

OPERATIONS RESEARCH ISSUES

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COMMUNITY
HEALTH
WORKERS

Morris Schaefer
Jack Reynolds

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Series
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**COMMUNITY
HEALTH
WORKERS**

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Primary Health Care Operations Research

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Operations Research Methods: Cost-Effectiveness Analysis

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PREFACE

Primary Health Care Operations Research (PRICOR) is a project of the Center for Human Services and is funded by the United States Agency for International Development (AID) under a cooperative agreement (AID/DSPE-5920-A-00-1048-00). The Center for Human Services is a nonprofit, development services organization specializing in the design and management of programs that address the basic needs of people in developing countries and the United States. PRICOR's objective is to promote operations research as a tool to help program managers and policