROGRAMS	AFRICAN PROGRAMS	LATIN AMERICAN PROGRAMS
FACILITY	$11.74 (n=6) S.D.=$4.89	$16.41[1] (n=2) S.D.=$2.59	$9.41 (n=4) S.D.=$4.11	na
MOBILE TEAMS	$12.91[2] (n=2) S.D.=$1.18	-----	$12.91 (n=2) S.D.=$1.18	na
CAMPAIGNS	$15.62 (n=3) S.D.=$5.29	-----	$15.62 (n=3) S.D.=$5.29	na
ALL	$13.01 (n=11) S.D.= 4.89	$16.41 (n=2) S.D.=$2.59	$12.25 (n=9) S.D.=$4.96	na

Source: Tables 4 and 5; Appendix A.
(1) Range of figures is $13.82 to $19.00 per fully immunized child.
(2) Range of figures is $11.72 to $14.09 per fully immunized child.

b. Cost profiles

Cost profiles denote the proportion of total program cost represented by a collection of individual cost elements (e.g., salaries or vaccines). Profiles refer to a summary presentation of significant cost components for comparative purposes. These figures can be used to determine which cost elements absorb the most or least resources in relation to the overall importance of the cost component for achieving program goals and objectives. Figure 1 illustrates the cost profiles for selected cost-effectiveness studies for alternative immunization strategies. Appendix A presents these data in tabular form. This analysis is based on data collected by Haaga (20) and for this review. A total of thirteen routine programs, six campaigns and three mobile teams serve as the basis of analysis, including those presented in Tables 4, 5 and 6. These data suggest the following:

1) The share of cost components is not identical for the three principal strategies: fixed facilities, mobile teams, and national campaigns;

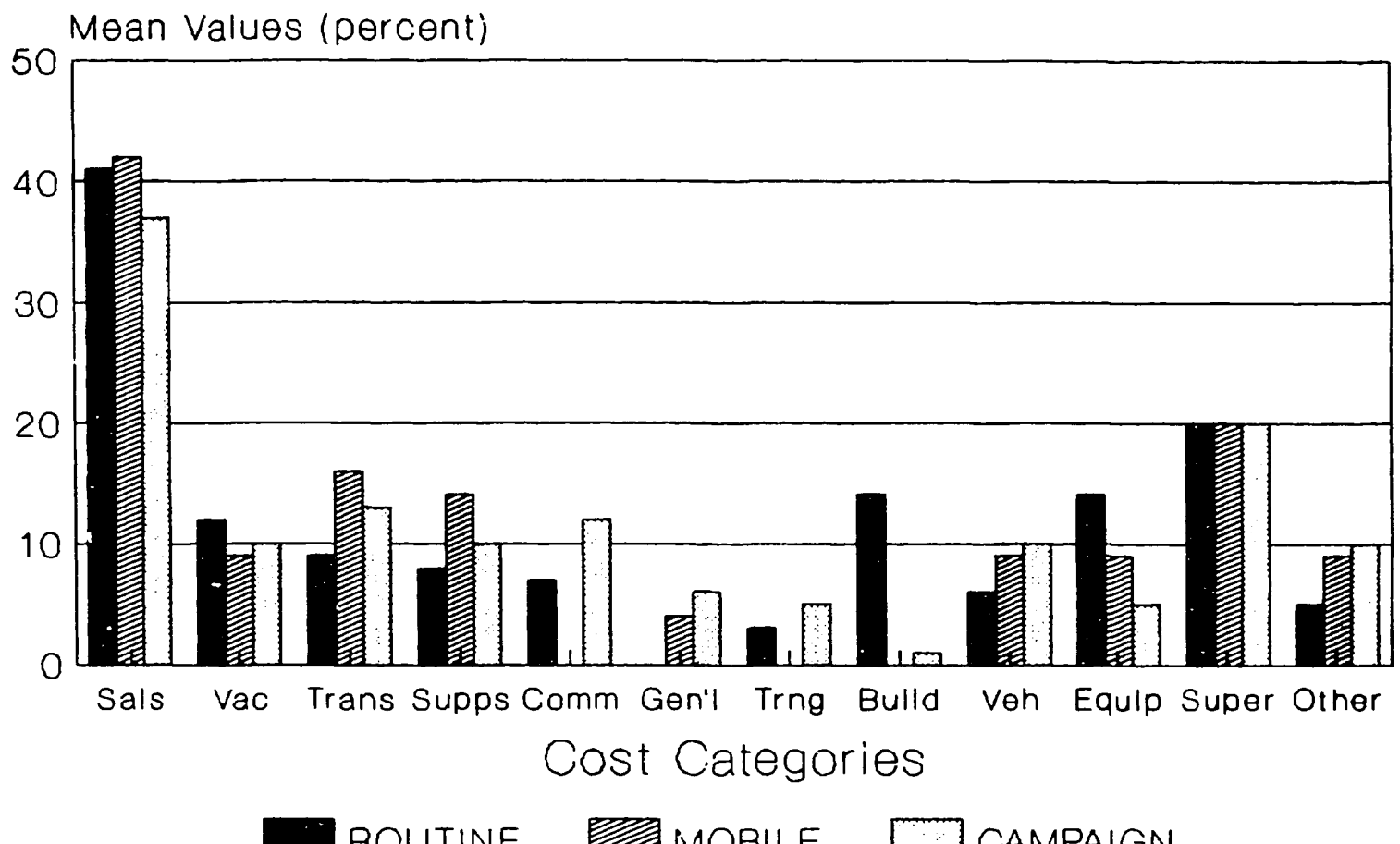
2) Salaries and wages are the predominant cost category for all strategies, ranging from 37% for campaigns to 45% and 42% for fixed facilities and mobile teams, respectively;

3) Supervision and management categories were the second highest cost element due to inclusion of transport and per diem costs in this category;

4) The importance of the annualized value of buildings and vehicles, supplies, equipment, transportation, and communications varied according to strategy. Not surprisingly, buildings were most important for fixed facility programs and least important for mobile teams. Communications costs were more important for campaigns than the other two strategies, and transportation was highest for mobile teams;

Figure 1

PERCENT DISTRIBUTION OF ANNUAL COSTS BY COST CATEGORY BY STRATEGY



Sals=salaries and benefits; Vac=vaccine costs; Trans=transportation costs; Supps=supplies costs (syringes, needles); Comm=costs of social mobilization; Gen'l=miscellaneous and overhead costs; Trng=training costs; Build=building costs (annualized); Veh=vehicle costs (annualized); Equip=equipment costs (annualized); Super=supervision and management costs; and Other=other costs.

5) Vaccine costs ranged from nine to twelve percent of total costs, except in two cases: 1) programs which used injectable polio vaccine, and 2) Tanzania. In Senegal, vaccine costs represented 35% of total cost for the campaign and in Burkina Faso, these costs accounted for 44% of the total cost of the EPI in Sissili Province. This trend is due to the significant difference in unit costs per dose of IPV and OPV vaccines ($0.69 versus $0.03). In Tanzania, the 42% of total cost for vaccine was attributed to high wastage rates because of the small numbers of children to be immunized in remote facilities. This scale and intensity effect needs to be substantiated with further studies.

6) The category for "other" costs was sufficiently large in all cases (ranging from six to ten percent) to warrant more thorough disaggregation of this category in future studies; and,

7) Four studies (5, 7, 28 and 30) had a more detailed classification of cost categories.

The results of this analysis differ from previous comparisons of cost profiles (11 and 36) of immunization programs in two major ways (refer to Table 7). First, the proportion of total costs for vaccines is lower for campaigns (5%) and mobile strategies (11%) than for fixed facilities (12%) and is lower than estimated on average for all strategies in earlier reviews (14%). This discrepancy among strategies can be explained by the larger investments for transport, communications, and equipment for mobile teams and national campaigns compared to fixed facilities. Therefore, changes in vaccine technology and its associated cost may be more strongly felt in the cost of fixed facilities than for the other two strategies.

Second, differences also exist between earlier estimates for transportation and capital costs. Both cost categories appear to play a greater role than previously thought (approximately 14% as compared to 8%), especially for routine strategies through fixed facilities.

Table 7
Comparison of Cost Profiles for Selected Categories
(in percent)

COST CATEGORY	1984[1] Bellagio	1986[2] REVIEW	FIXED	CAMPAIGNS (based on current figures)	MOBILE
Salaries	45	38/39	45	35/39	50
Supervision	unknown	20	20	14/20	19.5[3]
Vaccines	14	10/12	12	5	5
Transport	11	8/9	10	6/12	14
Other	13	5/7	5	6	8.5[3]
Capital	17	14/16	16	5	8.5[3]

Figures represent median values of proportion of total cost.
[1] From presentation by Dr. R.H. Henderson, Bellagio Conference, 1984.
[2] From Creese, 1986.
[3] Mean values only.

c. Cost profiles of campaigns per fully vaccinated child

Table 8 presents campaign cost data in 1987 dollars by cost category for three immunization campaigns in Senegal, Cameroon and Mauritania. These studies used similar methodologies to estimate costs and effectiveness of the EPI. Total cost per fully immunized child minus technical assistance were disaggregated by cost element. The results show the following trends:

a) The salary component is the most expensive per child in Cameroon at $12.92 per fully vaccinated child, compared with Senegal and Mauritania at $3.66 and $3.28 respectively. One possible explanation for this difference is that the Cameroon campaign relied more heavily on professionals, such as

teachers and civil servants, to work at approximately 2,000 vaccination posts. It is estimated that between 12,000 and 16,000 individuals participated in the campaign. Another source of the differences per fully vaccinated child is variation in the input prices of labor as average monthly salary for a health worker ranged from approximately $200 in Mauritania to $500 in Cameroon.

b) Vaccine costs per fully vaccinated children are highest in Senegal ($7.01) as compared to $0.28 in Mauritania and $0.94 in Cameroon. These differences may be explained by two factors. First, Senegal used injectable polio vaccine during the national campaign which has a high unit cost per dose of $0.69. Secondly, greater absolute numbers of doses of vaccine were administered in Senegal than in Mauritania (1.7 million). These data raise doubts about whether there are economies of scale in administering large quantities of vaccines during a campaign setting. Also, the scale of the program may produce greater wastage and more partially immunized children.

c) Transportation costs are highest for Senegal ($3.56 as compared to $1.17 and $1.18 in Cameroon and Mauritania, respectively). Though one would expect that the dispersion of the population and great distances among vaccination sites would result in higher costs per fully vaccinated child in Mauritania, the figures in Senegal may reflect the amount of travel utilized for the training and social mobilization effort which was a distinctive feature of that campaign.

d) Finally, when the total cost of each campaign is "standardized" to one million children fully immunized (using the formula, 1,000,000 multiplied by original cost divided by original number of fully immunized

children), the Senegal campaign emerges as the most costly. In fact, the Senegalese effort was nearly seven times as costly as the Mauritanian campaign and nearly three times as expensive as the Cameroonian campaign. This may be a result of the large purchases for equipment and vehicles in order to put in place the necessary infrastructure for a campaign strategy. The Mauritanian focus on a specific target population may explain this campaign's lower costs relative to the other country experiences, which were broader and more vast.

d. Relationship of cost data to coverage levels

Figures 2, 3 and 4 illustrate the relationship between total strategy cost and coverage levels. Figure 2 compares the average cost of immunization campaigns in Ecuador, Senegal, Mauritania, and Cameroon with the incremental gain in total coverage of fully immunized children (as estimated through coverage surveys). This figure suggests that average costs per fully immunized child rises with larger incremental gains in coverage, except in the case of Mauritania which had the largest incremental coverage gain (27.9 percentage points) and a relatively low average cost. These data may suggest some efficiencies in the Mauritanian campaign.

Figure 3 compares absolute coverage levels of fully immunized children (after the campaign) with total average cost. This figure shows that average cost per child declines with increasing coverage levels (up to 63%) suggesting some economies of scale. It is not known whether average cost will rise once coverage surpasses higher levels.

TABLE 8

Cost per Fully Immunized Child by Cost Category for Campaigns (including technical assistance)

COST CATEGORY / COUNTRY	SENEGAL (a) COST	SENEGAL (a) COST/FIC	CAMEROON COST	CAMEROON COST/FIC	MAURITANIA COST	MAURITANIA COST/FIC
SALARIES	$934,029	$3.66	$2,440,218	$12.92	$83,712	$3.28
VACCINES	$1,787,521	$7.01	$178,276	$0.94	$7,077	$0.28
TRANSPORT	$907,261	$3.56	$220,829	$1.17	$30,046	$1.18
SUPPLIES	$432,159	$1.69	$141,785	$0.75	$46,625	$1.83
MEDIA	$500,771	$1.96	$103,935	$0.55	$10,869	$0.43
GENERAL OPER	$191,224	$0.75	$247,824	$1.31	$158	40.01
COLD CHAIN MAIN	$11,675	$0.05				
TRAINING			$87,901	$0.47	$47,460	$1.86
FOOD			$141,740	$0.75		
BUILDINGS	$29,417	$0.12	$49,084	$0.05	$3,116	$0.12
VEHICLES	$220,177	$0.86	$121,654	$0.64		
EQUIPMENT	$93,837	$0.37	$14,037	$0.07	$12,528	$0.49
TOTAL COST	$5,108,071	$20.03	$3,705,445	$19.63	$241,592	$9.47
NUMBER FULLY IMMUNIZED	255,000		188,864		25,507	
TOTAL POPULATION	6,200,000		10,450,000		1,792,890	
POPULATION < 5 YRS	1,200,000		2,121,350		376,507	
COST/1 MILLION <5	**$4,256,726**		**$1,746,739**		**$641,666**	

(a) From Brenzel, et. al., "Rapid Assessment of Senegal's Acceleration Phase," UNICEF, 1987.

(b) From Brenzel, et. al., "Rapid Assessment: Cameroon's National Vaccination campaign", UNICEF, 1987.

(c) From Brenzel, L., "Cost-Effectiveness Analysis of Immunization Strategies in the Islamic Republic of Mauritania," UNICEF, 1986.

FIC=Fully Immunized Child

Refer to Appendix A-1.

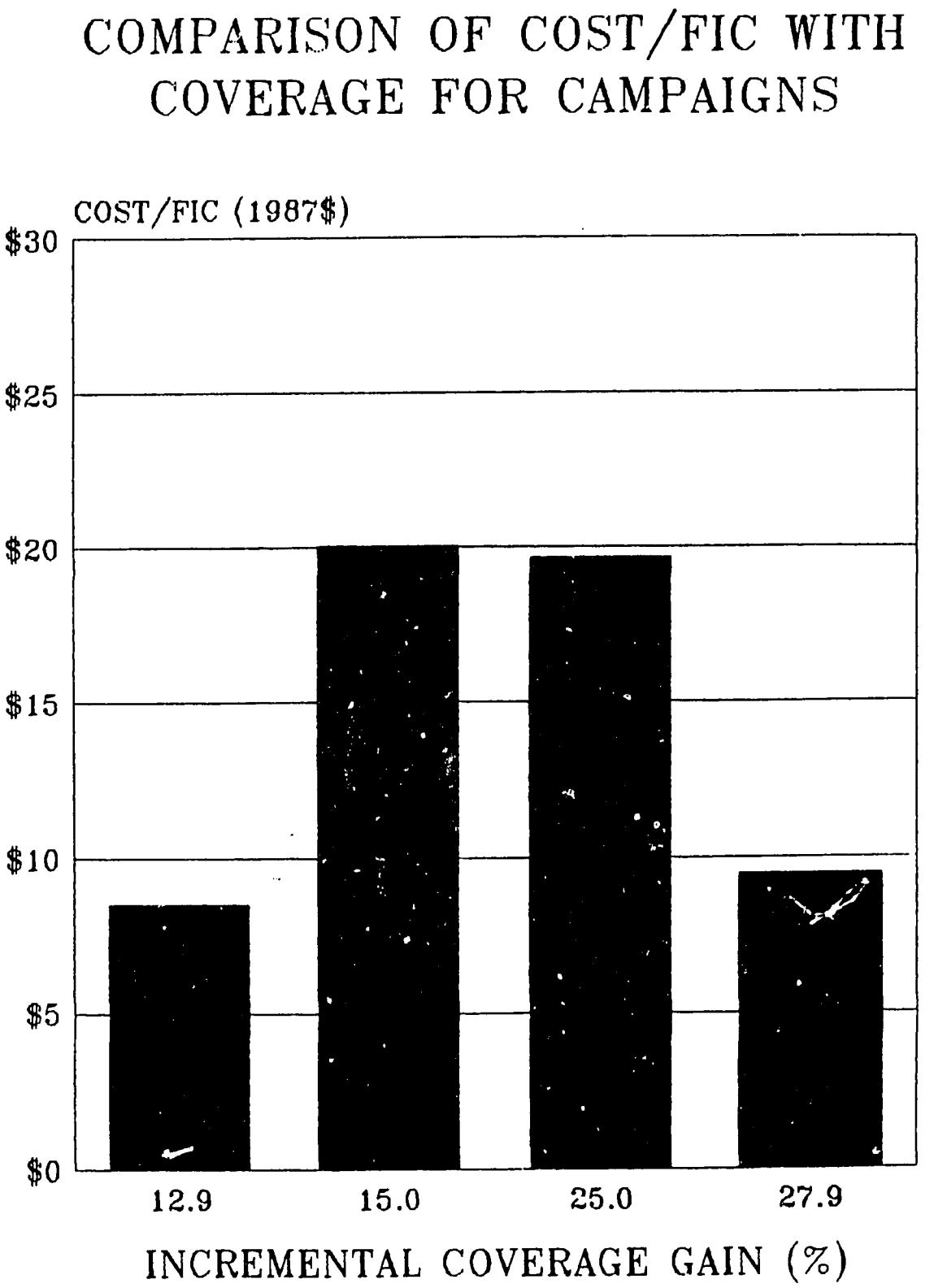
Figure 4 suggests a possible production function for EPI, as it compares total outcomes with cost, based on figures in Table 4. There appears to be two functions, one at a lower level of coverage and the second at a higher level of coverage. This figure suggests that to achieve higher levels of coverage, an EPI has to make additional investments in infrastructure, thus significantly raising the total program cost. Appendix B compares outcomes and costs for different strategies and reveals a linear relationship: the higher the coverage level, the higher the cost.

e. Financing sources

Table 9 demonstrates the proportion of total strategy costs financed by national governments, donor resources, or other sources. For routine services provided through fixed facilities, governments are financing 55% of total national EPI costs. For campaigns, fewer government resources are devoted to the program (as a percent of total cost) at 44%.

Analysis of comparable and recent study data suggests that national governments are funding fewer EPI costs than previously estimated for the Bellagio Conference in 1984, where it was calculated that governments were responsible for nearly 80% of total costs. In addition, these data highlight the difficulty that countries have in financing the current organization and delivery of EPI services, particularly those expenses that require foreign exchange, such as vaccine, training, syringes, cold chain equipment and vehicles.

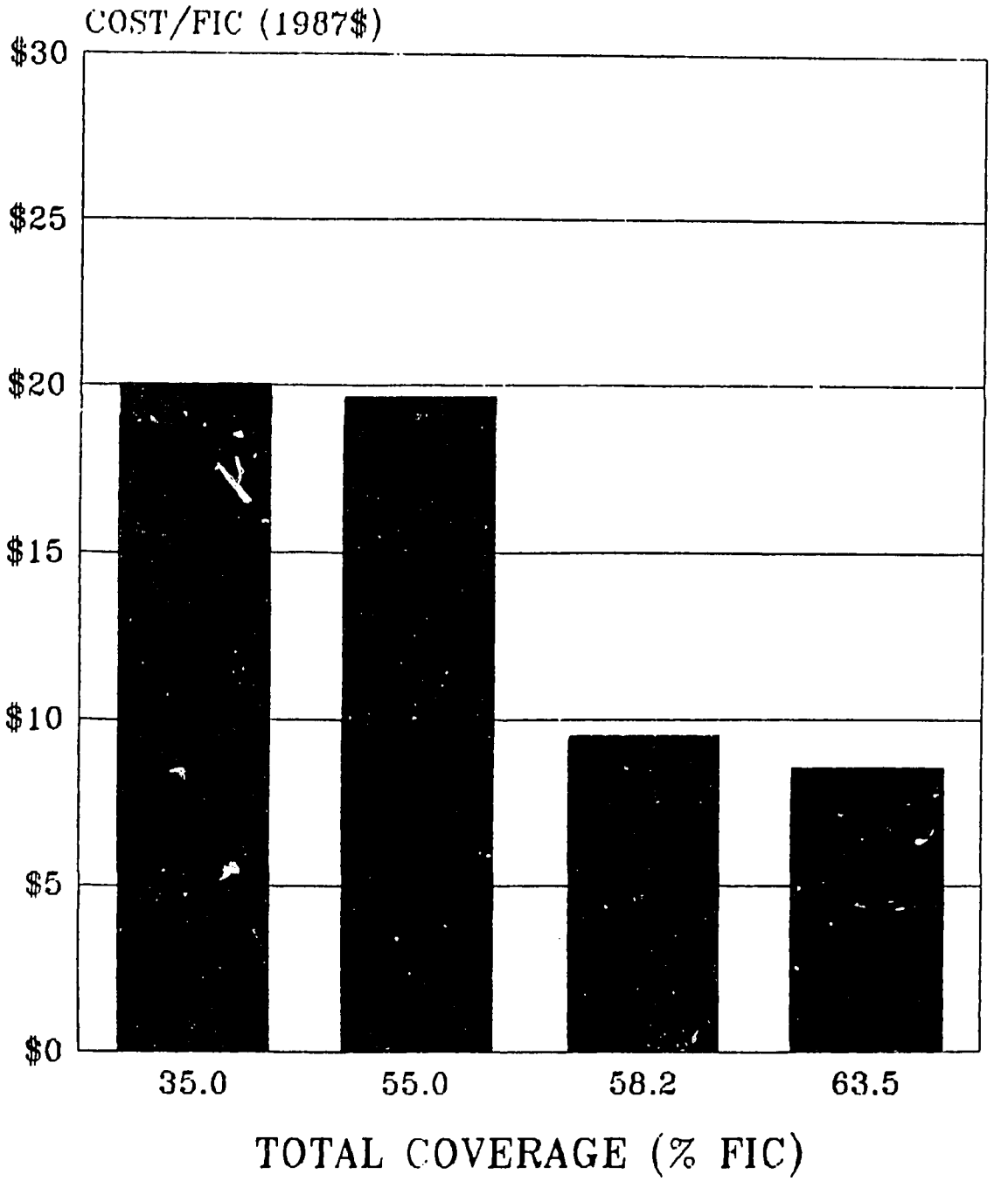
Figure 2



See Appendix A-1 for details.

Figure 3

COMPARISON COST/FIC WITH TOTAL COVERAGE RATE FOR CAMPAIGNS



See Appendix A-1 for details.

Figure 4

GRAPH OF EPI OUTCOMES VS COST

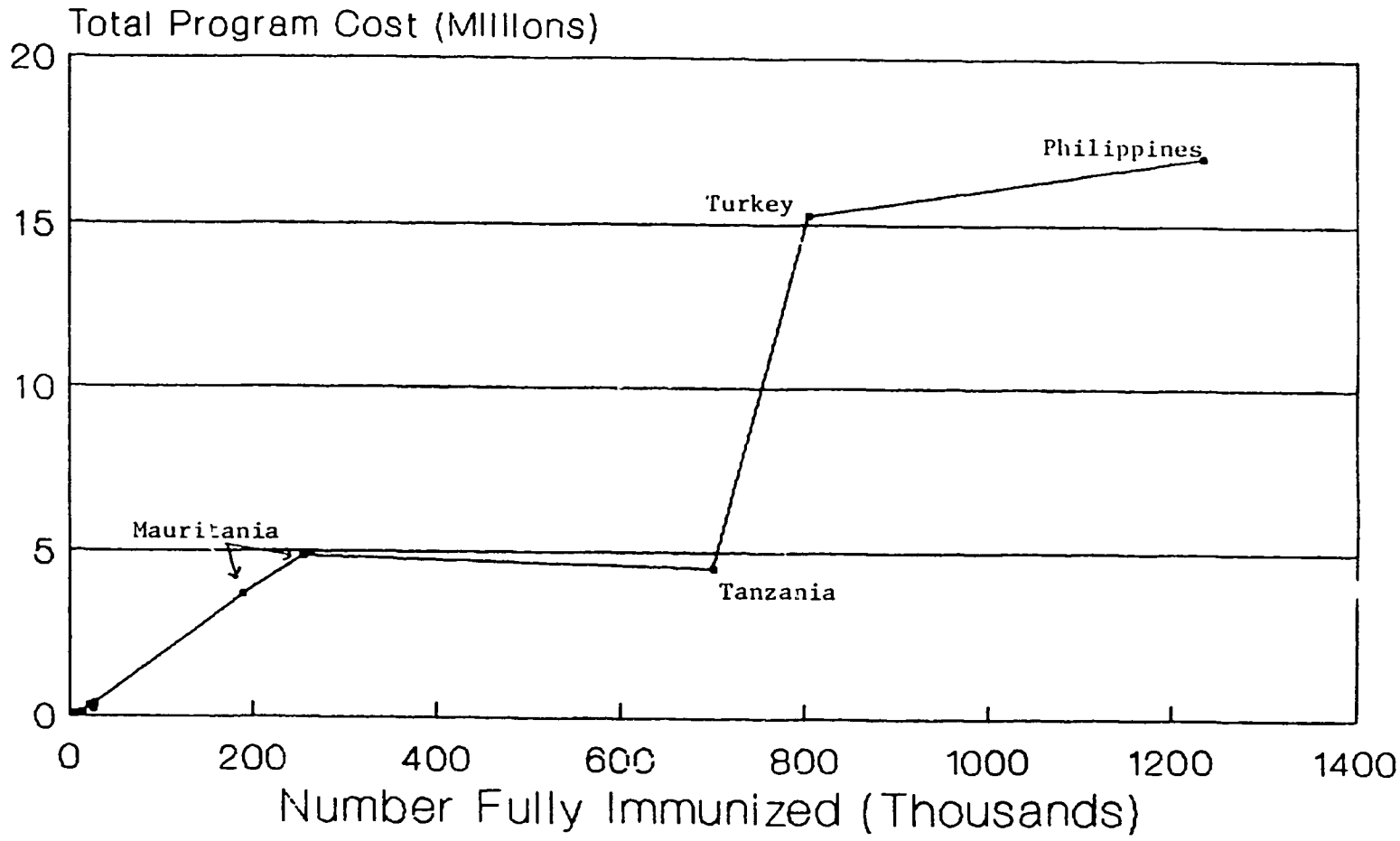


Table 9

DISAGGREGATION OF COUNTRY STUDY RESULTS BY SOURCE OF FINANCING FOR THE EPI (in percent)

COUNTRY	MOH	DONORS	TOTAL
Routine Strategies			
-- Turkey	96.5%[1]	3.5%	100.0%
-- Mauritania	41.0%	59.0%	100.0%
-- Philippines	84.0%	16.0%	100.0%
-- Tanzania	35.0%	65.0%	100.0%
-- Burkina Faso	27.0%	73.0%	NA
-- Average	55.0%	43.3%	100.0%
Campaigns			
-- Mauritania	15.0%	85.0%	100.0%
-- Cameroon	87.0%	13.0%	100.0%
-- Senegal	29.0%	71.0%	100.0%
-- Average	43.7%	56.3%	100.0%
Mobile Team			
--Mauritania	31.0%	69.0%	100.0%

[1] Includes parastatal costs for national radio and television broadcasting.

Table 10 divides total EPI costs by source of financing and cost category. This table clearly illustrates several trends.

1) The costs of salaries, communication, general expenditures, and buildings tend to be financed by government resources rather than by donors. These costs do not usually represent additional outlays for immunization programs but are part of the public health system or public broadcasting networks.

2) The costs of vaccines, training, supplies, vehicles and equipment are paid for primarily by donor organizations. These components of EPI (with the exception of training) usually require foreign exchange. Although some countries (those based on the French CFA, for example)

have relatively better access to foreign exchange, the public health sector in most countries competes poorly with other sectors for limited foreign exchange.

3) Transportation and vaccine costs are shared between governments and donors (with the exception of Mauritania and Senegal), perhaps representing the first two EPI components that will be absorbed by governments after primary donor financing.

4) Countries that have a higher GNP per capita (Turkey and Cameroon) are financing greater shares of individual cost components than countries that have lower GNP per capita (Mauritania and Burkina Faso).

These data suggest that the financial sustainability of country programs may depend on how well the public health sector is able to finance foreign-exchange - requiring components in the future. It appears that economically well-off countries are able to finance the costs of the EPI to a greater extent and that the resolution of the issue of program financial sustainability will depend largely on general economic development.

Most of these studies considered only two sources of financing, donors and governments (contributions of the private voluntary sectors were not assessed). This study suggests that donor financing will be necessary for implementation of the EPI in the near future.

Table 10

Breakdown of Total EPI Cost by Source of Financing and Cost Category

Category	Turkey		Burkina Faso		Senegal		Cameroon		Mauritania(1)		Mauritiania(2)		Mauritania (3)	
	Gov.	Donor	Gov.	Donor	Gov.	Donor	Gov.	Donor	Gov.	Donor	Gov.	Donor	Gov.	Donor
Salaries	100%	0%	8%	92%	75%	25%	98%	2%	29%	71%	48%	52%	79%	11%
Vaccines	40%	60%	41%	59%	1%	99%	62%	38%	0%	100%	0%	100%	0%	100%
Transportation	87%	13%	0%	100%	7%	93%	49%	51%	1%	99%	36%	64%	54%	46%
Training	72%	28%	0%	100%	0%	100%	0%	100%	15%	85%	0%	100%	0%	100%
Communication	98%	2%	na	na	100%	0%	86%	14%	19%	81%	na	na	na	na
Supplies	3%	97%	0%	100%	0%	100%	18%	82%	0%	100%	4%	96%	4%	96%
General/Other	95%	5%	na	na	14%	26%	98%	2%	0%	100%	53%	47%	100%	0%
Vehicles	99%	1%	na	na	11%	89%	75%	25%	na	na	0%	100%	0%	100%
Equipment	82%	18%	na	na	0%	100%	75%	25%	0%	100%	0%	100%	0%	100%
Buildings	100%	0%	na	na	100%	0%	100%	0%	100%	0%	na	na	99%	1%

(1) Campaign
(2) Mobile Team
(3) Fixed Facilities

Donor figures include contributions of NGOs.
Government figures include contributions by parastatal organizations.

f. Implications for long-term financing by governments

Table 11 compares figures for cost per fully immunized child (1987) with GDP and government health expenditures per capita (1986) in selected countries. The results suggest that immunization strategies do not represent large proportions of total national resources from 2% to 10% of GDP/capita, which is similar to results found by Haaga (20). However, **the cost per child represents from two to eleven times the health expenditure per capita in these countries.** Although this analysis does not segregate health expenditures for children and adults, the figures show a discrepancy between average government spending for all health activities per person and the per capita requirement for the EPI. As expected, poorer countries, on the basis of GNP per capita, also have lower health expenditures per capita and therefore have less to spend on EPI. On average, governments would have to spend nearly 50% of their resources to finance the immunization strategies as evaluated in these studies.

Though these figures make only crude comparisons of total immunization strategy costs and current health expenditures, they suggest that it will be difficult for most governments to finance the costs of the EPI, given current patterns of investment and spending. In order to cover the costs of immunization programs in their current form, governments must reallocate substantial resources from curative hospital care or undertake major improvements in the management and efficiency of government health resources. These issues will be explored in greater depth in a separate document of the Immunization Sustainability Study.

Table 11
Comparison of Cost per Fully Immunized Child with Economic Indicators

COUNTRY	COST/FIC	PERCENT OF HEALTH EXPEND. PER CAPITA	PERCENT OF GDP PER CAPITA
BURKINA FASO:F	$ 9.72	942%	8%
BURKINA FASO:M	$11.72	1135%	10%
TANZANIA:F	$ 6.48	221%	4%
MAURITANIA:F	$ 7.21	na	2%
MAURITANIA:M	$18.35	na	4%
MAURITANIA:C	$ 9.46	na	2%
SENEGAL:C	$20.03	na	4%
PHILIPPINES:F	$13.29	366%	2%
CAMEROON:C	$19.62	189%	2%
TURKEY:F	$19.00	357%	2%

Percent of GDP per capita based on World Development Report, 1988.
Na = Not available.

B. ISSUES WHICH REMAIN TO BE ADDRESSED

The previous section identified some of the weaknesses of previous studies, such as wide variations in: a) quantifying program inputs; b) input prices; c) technologies that are covered; d) outcome measures; and e) the scale and objectives of the studies. This section discusses methodological areas which remain to be addressed in the future.

1. Programmatic and Policy-Level Questions of Importance

One of the conclusions of this review is that the rationale for undertaking cost and cost-effectiveness studies has varied and evolved over time. This has affected how and how well studies have been conducted. Results from these studies should be useful to program managers and policy-makers, but the type of questions to be addressed may be different

for these two groups. For instance, a policy-maker may be concerned with how much it will cost to reach higher levels of coverage and where will the resources will come from to finance the program. A manager may be more interested in knowing how a better distribution of resources could affect outcomes in the short run. A donor organization may be more concerned with a comparison of cost-effectiveness ratios among recipient countries or the impact on costs of using different vaccines. Each of these issues requires a somewhat different method and manner of classifying cost information. Therefore, attention needs to be paid to determine what the priority areas of interest are for policy (on a global level), for management and subsequent development of uniform and consistent methods of measurement and interpretation.

2. Economies of Scale

Economies of scale exist in the production of a good or service when the average cost of production declines as the quantity produced increases. Diseconomies of scale exist when average cost rises as the quantity of goods produced increases. A common hypothesis of economic theory is that the average cost curve is U-shaped, and that average costs are higher at both high and low levels of output. However, in between there is some optimal level of output that corresponds to the minimum average cost. In theory, such a plot should reveal economies of scale (average cost decreases as output increases), diseconomies of scale (average cost increases as output increases) or constant returns to scale (average costs do not change as output levels change). This analysis should help assess the relationships between investments into an EPI and anticipated results (in terms of immunization activity).

Unfortunately, data from previous studies are insufficient to estimate the average cost curve, primarily because they do not evaluate changes in outputs or outcomes relative to changes in cost; and there are very few observations of cost-effectiveness within a country with which to estimate a production function for EPI. A production function shows how costs change with increasing outcomes or outputs and would be important to estimate for EPI in order to project program costs for higher coverage levels or larger population sizes.

In order to measure this function, estimates of costs would need to be made at varying (increasing) levels of coverage over a period of time from a sample of health facilities or other service delivery units. No study in the foregoing analysis measured costs and outcomes over a period of time.

3. Measurement of Cost

Methods of measuring program costs vary in the 28 studies reviewed, despite a standardized methodology developed by WHO (44). Variation exist in the organization and classification of cost categories, the allocation of joint or shared costs, how facility-based data are generalized to national figures, and whether economic or financial data are used in cost calculations. Variation may have been the result of the difficulty in collecting cost information in some countries. Attempts are underway by WHO and REACH to standardize the classification and analysis of data.

In addition, little attention has been paid to developing a method for estimating accurately the cost of one EPI component, such as the cost of delivering measles or tetanus toxoid. Although several studies (3, 41) have attempted to evaluate vaccines separately, allocation of shared costs

among vaccine types has been made on a proportional basis, obscuring differences in the technologies and time required for each type of vaccination. The value of such analysis comes when estimating incremental costs to the EPI of adding additional or alternative vaccines.

4. Effectiveness Measures

In the sample of 19 cost-effectiveness studies, the most common measures of effectiveness have been the numbers of doses administered and the numbers of fully immunized children. However, figures of the average cost per dose mask the differences among the types of vaccines which are a part of the EPI series. Only recently have standardized methods for calculating immunization coverage, especially for children receiving all doses, been developed and used in the field. As these new tools are used routinely, their results should be factored into cost-effectiveness analysis.

5. Externalities

EPI activities may impose costs on other components of the health care system (negative externality) or confer benefits other than the intended objectives (positive externality). An example of a negative externality of EPI may be the interruption of other primary health care services during a national immunization campaign. An example of a positive externality may be improved technical capabilities, motivation of health staff or

improvement in surveillance. Few studies of EPI have included the "costs" of positive or negative externalities because, in practice, they are difficult to identify and measure.

Few studies have examined the cost of immunization programs to the individual or to the household (i.e., waiting or traveling time or time lost from work to immunize children). UNICEF recommended that the social costs of immunization programs be considered in the future (39). Haaga also makes this point in his review of cost-effectiveness and cost-benefit studies (20).

IV. CONCLUSIONS AND POLICY IMPLICATIONS OF THIS REVIEW

This overview supports and, in some cases, revises the findings of previous reviews of the literature of cost-effectiveness studies of the EPI (11, 20, 27). In addition, an average cost of $13.00 per fully vaccinated child supports higher estimates made earlier for the Bellagio Conference in 1984.

On the basis of nine studies, Creese (11) proposed that four factors appear to affect the short-run costs of EPI: 1) the magnitude of the fixed cost component, 2) the level of output, 3) the prices used in cost calculations, and 4) the particular technology used. The larger the fixed costs (investments for capital equipment), the higher the cost per immunized child in the short run. If an EPI immunizes a larger number of children in the short run, then the cost per child will be reduced. Input prices affect total cost, especially when the program is large, as small variations in the price of vaccine, for example, can have major

consequences on variations in total cost. The technology used has an effect both on costs and outcomes. A new technology or strategy may be more or less expensive than older technologies, but they may require better trained workers or ancillary costs which increase the overall program cost. The appropriateness of a strategy or technology will also have cost implications.

This current review supports these findings, although it remains unclear how the level of output influences total cost and whether the cost of approximately $13 per fully immunized child will increase, decrease or remain the same with increasing coverage levels.

In his review of 10 cost-effectiveness and cost-benefit studies, Haaga (20) compared the cost per fully vaccinated child with the GDP per capita and total national health expenditures. It was found that immunization represented a relatively small proportion of total GDP, whereas the EPI represents a large share of total government health expenditures. Similar trends were found in this review, with EPI costs representing between 2% to 8% of GDP per capita and between 200% and 1100% of current health expenditures per capita in a country. Those countries with a lower GNP per capita had EPIs which represented greater proportions of total health expenditures (e.g., Burkina Faso).

The conclusion is that national immunization programs are not inexpensive (in absolute terms) and that securing greater government resources for preventive programs will require some combination of reallocation of resources within the health sector, improved efficiency in service delivery, or payment of immunization services by the population or community.

The major findings of the REACH review can be summarized as follows:

A. The cost per fully immunized child of $13.00 supports previously reported findings at the Bellagio Conference in 1984. This figure varies only slightly according to the particular strategy or region under consideration. Routine services through fixed facilities have the lowest cost per fully immunized child on average ($11.74). Immunization campaigns have a higher cost per fully immunized child at $15.62. However, the differences are small between facility-based and campaign strategies. An average figure of $13 per fully immunized child could be used to approximate the cost EPI worldwide, regardless of approach used. However, because few cost-effectiveness studies have used similar methods for calculating costs and, more importantly, effectiveness of EPI, this estimate of cost per child should be verified with information from future studies utilizing similar methods.

B. The contributions of national governments to immunization programs, approximately 50% of total program cost, is lower than expected. For routine services through fixed facilities, the proportion of government contribution is greatest at 55% of total; this proportion diminishes to 40% for campaign strategies. In addition, government contributions to the EPI tend to be in the form of salaries for health workers, building depreciation costs and, in some instances, transport costs. However, the bulk of EPI costs, particularly those which require foreign exchange such as vaccines, syringes, cold chain equipment, vehicles, and even local

training costs, are being borne by international organizations and outside donor agencies. The study found that countries with lower GNP/capita make less of a contribution to the EPI from government resources.

C. This study suggests that the larger the population reached by EPI, the larger the total program cost. This relationship supports earlier impressions of Creese and has implications for the ability of highly populated countries (Nigeria, Indonesia, for instance) to finance a national EPI at high coverage levels. The results from the Mauritania study, showing a cost-effectiveness ratio for the national campaign nearly half that of the campaigns in Cameroon and Senegal, support this finding as well.

D. Sustaining immunization programs and strategies using only government resources will be difficult in some countries, particularly when government health expenditures are low. It was expressed at the Bellagio Conference in 1984 that the implementation of the EPI cannot occur without the continued high commitment of international donor organizations. Securing national government resources for preventive programs will require some combination of reallocation of resources from curative to preventive programs or to the health sector from other sectors, improved efficiency of service delivery, or financing of immunization by individuals.

E. At the present time, insufficient empirical data exist that can be used to determine what the cost of an EPI would be at higher than observed coverage levels, although it appears that average cost may decline with increasing coverage levels. Studies have not been undertaken at repeated intervals to measure the costs of incremental coverage gains. Studies

should be designed that measure the relationships between costs and coverage levels better so that estimates can be made of the future costs of 80% and 100% coverage coverage and disease eradication.

F. This review has confirmed earlier observations of previous summaries (Creese, Haaga, and Parker) on the varied quality and lack of consistent methodology for cost-effectiveness. A study protocol should be developed that not only standardizes basic costing and effectiveness terminology and methods, but also addresses the needs of program managers and policy makers. This study protocol would help managers evaluate the distribution and use of EPI resources in order to improve effectiveness study strategy. It would also take into account issues relevant to policy makers, such as the cost of reaching higher coverage rates or eradicating disease.

G. The rationale and impetus for cost and cost-effectiveness studies of the EPI has evolved since the late 1970s because of our greater understanding of the utility of cost information, the change and improvement in EPI services delivery and the improvement in evaluation techniques. Although this evolutionary process has hampered our ability to compare data among countries and to standardize methods, sufficient information exists regarding the use and methods of cost-effectiveness studies to permit us to plan, organize and implement future studies which will address pressing issues and be more useful to managers and policy-makers.

H. In the course of producing this review, it was clear there had been insufficient dissemination of study findings from one country to another or use of study results in-country. Evidence suggests that most studies are conducted on an ad hoc basis, without building upon previous experience in the region or within a particular country.

V. RECOMMENDATIONS FOR FUTURE STUDIES

This review has highlighted the lack of specificity of previous studies in assessing the relationships between program inputs and outcomes. It is therefore recommended that the next generation of studies redress some of the remaining methodological issues and respond to outstanding questions regarding costs and coverage relationships.

Some of the questions which have been addressed in the studies analyzed for this review include:

1) What is the total cost of the national and regional EPI? What is the recurrent cost and what is the annual investment cost?

2) What are the individual cost elements of the national and regional program and what percent of total cost does each of these elements represent?

3) What are the contributions to the total cost of the Ministry of Health, USAID, UNICEF and other donor organizations?

4) What is the cost of delivering the EPI through alternative strategies: fixed facilities, mobile teams, national campaigns, outreach from health facilities, oral versus killed polio vaccine, or channeling?

Some of the questions which remain to be examined in order to provide a greater understanding of the economic requirements of Universal Immunization and reduction or elimination of disease are the following:

1) What is the average cost of delivering immunization services through different types of health facilities (e.g., health centers, dressing stations, dispensaries, primary health care units, district hospitals, urban and rural facilities?);

2) What is the best measure of effectiveness of the program?

3) What is the cost-effectiveness of the EPI at different levels of the health system?

4) What will it cost next year to maintain current coverage levels?

5) What will it cost in the future to increase coverage levels by alternative strategies?

6) What would be the cost savings of integrating EPI services with other primary health care services?

7) What is the total foreign exchange requirement of the national and regional EPI?

8) How efficient are immunizations provided through different strategies and how can efficiency be improved?

9) What is the marginal or incremental cost of preventing missed opportunities?

10) How might the EPI be financed in the future by government or local resources?

11) What will it cost to eradicate specific diseases (e.g., poliomyelitis)?

12) What will the economic burden be (measured as percent of GDP or percent of government health expenditures) for different countries to achieve Universal Childhood Immunization?

13) What would coverage levels be (of fully immunized infants) for different countries at the same level of economic burden?

14) How long will it take to achieve Universal Childhood Immunization based on current economic capacity within a country and donor willingness to finance the recurrent and foreign exchange requiring components of the program?

15) What would it have to cost per fully immunized child so that all or most countries could afford at least 80% coverage?

Although it is difficult to specify a better approach to cost-effectiveness studies of the EPI because the study methods are derived primarily from the research questions which are being raised, future studies should attempt to incorporate some of the following elements in order to improve our understanding of cost and coverage relationships:

1. Repeated or longitudinal design;
2. Direct linkage with coverage survey data collection methods and routine surveillance for diseases;
3. Larger sample sizes of delivery sites;
4. More focus on district or regional analysis;
5. Greater focus on measurement of fully immunized children rather than doses or calculations of cases and deaths prevented.

The overall conclusion of this review is that previous studies' results do not provide enough predictive power to determine what the future costs of the EPI at higher levels of coverage. In addition, these studies have not provided enough management information from which to make resource allocation decisions to improve efficiency of service delivery. The approaches described below are aimed at improving the quality of results for both management and policy purposes.

Repeated or longitudinal design

All of the previous cost-effectiveness studies have been "one-time" analyses and the lack of repeated or continuous evaluation has limited our ability to learn how total program cost varies with increasing or decreasing coverage levels. Future cost-effectiveness studies should be carried out over a period of years so that a set of baseline data can be

compared with future costs and outcomes of the EPI. Only by measuring and monitoring cost-effectiveness ratios over time will we be able to analyze the marginal cost of immunizing one additional child in order to predict the future cost of reaching the last ten to twenty percent of the population. Further, this information will show how average costs change with increasing and decreasing outcomes.

In addition, a longitudinal design allows for actual comparisons of costs with reduction in disease incidence and perhaps mortality over time.

Direct linkage with coverage survey data collection methods

Most of the criticism of earlier cost-effectiveness studies stems from the poor quality of denominator data on outcomes. With the advent of newer and better technologies for measuring coverage rates of infants fully immunized (i.e., COSAS, EPIInfo), future cost studies should only be conducted in tandem with coverage surveys. In addition, cost information at the delivery site level should be matched with coverage data, either by selecting delivery sites which correspond to cluster survey samples or by conducting sample surveys of 210 children in the catchment areas of facilities and other delivery modalities. In this manner, inputs into the program can more closely be attributed to outcomes at a micro level so that relationships between costs and coverage can become clearer.

Larger sample size

Some of the studies reviewed in this document used a sample of health facilities as the basis for analysis and comparison. However, these studies have not used coverage survey data to measure outcomes and have not

had a large enough sample size to cover the wide range of variation in service delivery to have statistically significant results. The next generation of studies should collect data from a larger sample of facilities or mobile teams in order to determine clearly which factors affect the cost of delivering services and the cost-effectiveness of EPI. Once these factors are identified, management decisions can focus on making these aspects of the program more efficient.

Focus on regional or district analysis

There have been no studies which compare the cost-effectiveness of the EPI by region or district within a country. For management purposes, these evaluations could identify which regions and districts are performing more efficiently and effectively than others and areas where management at regional and district levels can be improved.

Fully immunized infants

Because the goal of the EPI is to immunize all children less than one year of age with six antigens in order to reduce disease morbidity and mortality, the best measure of program effectiveness at the present time is the number of children fully immunized less than one year of age. Efforts should be made to develop methods for costing individual components of EPI in the future so that estimates of the cost of providing new or different vaccines can be made.

APPENDIX A

REFERENCE TABLES FOR COST-EFFECTIVENESS STUDY CALCULATIONS

APPENDIX A-1

CALCULATION OF CURRENT EPI COSTS IN CURRENT 1987 U.S. DOLLARS
(including technical assistance)

YEAR USD	COUNTRY	STRATEGY AND STUDY	TOTAL COST (CONSTANT USD)	MULTI-PLYING FACTOR	TOTAL COST U.S. 1987	Number FIC	Number Doses	Cost/FIC Current USD	Cost/FIC 1987	Cost/Dose Current USD	Cost/Dos 1987
1982	Brazil	Routine:opv		1.18				$4.77	$5.61	$1.59	$1.87
1982	Brazil	Campaign:opv		1.18				$2.04	$2.40	$0.68	$0.80
1982	Brazil	Routine: measles		1.18				$4.63	$5.45	$4.63	$5.45
1987	Burkina Faso	Routine	$58,115	1.00	$58,115	5,977		$9.72	$9.72		
1987	Burkina Faso	Mobile	$27,239	1.00	$27,239	2,325		$11.72	$11.72		
1986	Cameroon	Routine	$41,312	1.04	$42,815	18,864	389,225	$2.19	$2.27	$0.11	$0.11
1986	Cameroon	Campaign	$3,575,392	1.04	$3,705,445	188,864		$18.93	$19.62		
1984	Colombia	Routine		1.09				$26.59	$29.09	$2.54	$2.78
1984	Colombia	Campaign	$10,240,000	1.09	$11,200,888	179,965		$56.90	$62.24	$3.56	$3.89
1980	Cote d'Ivoire	Routine	$527,250	1.38	$727,078	42,866	71,250	$12.30	$16.96	$7.40	$10.20
1985	Ecuador	Routine	$675,000	1.06	$713,003	136,000	2,300,000	$4.96	$5.24	$0.29	$0.31
1985	Ecuador	Campaign	$1,665,000	1.06	$1,758,740	206,400	2,000,000	$8.07	$8.52	$0.83	$0.88
1978	Indonesia	Routine		1.74				$3.69	$6.43		
1987	Indonesia	Routine	$108,355	1.00	$108,355	67,962		$1.59	$1.59		
1984	Malawi	Routine	$1,588,776	1.09	$1,737,862	138,395	1,604,824	$11.48	$12.56	$0.99	$1.08
1985	Mauritania	Routine	$83,970	1.06	$88,698	12,297		$6.83	$7.21		
1985	Mauritania	Campaign	$228,715	1.06	$241,592	25,507		$8.97	$9.47		
1985	Mauritania	Mobile	$357,880	1.06	$378,029	20,604		$17.37	$18.35		
1979	Philippines	Routine		1.56				$4.93	$7.71		
1987	Philippines	Routine	$17,286,549	1.00	$17,286,549	1,233,147		$14.02	$14.02		
1986	Senegal	Routine		1.04				$8.00	$8.29		
1986	Senegal	Campaign	$4,928,788	1.04	$5,108,071	255,000		$19.33	$20.03	$1.30	$1.35
1984	Swaziland	Routine	$412,542	1.09	$451,254	8,158		$50.57	$55.32	$2.06	$2.25
1987	Tanzania	Routine	$4,571,000	1.00	$4,571,000	700,000		$6.53	$6.53		
1979	Thailand	Routine		1.56				$10.73	$16.79		
1982	The Gambia	Routine	$600,126	1.18	$706,422	26,791		$22.40	$26.37	$1.75	$2.06
1985	Turkey	Campaign	$29,695,175	1.04	$30,775,324		27,495,532			$1.08	$1.12
1987	Turkey	Routine	$15,265,676	1.00	$15,265,676	803,568		$19.00	$19.00		
Average			$4,596,843		$4,747,608	214,352		$13.64	$15.13	$2.06	$2.44

Multiplying Factor equivalent to the Consumer Price Index in 1987 divided by that of the study year. See Appendix B.

FOOTNOTES TO APPENDIX A-1

Data for Brazil from Creese, 1984.

Data for Bukina Faso from de Champeaux, 1987. Total cost of EPI allocated to fixed and mobile strategies based on percent of immunization activity quoted in document of 28% for mobile teams and 72% for fixed facilities. Total number of children fully immunized determined from coverage data as 29% of the target population or 8,302 total, resulting in 2,325 children being fully immunized by the mobile teams and 5,977 being fully immunized by fixed facilities.
Study reports that 26% of total cost is for the mobile teams. Figures are based on minimum costs reported. The analysis used an exchange rate of 400 CFA per USD.

Data for Cameroon from Brenzel, 1987.

Data for Colombia from Creese, et. al., 1987. FIC and doses calculated from cost and cost-effectiveness ratios.

Data for Cote d'Ivoire from Shepard, WHO Weekly Epidemiologic Review, 1982. Data on FIC and doses calculated from total cost and cost-effectiveness ratios.

Data for Ecuador from Shepard, et. al., 1988.

Data for Indonesia (1978) from Creese, 1982.

Data for Indonesia (1982) from Berman, 1987.

Data for Malawi from Robertson, 1985. Figures on doses and FIC calculated from total cost and cost-effectiveness ratios. This study uses reported average cost per fully immunized child in a sample of health facilities.

Data for Mauritania from Brenzel, 1986 and Brenzel, Claquin in progress.

Data for Philippines (1979) from Creese, 1982. This study used average cost per fully immunized child.

Data for Philippines (1987) from Turner, 1987.

Data for Senegal from Brenzel, 1987.

Data for Swaziland from Robertson, 1985. This study used reported average cost per fully immunized child from a sample of health facilities.

Data for Tanzania from Feilden, 1987 (Joint Review) updated 1989.

Data for Thailand from Creese, 1982. This study uses reported average cost per fully immunized child for a sample of health facilities.

Data for The Gambia from Robertson, 1985. This study uses reported average cost per fully immunized child for a sample of health facilities. In addition, additional technical assistance costs of $225,362 were added to total cost. Figures on number of children fully immunized calculated from total cost and cost-effectiveness ratios.

Data for Turkey (1985) from UNICEF Rapid Assessment, 1985.

Data for Turkey (1987) from Brenzel, 1988. Figure includes buildings cost which was not reported in the earlier version.

APPENDIX A-2

COMPARISON OF COST-EFFECTIVENESS STUDIES OF THE EPI
USING SIMILAR METHODS
(with technical assistance)

COUNTRY	STRATEGY	COST U.S. 1987	NO. FIC	COST/FIC
Tanzania	Routine	$4,571,000	700,000	$6.53
Mauritania	Routine	$88,698	12,297	$7.21
Mauritania	Campaign	$241,592	25,507	$9.47
Burkina Faso	Routine	$58,115	5,977	$9.72
Burkina Faso	Mobile	$27,239	2,325	$11.72
Philippines	Routine	$17,286,549	1,233,147	$14.02
Mauritania	Mobile	$378,029	20,604	$18.35
Turkey	Routine	$15,265,676	803,568	$19.00
Cameroon	Campaign	$3,705,445	188,864	$19.62
Senegal	Campaign	$5,108,071	255,000	$20.03
The Gambia	Routine	$706,422	26,791	$26.37
Average: all (n=11)		$4,312,440	297,644	$14.73
Standard deviation		$5,944,640	402,779	$6.07

FIC= Fully Immunized Child
Data from Table A-1.

APPENDIX A-3

COMPARISON OF COST-EFFECTIVENESS STUDIES OF THE EPI
BY STRATEGY
(with technical assistance)

COUNTRY	STRATEGY	COST U.S. 1987	NO. FIC	COST/FIC
Tanzania	Routine	$4,571,000	700,000	$6.53
Mauritania	Routine	$88,698	12,297	$7.21
Burkina Faso	Routine	$58,115	5,977	$9.72
Philippines	Routine	$17,286,549	1,233,147	$14.02
Turkey	Routine	$15,265,676	803,568	$19.00
The Gambia	Routine	$706,442	26,791	$26.37
Average (n=6)		$6,329,413	463,630	$13.81
Standard deviation		$7,221,509	477,417	$7.05
Mauritania	Campaign	$241,592	25,507	$9.47
Cameroon	Campaign	$3,705,445	188,864	$19.62
Senegal	Campaign	$5,108,071	255,000	$20.03
Average (n=3)		$3,018,369	156,457	$16.37
Standard deviation		$2,045,272	96,452	$4.88
Burkina Faso	Mobile	$27,239	2,325	$11.72
Mauritania	Mobile	$378,029	20,604	$18.35
Average (n=2)		$202,634	11,465	$15.03
Standard deviation		$175,395	9,140	$3.32

FIC= Fully Immunized Child
Data from Table A-1.

APPENDIX A-4

COMPARISON OF COST-EFFECTIVENESS STUDIES OF THE EPI
BY REGION
(including technical assistance)

COUNTRY	STRATEGY	COST U.S. 1987	NO. FIC	COST/FIC
AFRICAN PROGRAMS				
Tanzania	Routine	$4,571,000	700,000	$6.53
Mauritania	Routine	$88,698	12,297	$7.21
Mauritania	Campaign	$241,592	25,507	$9.47
Burkina Faso	Routine	$58,115	5,977	$9.72
Burkina Faso	Mobile	$27,239	2,325	$11.72
Cameroon	Campaign	$3,705,445	188,864	$19.62
Mauritania	Mobile	$378,029	20,604	$18.35
Senegal	Campaign	$5,108,071	255,000	$20.03
The Gambia	Routine	$706,422	26,791	$26.37
Average (n=9)		$1,653,846	137,485	$14.34
Standard Deviation		$2,022,435	216,682	$6.54
ASIAN PROGRAMS				
Philippines	Routine	$17,286,549	1,233,147	$14.02
Turkey	Routine	$15,265,676	803,568	$19.00
Average: all (n=2)		$16,276,113	1,018,358	$16.51
Standard Deviation		$1,010,437	214,790	$2.49

FIC= Fully Immunized Child
Data from Table A-1.

APPENDIX A-5a

PERCENTAGE DISTRIBUTION OF ANNUAL IMMUNIZATION COSTS BY MAJOR COST CATEGORY
FIXED CENTER STRATEGY

COMPONENT/ COUNTRY	SALARIES	VACCINES	TRANSPORT	SUPPLIES	COMMUNI-CATION	GENERAL OPERATE	TRAINING	BUILDINGS	VEHICLES	EQUIPMENT	SUPERVISION, MGMT	OTHER	TOTAL
BRAZIL	68%	5%	1%							9%	14%	3%	100
CAMEROON	60%	13%	8%							14%		5%	100
COTE D'IVOIRE	62%	10%	0%								23%	5%	100
GAMBIA	45%	12%	15%	9%			3%	2%		14%			100
GHANA	51%	6%	21%							13%		9%	100
INDONESIA	25%	21%	14%							18%	12%	10%	100
KENYA	27%	3%	0%							16%	43%	11%	100
MAURITANIA	15%	11%	13%	14%				22%	5%	16%	4%		100
PHILIPPINES	31%	12%	14%							19%	22%	2%	100
PHILIPPINES	47%	7%	7%	1%	4%		2%	29%		3%		1%	100
TANZANIA	11%	42%	10%	12%				2%	6%	16%		1%	100
THAILAND	28%	13%	9%							26%	20%	4%	100
TURKEY	65%	2%	3%	3%	10%		1%		7%	8%		1%	100
RANGE	11%-68%	3%-42%	1%-21%	1%-14%	4%-10%		1%-3%	2%-28%	5%-7%	3%-26%	4%-43%	1%-11%	
MEAN	41%	12%	9%	8%	7%		3%	14%	6%	14%	20%	5%	
MEDIAN (%)	45	12	10	9	--	--	2	2/22	6	14/16	20	3.5	

Data for Brazil from Creese, 1984.
Data for Cote d'Ivoire from Creese, 1986 and Haaga 1982.
Data for Gambia from Robertson, 1985.
Data for Ghana from Creese, 1986 and Haaga, 1982.
Data for Indonesia from Creese, 1982.
Data for Kenya from Creese, 1986 and Haaga 1982.
Data for Mauritania from Brenzel, 1986.
Data for Philippines from Creese, 1986 and Turner, 1987.
Data for Tanzania from Feilden, 1987 and 1979.
Data for Thailand from Creese, 1986.
Data for Turkey from Brenzel, 1988.

APPENDIX A-5b

PERCENTAGE DISTRIBUTION OF ANNUAL IMMUNIZATION COSTS BY MAJOR COST CATEGORY FOR CAMPAIGNS

COMPONENT/ COUNTRY	SALARIES	VACCINES	TRANSPORT	SUPPLIES	COMMUNI-CATION	GENERAL OPERATE	TRAINING	BUILDINGS	VEHICLES	EQUIPMENT	SUPERVISION, MGMT	OTHER	TOT
MAURITANIA	35%	3%	12%	19%	5%			1%	0%	5%	20%		1
CAMEROON	66%	5%	6%	4%	3%	7%	2%	0%	3%	0%		4%	1
TURKEY	41%	5%	4%		27%				23%				1
ECUADOR	23%	8%	29%	7%	19%		7%	1%		0%		6%	1
SENEGAL	18%	35%	18%	8%	10%	4%		1%	4%	2%			1
BRAZIL	39%	4%	6%		5%					7%	19%	20%	1
RANGE	18%-66%	3%-35%	4%-29%	4%-19%	3%-27%	4%-7%	2%-7%	1%	3%-23%	2%-7%	19%-20%	4%-20%	
MEAN	37%	10%	13%	10%	12%	6%	5%	1%	10%	5%	20%	10%	
MEDIAN (%)	35/39	5	6/12	7/8	5/10	NA	NA	1	3/4	5	14/20	6	

Data for Mauritania from Brenzel, 1986.
Data for Cameroon from Brenzel, 1987.
Data for Turkey from Brenzel, 1988.
Data for Ecuador from Shepard, et. al.,1988.
Data for Senegal from Brenzel, 1987.
Data for Brazil from Creese, 1986.

APPENDIX A-5c

PERCENTAGE DISTRIBUTION OF ANNUAL IMMUNIZATION COSTS BY MAJOR COST CATEGORY
FOR MOBILE TEAMS

COMPONENT/ COUNTRY	SALARIES	VACCINES	TRANSPORT	SUPPLIES	COMMUNI-CATION	GENERAL OPERATE	TRAINING	BUILDINGS	VEHICLES	EQUIPMENT	SUPERVISION, MGMT	OTHER	TOTAL
COTE D'IVOIRE	24%	17%	8%								38%	13%	100%
GHANA	51%	4%	27%							14%		4%	100%
MAURITANIA	50%	5%	14%	14%	0%	4%		0%	9%	3%	1%		100%
RANGE	24%-51%	4%-17%	8%-27%										
MEAN	42%	9%	16%							9%	20%	9%	
MEDIAN	50	5	14	NA	NA	NA	NA	NA	NA	NA	NA	NA	

Data for Cote d'Ivoire and Ghana from Creese, 1986.
Data for Mauritania from Brenzel, 1986.

APPENDIX B

FIGURES USED IN THE CALCULATION OF
CURRENT 1987 U.S. DOLLARS

YEAR	CONSUMER PRICE INDEX
1978	79.19
1979	88.13
1980	100.00
1981	110.35
1982	117.15
1983	120.91
1984	126.07
1985	130.55
1986	133.06
1987	137.90[1]

Source: International Financial Statistics Quarterly, The World Bank, January 1988.

[1] Calculated based on average of Quarter I-IV for 1987, from December 1988 issue.

APPENDIX C

DESCRIPTION OF COST CATEGORIES USED IN COST-EFFECTIVENESS STUDIES OF THE EPI

This appendix describes the types of inputs included in cost categories for cost-effectiveness studies of the EPI and briefly how these costs are calculated. For a more detailed description, refer to the ANE Bureau Guidance on Costing of Health Service Delivery Projects (REACH, 1988) and the WHO EPI Costing Guidelines (WHO/EPI/79/5).

Personnel costs: Included in this cost category are the salaries (earnings from all sources) and benefits (such as housing, post allowance, insurance, uniforms and incentive payments) of health workers, administrators and technical personnel who are involved in an immunization strategy. These costs are difficult to estimate because of the wide variety of personnel involved at different levels of the health system. These include physicians, nurses, health assistants, program managers, supervisors, statisticians, supply officers, vaccinators, cold chain technicians, drivers, guards and technical assistance personnel.

Personnel costs represent the opportunity cost of using personnel for the EPI rather than another health activity which may also satisfy the goal of reducing childhood morbidity and mortality. To estimate personnel costs, the number and type of personnel used by the program is multiplied by a proportion of the total average annual earnings, including benefits, of each type of personnel. This proportion is determined best on the basis of the number of hours worked per week (or the proportion of time spent each week on EPI if more detailed information is not available.) Wages which do not represent the true marginal product of labor should be adjusted based on the shadow price of labor (see glossary). Although better methodologically, this has not been performed for any cost-effectiveness study of the EPI.

Vaccine cost: These costs represent the value of vaccine administered and wasted by the EPI. Traditionally, these costs have been calculated by multiplying the total number of doses administered per year for each antigen by a unit price per antigen and an estimate of wastage for each antigen. More recent studies base estimates on the total numbers of vials consumed during a year rather than the number of doses to arrive at a better measure of wastage and cost.

Transportation cost: This cost category includes resources used to operate vehicles, to travel using other modes of transportation (e.g., bus, taxi, train, plane), to ship or transport supplies internationally and domestically, and customs duties. Data on expenditures for customs duties, freight and travel tickets and fares can be used to calculate some transportation costs. However, data on total gallons of fuel, oil and lubricants consumed or on internal travel cost may be difficult to retrieve. In such cases, the total distance travelled can be multiplied by the cost per gallon (or liter) of fuel and divided by the distance travelled per gallon. The number of taxi or bus trips per month can bee multiplied by the cost of a ticket and adjusted for the entire year.

Supplies cost: This category represents the value of syringes and needles consumed within a year, but may also include the cost of audiovisual supplies and medical supplies as well. Cost figures are either based on recorded expenditures or are estimated based on the total number of doses administered.

Social mobilization cost: This category includes the value of donated radio and television time as well a donated print media space. In addition, the production cost of radio and television shows and of other publicity media is included here. These costs are based on the frequency of transmission, the duration in minutes or seconds and the cost per unit of broadcasting (which is normally equivalent to advertising costs).

Supervision and management costs: This cost category includes the travel, per diem and personnel costs of supervisory staff. In some cases, supervision costs will not be distinct category from personnel, travel or per diem categories.

Vehicles cost: This category reflects the annualized value of vehicles used in the delivery of immunization services or of supervising and managing the program. Calculations are made on the basis of the purchase price of a vehicle, its useful life in the country in question, and the proportion of time used for EPI in case it is shared with other health programs. Annualization also adjusts for the changing value of money in the future relative to the present. A more detailed description and explanation of the methods is found in the Guidelines for Costing of Health Service Delivery Projects.

Equipment costs: This category includes the annualized value of all types of cold chain equipment and other equipment (e.g., generators) for the EPI. They are calculated in the same manner as vehicles.

Buildings costs: The annual value of buildings is important for the EPI in cases where access to health services (and EPI services in particular) is influenced by the number and location of facilities. Building estimates are based on construction costs, the useful life of facilities and proportion of the facility used for EPI (ususally based on floor space and frequency of use).

Other costs: This category will include overhead costs or the value of other items not captured in the other cost categories.

Sensitivity Analysis: An analysis which changes the key assumptions made in a cost-effectiveness study to test whether the original assumptions were faulty or whether different assumptions result in large variations in the cost-effectiveness ratio.

Shadow Pricing: The adjustment which is made to unit prices when they do not reflect the true market value of labor or materials. For example, in some countries, wages for health workers are low and workers may have other jobs in order to earn sufficient income. Shadow pricing would adjust annual earnings by a factor to reflect full annual income and value to society.

APPENDIX D

DESCRIPTION OF COST-EFFECTIVENESS STUDIES

This appendix reviews the literature on EPI cost-effectiveness studies. The purpose, methods, results and conclusions of each study or article is presented. More detail on methods can be found in the original published documents or obtained from the authors themselves.

A. SUMMARY ARTICLES

1. Creese, Andrew L., "Cost Effectiveness of Potential Immunization Interventions Against Diarrhoeal Disease," Social Science and Medicine, Vol. 23, No. 3, pp. 231-240, 1986.

The author estimates the cost per death averted and the cost per case prevented of three possible immunizations against diarrheal disease: cholera, rotavirus and measles. These estimates are based on information assembled from nine studies of the costs and cost-effectiveness of immunization programs worldwide, and thus this article represents the second review of the EPI cost-effectiveness literature. The first review was undertaken by Haaga (see 14 below), who combined cost-effectiveness data with those on incidence of disease in order to assess the likely impact of the vaccines on mortality and morbidity from diarrheal disease.

According to Creese, the nine studies reviewed (Ivory Coast, Kenya, Gambia, Cameroon, Ghana, Indonesia, Philippines, Thailand and Brazil) employed a common approach to specify and measure program costs. In addition, the cost information was relatively recent (i.e., post 1977). The costing methods were based upon or similar to the WHO/EPI costing guidelines. However, these studies did not adjust for economic distortions, such as shadow prices of labor.

Differences in study methodologies arise in their measurement and identification of immunization program effectiveness. Variations are due to three principal characteristics of immunization programs: 1) the types of vaccines provided, including the vaccination schedule; 2) the age group targeted for vaccination services; and 3) the strategies used to deliver immunization services.

This article proposes four factors that appear to affect short-run EPI costs: 1) the magnitude of fixed costs; 2) the level of output; 3) the prices used in cost calculations; and 4) the particular technology used. The fixed cost element was found to be extremely important in determining the magnitude of total short-run costs in these studies. In addition, salaries and wages represented the largest component of total cost in all studies reviewed. The data suggest (Ghana and Brazil) that mobile (or partially mobile) services may be more cost-effective than services provided through static health facilities. The size of the population receiving services also affected the average cost per dose, with larger populations being more efficient than smaller.

The analysis also suggests that rotavirus and measles immunization would be more cost-effective than cholera vaccination in reducing the mortality and morbidity associated with diarrheal disease among infants.

However, because complete protection with rotavirus vaccine requires multiple doses, measles vaccinations would be the most cost-effective in the long-run.

2. Creese, A.L. and Henderson, R.H., "Cost-benefit analysis and immunization programs in developing countries," Bulletin of the World Health Organization, 58 (3): 491-497 (1980).

This article argues for more cost-benefit analyses of national immunization programs, because cost-benefit analysis shows whether a particular investment is economically justified or makes a contribution to economic development within a country.

The article states that "the difficulty of establishing whether the most services are worthwhile derives from problems of measuring overall health status and calculating the contributions of health services to changes in that status. Lack of quantifiable outcomes has led to economic analyses in the health sector commonly being focused on comparisons of the cost-effectiveness of alternative strategies for attaining a given goal. Although useful, this is far less ambitious than cost-benefit analysis, which seeks to compare the worth of investments toward different goals, both within and outside the health sector."

Different methods for valuing life are presented, along with their advantages and disadvantages. The article recommends that distributional weights be used to evaluate whether an investment is economically justified between rural and urban areas, because current methods evaluate these two target groups evenly.

3. Haaga, John, "Cost-effectiveness and cost-benefit analyses of immunization programs in developing countries," in D. Jelliffe and E.F.P. Jelliffe, eds., Advances in International Maternal and Child Health, vol. 6, 1986, New York, Oxford University Press, 1986.

This article represents the first serious review of ten cost-effectiveness and cost-benefit analyses of immunization programs. The author argues that cost-effectiveness analyses should be useful to decision makers to improve health planning and allocation of scarce resources and that cost-benefit analysis accomplishes this to a lesser extent.

Haaga selected studies for this review based on their comparability in data collection and reporting. He states that there is some degree of standardization as a result of the WHO/EPI costing guidelines. In all studies, fixed costs were much greater than variable costs of immunization strategies, and as fixed costs are spread over a larger number of immunizations, "average costs should decline, over a broad range until capacity limitations are reached and marginal costs begin to rise, pulling up average costs."

Studies were compared by putting all costs into 1980 U.S. dollars. When the cost per fully vaccinated child is compared to GDP per capita, immunization programs do not appear to represent significant proportions of GDP. The range was between 1.2% in Cote d'Ivoire to 0.1% in Cameroon. However, when these data are compared with the percent of government health expenditures per capita, it is clear that expanding immunization programs would entail large increases in health budgets in many countries. For example, the cost per fully vaccinated child represented 133% of national

health expenditures per capita in Cote d'Ivoire. In Niger, the cost per capita of immunization programs represented between 1 and 11% of per capita health expenditures. These data have implications for how immunization programs can be financed in these countries in the future.

Haaga also points out differences in how costs and effectiveness measures were calculated. Nearly all of the variation in costing methodologies were a result of the manner in which joint costs were allocated among health activities to the immunization program. He states that there "is not single, universally satisfactory method for allocating joint costs." Further, he discusses the differences between reported coverage figures and those calculated from national or region-specific coverage surveys and states that not all studies were measuring the same output of immunization programs. One of the major limitations of previous studies has been their measure of effectiveness, and the author recommends that more field studies of effectiveness should be conducted.

Other points regarding previous studies are: 1) rarely are the private costs of seeking immunization services factored into these analyses; 2) many program decisions could be aided if the incremental costs of adding services to existing ones could be estimated more precisely; 3) the costs and effectiveness of campaigns and acceleration strategies should be estimated and the results used in planning alternative strategies; and, 4) the value of immunization against one disease should be evaluated better, to decrease reliance on measures of full vaccination.

The article discusses at length different methods used to calculate cost per case prevented, cost per death averted, and cost per year of life added, concluding that there is much debate over how to measure these for benefits of immunization programs. This article serves as one of the bases for current review of cost and cost-effectiveness analyses of EPI.

4. Mills, Anne, "Survey and Examples of Economic Evaluation of Health Programs in Developing Countries," World Health Statistical Quarterly, 38 (1985).

This article reviews economic evaluations of health programs in general and provides a brief assessment of evaluations of immunization programs. The author believes that few economic evaluations have been able to offer practical advice to governments. Immunizations services are thought the lend themselves more readily to economic evaluations because of the possibility of separating immunization activities from other preventive health activities. In addition, the linkage between inputs and effects are understood.

B. COST-EFFECTIVENESS AND COST-BENEFIT STUDIES OF IMMUNIZATION PROGRAMS

1. Barnum, N.H., Tarantola, D., and Setiady, I. F., " Cost-effectiveness of an immunization program in Indonesia," Bulletin of the World Health Organization, 58(3): 499-503 (1980).

This study was undertaken in 1978 to compare the cost-effectiveness of immunizations provided through the EPI (DPT, TT and BCG) and treatment of disease. The study used a five-year time horizon beginning in 1979-1980 to determine the effects of immunization services on infant morbidity and mortality . Costs are estimated from financial data provided by the central EPI office for a joint program that delivers all antigens and for each antigen separately. Antigen-specific costs (e.g., vaccine and syringe costs) are allocated directly to their appropriate programs whereas joint program costs are allocated in their entirety to each antigens under the assumption that these costs would be the same for each separate program.

The cost per dose was $0.66 and the cost per fully immunized infant (those receiving three doses of DPT and one dose of BCG) was $3.37. The cost of preventing disease through immunization was found to be one-third that of treating disease in a hospital. A BCG immunization program operated separately is not as cost-effective as programs for the other antigens; however, when BCG is integrated into a larger program it becomes more cost-effective.

2. Berman, Peter, and Quinley, John, "Mass Campaign or Routine Program? A Cost-effectiveness Comparison of Tetanus Immunization Programs in Aceh," draft report, CHIPPS Project, January 1987.

This study compared the costs and effectiveness of routine tetanus toxoid (TT) vaccination given to pregnant women with a campaign for all women of reproductive age (15-49 years). The study, conducted in Aceh province, contrasted cost-effectiveness of vaccination strategies operating in two different regencies in late 1985.

The study used budget figures to estimate the costs of both strategies, including the costs of equipment, personnel, expendables and transport (travel and per diem). Effectiveness was measured by the number of women receiving two doses of TT (TT2 coverage). Preliminary analysis shows that the cost/TT2 averaged $1.54 for routine services and $1.59 for the campaign. However, the total cost of the campaign was 10 times that for the routine services and was equal to 70 percent of the immunization budget for Aceh for 1985-86.

This study raises the issue of whether the campaign strategy would be affordable to the Aceh province in the future. The authors conclude that it could because the province did not use its entire yearly budget and had resources available for other health activities. The data suggest that the campaign was somewhat less efficient than the routine program, though not to a great extent.

3. Brenzel, L. and Claquin P., "Cost-effectiveness of Alternative Immunization Strategies in the Islamic Republic of Mauritania," in progress.

Between May and June 1986, a study of the cost-effectiveness of three complementary vaccination strategies was undertaken in the Islamic Republic of Mauritania. The study examined the relative costs and effectiveness of delivering vaccinations through routine services provided by fixed maternal and child health centers (PMIs), through routine services provided by mobile teams, and a mass immunization campaign between November 1985 and January 1986.

The study adapted the methods recommended in the EPI costing guidelines (EPI/GEN/79/5) in calculating the costs of the various strategies. Costs were estimated for personnel, transport, vaccines, supplies, media, general operating, vehicles, cold chain equipment and buildings. The number of children fully immunized was determined from records of the national campaign and other routine strategies. A cluster sample survey conducted in 1986 confirmed the national coverage figures for children fully immunized less than five and less than one year of age.

The cost per fully immunized child less than five years of age varied among the strategies: approximately $6.80 for the fixed centers, $9.00 for the mass campaign, and $17.40 for the mobile teams. Although the mobile teams were the most costly strategy, they formed an integral part of the EPI in Mauritania, providing services to the nomadic population. In addition, the mass campaign contributed significantly to the coverage rate in 1985 (28% of the total of 53%). Therefore, an association of vaccination strategies was necessary to achieve a high coverage rate (53%) of the population.

The authors conducted a sensitivity analysis to determine alternative ways of reducing the costs or improving the coverage of each strategy. Recommendations such as improving the activities of the mobile teams by staying in villages longer were made. The study raised the issue of how to sustain the results of the campaign.

4. Brenzel, L. "Cost-effectiveness of Immunization Strategies in the Republic of Cameroon," REACH publication, August 1987.

In November and December 1986 and January 1987, the Government of Cameroon launched a national vaccination campaign to improve full coverage from an estimated 30% of children less than five years old. Women of reproductive age were also given tetanus toxoid during the campaign. This study was conducted as part of a UNICEF rapid assessment of the national campaign.

The study compares the costs of the routine EPI delivered primarily through health centers with campaign costs. The methods recommended in the WHO/EPI costing guidelines were adapted for this analysis. Both financial and economic costs were evaluated and compared by source of funding (government, UNICEF, USAID and other donors). Costs were classified as recurrent or investment. Recurrent costs included salaries, vaccines, transport, supplies, media, general operating, food and training costs. Buildings, vehicles, cold chain equipment and audiovisual equipment were calculated for investment costs. The total cost of the campaign was divided between women's and children's vaccines on the basis of the proportion of doses for each (95% for child vaccines).

At the time of this analysis, effectiveness could only be measured in terms of the number of doses administered during the campaign and during the year for routine services. However, in late 1987, a national coverage survey was conducted using the WHO-recommended method of a 30-cluster sample in both rural and urban areas.

This analysis shows that the campaign increased full coverage of children less than one year to 55% at a cost to the government and donors of approximately $4 million. The Government of Cameroon contributed nearly 85% of the total cost ($3,120,000), most of which was attributable to salaries (65%), general operating costs (6%) and transportation (3%). UNICEF was the major donor and was responsible for $312,000 of full resource costs. Recurrent costs accounted for 96% of all costs of the campaign.

Full resource costs were not estimated for routine services. However, the financial costs of the campaign and the routine EPI were compared. The financial cost per fully vaccinated child was $2.19 for routine services and $8.33 for the campaign. For the campaign, the full resource cost per completely vaccinated child was $18.93.

This study documents that, on economic grounds, the campaign was not as cost-effective as routine services and that resources intended for the routine EPI and other preventive programs had been used to finance the campaign. Although the decision to have a campaign is never made solely on economic grounds, financing and sustainability of programs should be considered more thoroughly when deciding to launch national campaigns.

5. Brenzel, L., et al., "Rapid Assessment of Senegal's Acceleration Phase," submitted to UNICEF, REACH publication, November 1987.

In 1987, Senegal launched an acceleration phase of the national EPI in order to increase coverage to at least 75% from an estimated 30%. In three rounds of a national campaign over a period of six months, all EPI vaccines and tetanus toxoid were administered to the population of children less than five and TT to women of reproductive age. This cost and cost-effectiveness evaluation was part of a UNICEF rapid assessment of the acceleration phase.

Both financial and economic costs were evaluated for the acceleration and projected for routine services provided in typical health centers. The methods recommended in the WHO/EPI costing guidelines were adapted for this study. The study assessed the relative contributions of the Government of Senegal and major donors such as UNICEF and USAID. Recurrent costs were divided into seven categories: salaries, vaccines, transportation, communications, supplies, operating costs, and cold chain maintenance costs. Investment costs included buildings, vehicles and equipment.

The cost analysis was complemented by a national coverage survey conducted in each of 10 regions in Senegal in a total of 300 randomly selected cluster samples. Coverage was analyzed in detail using a modified version of COSAS (Coverage Survey Analysis) software, which provided data on coverage of fully immunized children by age, for both before and after the acceleration phase. The campaign increased coverage of children less than one year of age from 20% to 35% fully immunized (receiving all required doses).

The total expenditures for the campaign were $3.5 million and the full resource costs was estimated to be close to $5 million. The difference was due largely to the annualized value of capital investments and salaries for the campaign. Of the total full resource cost, vaccines (35%), salaries (18%) and transportation (18%) accounted for the largest shares. The large vaccine costs were attributable to the use of the injectable polio/DPT combination vaccine that has a unit cost of $0.69 per dose. UNICEF was responsible for the seventy-one percent of total cost ($3.5 million) and the Government of Senegal accounted for most of the remaining balance.

The cost per fully vaccinated child was $19.33 for the campaign and approximately $8.00 for routine services. Because the annual per capita government expenditure on health is only $5.00 in Senegal, these figures raise the issue of how the coverage results from the campaign can be maintained without donor support for the EPI.

6. Brenzel, L., "Cost Analysis of the National Immunization and CDD Programs in the Republic of Turkey," REACH publication, March 1988.

This study was undertaken as part of a joint Government of Turkey/WHO/UNICEF/USAID Comprehensive Review of the Expanded Program on Immunization and the Program for the Control of Diarrheal Diseases in Turkey. The purpose of this study was to examine the costs of both routine programs in order to determine the level of resources needed in the future and sources of current financing of these programs. A cost-effectiveness analysis was performed as well to determine the relationship between program inputs and outcomes.

Full resource costs and annual expenditures were analyzed by source of funding for the national EPI program. In addition, a sample of health facilities was evaluated to assess how investments into the program translated into EPI outcomes at a "micro-level." The cost analysis followed the methods recommended by WHO, with few modifications. Costs were reported for investments and recurrent costs, such as salaries and benefits, per diem, transportation and travel, vaccines, vaccination supplies, media, other supplies, maintenance of vehicles and cold chain equipment, printing and reproduction, and other costs. Investment costs included cold chain, media and computer equipment, vehicles and technical assistance. A sensitivity analysis was conducted which altered assumptions used in the initial analysis.

The total cash expenditures for the EPI for 1987 were approximately $2 million and the full resource costs was nearly $14 million. Recurrent costs accounted for 83% of the total full cost, with salaries and benefits (65%), media (10%) and the annual value of cold chain equipment (8%), the three leading cost categories. The most important expenditure categories were vaccination supplies/disposable syringes and vaccines (34% and 33% of total expenditures). The Government of Turkey was financing approximately 97% of the total cost, except for the cost of syringes, vaccines, and training, which were largely funded by donors. This balance of financing raises questions about how the country will become self-sufficient in service delivery when the foreign-exchange-requiring items are financed by donors.

The cost analysis was complemented by a coverage survey in nine of the 67 provinces. Three provinces were selected to represent either high, average, or low coverage levels in both rural and urban settings. The data were analyzed using COSAS (Coverage Survey Analysis) software and were weighted to estimate the national coverage. 57% of all children less than one year were found to be completely vaccinated, giving a cost per fully immunized child of $17.08.

The facility study results suggest that the number and types of personnel involved in administering vaccinations and the monthly number of kilometers traveled to replenish stock had a measurable effect on the cost structure of the facility. The average cost per dose ranged from $0.24 to $8.15 in the sample. When these data were segregated by facility, the average cost per dose in village health centers ($6.46) was 19 times that in city health centers ($0.34). These data suggest that it is more costly to deliver services to rural populations. However, when these data are adjusted for population density, city health centers have the lowest "index of activity," which may reflect the presence of parallel providers of immunization or the difficulty in reaching a migratory, urban population.

7. Creese, Andrew L., et al., "Cost-effectiveness appraisal of immunization programs," Bulletin of the World Health Organization, 60 (4):621-632 (1982).

This article compares the cost-effectiveness of immunization programs in: the Philippines, Thailand, and Indonesia. These studies were undertaken to field test the EPI costing guidelines. These guidelines were developed in order to create a consistent methodology for estimating costs and benefits of immunization programs. A sample of health facilities was selected in each country to reflect the different delivery modalities of the EPI. In the Philippines, nine health centers were selected which represent different population sizes; in Thailand, 8 representative health centers and one hospital was selected; and in Indonesia, six health centers: three urban and three rural were included in the study.

Costs were divided into two major categories: operating and capital costs. Operating costs included salaries, vaccines, transport, training and other costs whereas capital costs included buildings, vehicles, refrigeration equipment and other (spare parts). Joint costs were allocated on the basis of interviews with health staff on the proportion of time spent delivering immunizations in the facility.

The study used the number of fully immunized children less than one year of age as a measure of effectiveness; however, this measure only required that a child receive one dose of BCG and two doses of DPT.

In the Philippines, the average cost per immunized child ranged from $2.50 to $7.02 in the nine delivery sites. In Thailand, the range was greater, from $4.96 to $35.69 per immunized child. In Indonesia, the cost per fully immunized infant was between $1.48 and $2.50. The author states that "although a classic U-shaped average cost curve appears to exist, the data conceal large differences in the organization, relative factor costs, and coverage of the programs; it is therefore, not possible to use the information to describe an internationally valid optimum immunization capacity." (p. 626)

Differences among these countries and among delivery sites reveal the importance of population size and inefficiencies in the organization of the program. In the Philippines, it was believed that using an immunization team of standard composition when the target population was small contributed to higher average costs in some centers. The number of target children immunized was the most important factor in cost-effectiveness in the case of Thailand because of the high fixed costs that do not relate to the population to be served.

The variation in costs among the countries as attributed to several factors, including the differences in relative cost of common inputs, such as health worker salaries, and the alternative immunization strategies in operation, such as outreach services.

8. Creese, Andrew L., "Cost Effectiveness of Alternative Strategies for Poliomyelitis Immunization in Brazil," Reviews of Infectious Diseases, Vol. 6, Supplement 2, May-June 1984.

This evaluation uses provisional data for the first six months of 1982 to compare the cost-effectiveness of alternative immunization strategies in Brazil. The study examined health centers in 16 municipalities. Costs included staff, transport, supervision, training, publicity and capital items. Costs were calculated according to the WHO/EPI costing guidelines (WHO/GEN/79/5). Health unit staff and national management costs were responsible for the greatest proportion of total cost.

Nationwide campaigns offering one dose of polio had been held twice annually since 1980. Immunizations are also provided on demand in health centers and through an intensification and outreach strategy. The number of fully immunized children was calculated as those receiving OPV3.

Average costs were estimated by multiplying the average cost per dose times the numbers of required doses (three in the case of polio). The study found that campaign and intensification strategies are roughly equivalent in their average costs for OPV, measles, DPT and BCG. For polio, the figures are $1.59, $0.82, and $0.68 for routine, intensification and campaign strategies. The major difference in costs between measles and polio was attributed to the increased staff time required to perform an injection for measles. The cost per fully immunized child (those receiving the required number of doses) ranged from $2.04 for polio to $1.74 for measles, figures which reflect the method of multiplying the average cost per dose by the number of doses. The cost per death averted was calculated for alternative strategies for polio and measles.

9. Creese, Andrew L. and Dominiguez-Uga, Maria Alicia, "Cost-effectiveness of immunization in Colombia," World Health Forum, Vol 8, 1987; and Creese, Andrew L., Dominiguez-Uga, Maria Alicia, "Cost-effectiveness of Immunization Programs in Colombia," bulletin of the Pan American Health Organization, 21 (4), 1987.

This study investigated the cost per immunization contact for routine services and compared these figures with the incremental costs of the 1984 national vaccination campaign in a sample of 10 health facilities. The general objective was to determine the cost-effectiveness of alternative

immunization strategies in Colombia and the policy implications for Colombia and other countries concerning the most effective strategy for a specific level of investment.

This study followed the methods recommended by the WHO/EPI costing guidelines (WHO/GEN 79/5) and calculated facility costs of the EPI as well as the aggregate figure for the national campaign. The total costs of routine services included personnel, vaccines, equipment, supplies and administrative costs. Costs at higher levels (national, regional and departmental) were allocated to health posts on a proportional basis. Personnel, equipment and vaccine costs were measured for the campaign in these same facilities.

Effectiveness of alternative strategies was based on the number of doses of DPT, OPV and measles given to children of all ages, with the number of fully vaccinated infants measured as the number receiving the third dose of DPT. The average cost per contact ranged from 257.2 pesos ($2.55) for routine services to 359.7 pesos ($3.56) for the national campaign. The cost per fully immunized child (those children less than one year of age receiving DPT3) was $26.59 for routine services and $59.90 for the campaign.

The national campaign increased the total EPI resources by $10.2 million while increasing DPT coverage by 16.7 percentage points for a total coverage of 66.8%.

The results suggest that "the size of the population served, rather than the mode of organizing routine services, was the major determinant of the average cost per unit output..." In addition, the authors believe that the costs per fully immunized child would increase as coverage is extended, and therefore some considerations about how to reduce the cost of a future campaign should be entertained. Two alternatives are proposed: 1) to limit the duration of the channeling efforts, and 2) to reduce the number of vaccination posts.

10. de Champeaux, Antoine, "Evaluation du Programme Elargi de Vaccination, Province de la Sissili," OCCGE, Unite de Vaccinologie, Centre Muraz, Burkina Faso, Novembre 1987.

The purpose of this study was to determine the total cost and cost-effectiveness of the EPI, including tetanus toxoid for women, in Sissili province, Burkina Faso. The study adapted the EPI costing guidelines to determine investment and recurrent costs of the provincial program. In addition, the study calculated the marginal cost of the EPI because the program is integrated into other PHC health services.

The cost analysis is highly detailed and reflects an intimate knowledge of the resource requirements of the immunization program, both for the fixed centers (18) and the mobile teams in the province. Costs are reported for different levels in the health system as well (e.g., national program management costs, provincial costs and costs for the mobile teams and dispensaries). The precision of each cost figure is included in the cost tables with overall precision of the estimates being approximately +/-20%.

Cost figures are matched with an effectiveness measure of the number of children less than two years completely vaccinated. This figure was determined through a 30-cluster sample survey in the province. The total number of children completely vaccinated in 1987 was 8,302 or 28% of the target population.

Results show that recurrent costs accounted for 88% of total cost (ranging between 34 million French CFA and 45 million FCFA) and investment costs for 12 percent. Less than one-third of the total cost was for mobile team operation (28%). The cost per fully immunized child was 4,082 FCFA ($15.70) to 6,002 FCFA ($23.09) using an exchange rate of 260 FCFA per U.S. dollar in 1987. The cost per woman fully immunized was 1,301 FCFA or $5.00.

Vaccine costs represented the largest cost category at 46% of total cost. The injectable polio vaccine accounted for 30% of the total cost. Expatriate salaries also represented a large share of total cost at 20%-25%. Donor contributions to the provincial program accounted for 73% of the total.

The marginal cost analysis classified total costs into fixed and variable costs in order to project program costs at future coverage levels. As coverage increases, the analysis shows that the cost per fully vaccinated child will decrease in Sissili.

11. The Government of the Republic of Uganda, "Report of the International Evaluation of the Uganda National Expanded Programme on Immunisation and Primary Health Care," 13 July - 31 July 1987.

This report provides data on the financing of the national immunization program collected during a comprehensive program review for primary health care. The methods used involved collection of budget allocations from the Ministry of Health and donor organizations for the EPI. The total budget in 1986 was approximately $4 million; total donor obligations to the program in 1987 amounted to over $12 million; and future obligations approached $4 million.

The major findings of the analysis are that 1) insufficient provision of government funds exists despite an adequate budget for EPI and 2) expenditures for the program do not match program priorities. The sustainability of the program is of concern given the substantial reliance on donor funding, which is decreasing.

12. Hartman, A. Frederick, et al., "The Cost Effectiveness and Benefits of Intensive Immunization Strategies in Honduras," presented to the National Council for International Health, Annual International Health Conference, June 12, 1986.

This study compares the cost-effectiveness of routine immunization services and the third round of the national vaccination weeks that took place in August 1984. Costs (or cost per applied dose) were measured for vaccines, salaries and administrative activities. These were compared with the number of fully vaccinated children, calculated as the numbers of doses of DPT3, polio3 and measles given per population. The study also presents data on the cost of treating illness, particularly pertussis, compared with the cost of immunization.

The cost of the campaign was four times that of routine services and the campaign was not thought to be cost-effective. However, when these data are compared with the cost of treating illnesses, immunization programs were preferred.

13. "Joint Review Report on EPI in Tanzania," Ministry of Health/Tanzania-Danida Review Team (September 1987), selected appendixes, by R. Feilden.

A study of the cost-effectiveness of the national EPI was conducted as part of a Government of Tanzania and DANIDA Joint Review in late 1987. Costs were reported for the current year of 1986-87 for salaries, training, vaccines, transport, other and capital goods (buildings, equipment and vehicles). Full coverage was projected from data from a rural coverage survey in 1985. Figures of 700,000 and 800,000 children less than one were used in the analysis to represent current and steady state coverage (coverage when more than 80% of the population will have access to EPI).

The total cost of the national EPI was approximately $4.5 million which represented $6.53 per child. Vaccine costs and capital costs took the largest share of total costs at 42% and 22%, respectively. Thirty-five percent of the total cost was financed by the Government of Tanzania, with the balance being financed by DANIDA.

A sensitivity analysis and cost-effectiveness projections were made to a steady state where greater than 80% of the population would have access to health centers. If immunizations were provided one or two days per month, costs could be reduced to $4.00 per fully immunized child. Significant savings in vaccine costs (from vaccine wastage) and in kerosene costs would occur.

14. Makinen, Marty, "A Benefit-Cost Analysis of Measles Vaccinations in Yaounde, Cameroon," Department of Economics, University of Delaware, June 1980.

This paper focuses mostly on the methods used to apply cost-benefit analysis to measles immunization programs. The measles campaign in Yaounde (the capital city), which took place between 1971 and 1976, was evaluated to help plan future campaigns.

Four types of benefits of the campaign were considered: 1) formal medical care costs avoided ($3.09 per case); 2) household care costs avoided ($2.38 to $4.49 per case); 3) future productivity losses saved ($2,094 to $408 per case); and 4) suffering and grief losses avoided. The study measured all of the benefits except for suffering and grief losses. The minimum benefit to measles avoidance was estimated to be $46.47 per case.

The costs of a measles campaign included direct fixed costs or administrative costs ($2,790); direct variable costs of vaccines, personnel, transport and materials (0.24 per dose); indirect costs of time foregone ($0.604 per dose); a utility cost (or the disutility of being vaccinated). The total number of vaccinations administered during the campaign was 68,809.

The study concludes that the benefit to cost ratio for the measles campaigns in Yaounde is 23.3 to 1. Therefore, measles vaccination is clearly socially beneficial for Yaounde.

15. Ponnighaus, J.M., "The Cost/benefit of measles immunization: a study from Southern Zambia," Journal of Tropical Medicine and Hygiene, 1980, 83, 141-149.

The principal research question for this study is whether the benefits of measles vaccination outweighs the cost of the program. This study contributed to the debate over prevention or cure of disease through a cost-benefit evaluation. Costs were collected from financial data on refrigeration equipment, staff salaries, vehicles and transportation, publicity, and vaccines. Storage costs were not included. Benefits were measured in terms of cost savings in the health sector from treatment of disease and gains in economic output from prevention of disease and death.

The study concludes that salary and transportation require the greatest amount of inputs for an immunization program. The author also found that a measles vaccination program was not cost-effective on a national level because of cold chain maintenance and operation. The major recommendation of the study was that vaccination programs should only operate in rural areas where there is electricity service 24 hours per day.

16. Qualls, Noreen, "CCCD Cost Study Report, People's Republic of the Congo," June 17-July 12, 1985.

The purpose of this study was to collect baseline cost information for the CCCD Project which promotes immunization, treatment of diarrheal disease and malaria prophylaxis and treatment in the People's Republic of the Congo. The author compares the cost of immunization services provided through the EPI in fixed facilities, through mobile teams, and through a pilot PHC project that uses an outreach approach.

Costs are calculated for salaries, vaccines, transportation, equipment and administrative categories. Budget figures are collected at several levels for each of these approaches, including costs at a selected health facility at the community level, central level project costs and national level Ministry of Health contributions. All costs are reported in FCFA for the period of July 1984 to June 1985. No information is reported on effectiveness of the alternative strategies.

The major recommendation of the study is to conduct a more thorough cost analysis of the CCCD Project interventions and to determine areas for improving the efficiency of service provision.

17. Robertson, Robert L., " Cost of the Combatting Childhood Communicable Diseases (CCCD) Project in Malawi, 1984-1985," submitted to University Research Corporation, September 1984.

This study measures the national cost of the CCCD Project in Malawi, including immunization activities, prevention of diarrheal disease, and malaria prophylaxis and treatment, after the first nine months of implementation.

The cost analysis modified the methods recommended in the WHO/EPI costing guidelines. Cost categories included for analysis were personnel, supplies and miscellaneous, vaccines and other medications, equipment, buildings, transportation, training and central costs. Amortized values of buildings were not included. Total national costs of each component was determined by extrapolating facility-based costs to the national level. A

sample of 24 facilities was selected on a judgment basis. These facilities represented the four different types of vaccination delivery sites in Malawi, and covered the three different types of facility ownership: government, mission and industry facilities. Central administrative costs were allocated evenly to all facilities on the proportion of central costs to total costs (8%).

Results from a previous national coverage survey were used to derive the measurements of effectiveness for this study: number of doses administered and number of children fully immunized. The coverage survey provided data on the number of doses each child received prior to becoming fully immunized (11.6). This figure was multiplied by the weighted average cost per dose of $0.99 for a total national cost of $1,588,776 (1984-85). The cost per fully immunized child was $11.48 for this study.

The study suggested that the average cost per dose found in clinics was lower than that for larger facilities (hospitals) presumably as a result of the high fixed costs in larger facilities. The range in average cost per dose among the facilities for which calculations could be made (18 out of 24 sampled) was between 0.15K and 3.26K. The total sample average was $0.99. Personnel costs were low in comparison with other cost categories at 15% of total costs whereas vaccine costs were relatively high at 23%. The low values for personnel could be explained by the low salaries of health personnel compared to salaries in other countries.

The study concludes by making recommendations for future study in the area of costing, including 1) a study of the incremental costs of adding components to the CCCD Project; 2) cost projections for increased coverage; 3) cost of developing a management information system; 4) routine cost reporting system development; 5) projections of future recurrent costs of CCCD activities; and 6) cost-effectiveness of alternative delivery strategies.

18. Robertson, Robert L. with Qualls, Noreen L., "Costs of the Combatting Childhood Communicable Diseases (CCCD) Project in Swaziland, 1984-1985," submitted to University Research Corporation, September 1985.

This study measures the national cost of the CCCD Project in Swaziland, including immunization activities, prevention of diarrheal disease, and malaria prophylaxis and treatment, after the first nine months of implementation.

The cost analysis modified the methods recommended in the WHO/EPI costing guidelines. Cost categories included for analysis were personnel, supplies and miscellaneous, vaccines and other medications, equipment, buildings, transportation, training and central costs. Amortized values of buildings were not included. Total national costs of each component was determined by extrapolating facility-based costs to the national level. A sample of 19 facilities was selected on a judgment basis. These facilities represented the four different types of vaccination delivery sites in Swaziland, and covered the three different types of facility ownership: government, mission and industry facilities. Central administrative costs were allocated evenly to all facilities on the proportion of central costs to total costs (38%).

Results from a previous national coverage survey were used to derive the measurements of effectiveness for this study: number of doses administered and number of children fully immunized. The coverage survey

provided data on the number of doses each child received prior to becoming fully immunized (19.6). This figure was multiplied by the weighted average cost per dose of $2.58 for a total national cost of $412,542 (1984-85). The cost per fully immunized child was $50.57 for this study.

The study suggested that the average cost per dose found in clinics was lower than that for larger facilities (hospitals) presumably as a result of the high fixed costs in larger facilities. The range in average cost per dose among the facilities for which calculations could be made (17 out of 19 sampled) was between $0.91 and $9.33. The total sample average was $3.57. When weighted by the total numbers and types of facilities in the country the national average cost per dose was $2.58 which was used to derive national cost figures. These figures for Swaziland are much higher than reported elsewhere, and the author suggests verification of the cost information prior to making policy decisions based on these results.

The study concludes by making recommendations for future study in the area of costing, including 1) a study of the incremental costs of adding components to the CCCD Project; 2) cost projections for increased coverage; 3) cost of developing a management information system; 4) routine cost reporting system development; 5) projections of future recurrent costs of CCCD activities; and 6) cost-effectiveness of alternative delivery strategies.

19. Robertson, R.L., et. al., "Cost-effectiveness of immunization in The Gambia," Journal of Tropical Medicine and Hygiene, 1985, 88, 343-351.

This study examines the cost per case and cost per death prevented for different antigens that are part of the Expanded Program on Immunization in The Gambia. The national program boasts high coverage and nearly universal access to immunization services (90%). A sample of 13 delivery sites were selected for analysis. Costs were divided into variable and fixed costs. Variable costs included personnel, supplies, vaccines, and transportation; fixed costs included personnel, transportation, buildings, equipment and training. Costs were also reported for different levels of the health system (e.g., national and provincial personnel costs).

The total cost ($374,764) was allocated evenly to each disease category based on the number of doses to become fully protected out of total doses for the EPI (8). For example, to calculate pertussis costs, the total cost was multiplied by 3/8 to represent the three doses required for full protection.

The number of cases and deaths prevented were calculated based on reported incidence figures, case fatality rates, and assumptions about the efficacy of the vaccines. The cost per pertussis case prevented was $1.30 and the cost per polio case was $655.54. The cost per death averted from measles was $40.83, from pertussis $99.85 and from neonatal tetanus $152.53.

20. Shepard, Donald S., et al., "The Cost-effectiveness of Immunization Strategies in Ecuador," REACH publication, August 1988.

This analysis attempts to measure and compare the cost-effectiveness of immunizations administered in fixed facilities and during a mass campaign held during 1985 and 1986 in Ecuador. The campaign was planned and

organized under the PREMI Project in order to accelerate immunization activities throughout the country and to complement services provided by the Ministry of Health, the Social Security System and private providers.

Data on the contribution of the campaign and routine services to total vaccination coverage in 1986 were derived from a national coverage survey conducted in June 1986. Based on this survey, the PREMI campaign contributed 13 percentage points to a total coverage of 54% and made significant contributions to vaccination of children less than two years of age.

Costs were estimated using a methodology developed by one of the authors as part of a larger study of the costs of primary health care delivered through health facilities, namely hospitals. A representative sample of 22 health facilities, primarily in two regions, was selected for analysis. For each facility, the average cost of vaccination services was calculated by dividing the total cost of vaccination services by the number of doses administered in 1985. Components of costs included personnel, transportation, vaccines and syringes, other vaccination supplies, buildings, equipment and furniture, training, promotion and indirect facility costs.

In addition to facility costs, national and provincial level costs were apportioned to each type of facility based on their proportion of total doses administered in 1985. National average cost per dose was calculated by weighting the average costs for each type of facility by the number of such establishments in the nation for the same year. A similar methodology was used to calculate the costs of the national campaign. Vaccination sites were selected during the third round, and the costs were multiplied by three to represent the entire three rounds of the campaign.

The national average cost per dose was $0.29 and the cost of routine services was estimated to be $653,000. Vaccines and syringes appeared to be important cost categories for each facility, though personnel costs represented the largest share of total cost in general.

For the campaign, the average cost per dose was $0.83 for a total campaign cost of $1.7 million. The cost per fully immunized child was $4.77 for routine services and $8.13 for the campaign. The study concluded that the campaign was less cost-effective as a strategy, but it increased coverage significantly for children less than two years of age.

21. Turner, Pamela, excerpts from a cost evaluation of the national EPI in the Philippines, results from a field test of the ANE Bureau Guidance for Costing of Health Service Delivery Projects, REACH, 1987.

The purpose of this analysis was to calculate costs of the national EPI in order to undertake a financial and economic analysis for a project paper for USAID/Manila. The ANE Bureau Guidance for Costing of Health Service Delivery Projects was used to estimate costs. The Guidance classifies costs into recurrent and investment categories. Recurrent costs contain 11 line items and investment costs, 10 line items. The Guidance provides details on how to collect and calculate each type of cost. The Philippines analysis estimated costs for a base year of 1988 and projected them until 1992 for USAID and other donors, as well as the Government of the Philippines.

Coverage targets were used for the effectiveness measure to determine whether the program as planned would be cost-effective. A figure of 70% coverage of children less than one year was chosen for the base year, and a figure of 90% was selected for 1992.

The total cost was $78 million for five years, with recurrent costs accounting for $70 million. The Government of the Philippines would be responsible for 84% of the total, according to plan. The government would finance salaries, buildings, and replenishment of vaccines. Donors would be responsible for capital investments, vaccines, transportation, training and technical assistance (16% of the total). The cost per fully immunized child would be $14.02 in 1988. This value would decrease in the interim years to a low of $6.77 per child. The five-year average is $10.14 per fully immunized child.

22. Weekly Epidemiologic Review, "An Economic Appraisal: Indonesia," No. 13 - 3 April 1981.

This article reports the findings of a study conducted in Java, Indonesia during the field-testing of the WHO/EPI costing guidelines. The purpose of the analysis was to determine how the guidelines could be used to determine the cost of delivering immunizations through fixed facilities.

The study estimated costs based on a sample of six health facilities, three rural and three urban. Costs were reported for salaries and allowances, vaccines, transport, training and capital equipment. Effectiveness was measured in terms of the number of children receiving one dose of BCG and two doses of DPT (considered sufficient to be fully immunized) in these facilities.

The average cost per fully immunized child ranged from $1.25 to $3.30, which is low by international standards. However, it was thought that these figures were representative for the EPI in this country. The author states that with increased activity in a health center, the average cost should decrease.

23. Weekly Epidemiological Review, Expanded Program on Immunization, "Cost Study," No. 38, 24 September 1982.

This study of the cost-effectiveness of EPI in The Gambia was conducted during a joint Government of The Gambia/WHO review in January 1982. The study modified the WHO/EPI costing guidelines to determine the costs of the national program. All costs are reported in 1981 U.S. dollars. Data on costs were collected from a sample of 13 delivery sites. Recurrent costs of personnel, supplies, vaccines and transport and non-recurrent costs of buildings, equipment and training were estimated. Personnel (45%), transport (15%) and equipment costs (14%) represented the greatest share of total costs.

The total cost of the national program was $375,000, excluding expatriate salaries, and $600,000 with these salaries. The cost per dose administered was $1.09. The cost per fully immunized child was estimated at $14.00 (excluding yellow fever). The study also examined the cost of the tetanus vaccination program. The cost per TT dose was $1.72 and the cost per pregnant woman fully immunized (those receiving their second dose of tetanus toxoid) was $3.78.

Data from cluster sample surveys conducted in the previous year (1981) were used to determine the number of fully immunized children less than one year of age (43%).

The article discusses the issue of economies of scale, in that delivery sites which administered more doses had higher costs. The author suggest that underemployment at lower volume sites leads to great inefficiencies in service delivery.

24. Weekly Epidemiologic Review, "Expanded Program on Immunization: Cost-effectiveness," #22, 4 June 1982.

This article presents preliminary results from an assessment of the costs and cost-effectiveness of the measles vaccination component of the EPI operating in three demonstration and training zones in Cote d'Ivoire. Costs were estimated from material budgets by source of funding and by year for equipment, fuel, supplies, travel and miscellaneous costs. Equipment costs were treated on a cash basis and not depreciated over time. The total cost of the EPI was approximately $703,000. It was assumed that 75% of these costs could be allocated to the measles component because of the level of publicity. Therefore, total measles costs were estimated at $527,250.

Effectiveness was measured in several ways: 1) the number of doses administered; 2) the number of cases averted; 3) the number of deaths averted; and 4) the number of years of life added as a result of measles vaccination. The study developed an effectiveness fraction based on diagnostic accuracy, efficacy rate of vaccine, provider compliance and patient compliance. The effectiveness fraction was used to determine the number of cases and deaths averted.

The cost per vaccine was estimated to be $12.30 and the cost per case averted was $13.90. The cost per death averted was $479.

APPENDIX E
GLOSSARY OF TERMS

Resource: The inputs which are used to provide or deliver immunization services. Resources consist of labor, materials, and money.

Cost: A cost refers to the value of resources used to deliver immunization services. In this report, the terms cost, full cost, resource cost, and full resource cost are synonymous.

Total Cost: The total cost of an EPI is equal to the sum of the value of all resources used. Total costs can be divided into fixed costs and variable costs. Fixed cost plus variable cost equal total cost.

Variable Cost: Variable costs equal the value of resources used each time an immunization is given. The cost of vaccines is a variable cost because each child receives a vaccine and incurs a cost for the EPI.

Fixed Cost: Fixed costs are those which do not increase or change with increasing numbers of children immunized. For example, one fixed cost for an immunization program is vehicle cost because each child immunized does not require a separate vehicle. However, all costs are variable in the long run.

Investment Cost: Investment costs (or capital costs) are the value of resources which accrue benefits in the future or which are used infrequently in a program. For example, building costs and vehicle costs represent investment costs for immunization programs.

Recurrent Cost: Recurrent costs (operating costs) are equal to the value of resources used on a frequent basis (e.g. each month, each day) to provide immunization services. For instance, vaccine costs occur every day of an immunization program and are therefore a recurrent cost of that program.

Opportunity Cost: An opportunity cost is a measure of the value lost by undertaking one activity or another. For instance, the value of a mother's time spent traveling to have her child immunized represents an opportunity cost to the mother, or the family, who could have been earning wages or performing other household activities.

Cost-effectiveness: A technique which determines whether the effectiveness of a program (health outcomes) are worth their costs. The ratio between the total cost and the effectiveness of a program is its cost-effectiveness ratio.

Cost Category: A name given to classify a wide variety of program inputs into similar groups such as personnel, transportation, media and equipment.

Cost Profile: A comparison of the value of cost categories (e.g., personnel) to the total cost of an EPI. This analysis gives proportions. It is calculated by taking ratios between total cost and the value of each cost category.

Expenditure: Money which is actually spent.

Budget: A yearly account which estimates how much money goes in and comes out of the national government or of a household. This budget may or may not be equivalent to the amount of money spent at the end of the year.

Financial Analysis: An evaluation of who is paying for immunizations and how much is being spent.

Financing: How something is paid for. When individual patients give donations to health centers, they are financing some part of the delivery of services.

Fully Immunized Child: In these studies, a fully immunized child refers to a child which has received at least one dose of BCG, one dose of measles, three doses of oral polio, and three doses of DPT. Children which have received most but not all of the doses mentioned above are not considered fully immunized.

Marginal or Incremental Cost: This is the additional cost to provide one more immunization with a country EPI. A marginal cost analysis would evaluate how much more it would cost at higher levels of coverage (greater numbers of children immunized).

Production Function: The relationship between the total cost of an EPI with varying and increasing levels of outcome. Usually, the higher the outcome, the higher the total cost.

Economics of Scale: This term is related to a production function as it measures the magnitude of inputs relative to outcomes at increasing levels of outcomes. If fewer inputs are required to produce one more immunized child than before, then there are economies of scale. If more inputs are required to immunize one more child than before, there are constant returns to scale. For immunization programs, it is generally thought that it will cost more and more on average to reach the last 10 to 20 percent of the population, so there will be diseconomies of scale.

Externalities: This term describes the benefits or disadvantages of an immunization program which are unforeseen and have a "cost" to society. For example, one externality of mass campaigns is that they may prevent the delivery of other preventive health programs because they require the full attention of administrative and health staff.

Sensitivity Analysis: An analysis which changes the key assumptions made in a cost-effectiveness study to test whether the original assumptions were faulty or whether different assumptions result in large variations in the cost-effectiveness ratio.

Shadow Pricing: The adjustment which is made to unit prices when they do not reflect the true market value of labor or materials. For example, in some countries, wages for health workers are low and workers may have other jobs in order to earn sufficient income. Shadow pricing would adjust annual earnings by a factor to reflect full annual income and value to society.

APPENDIX F

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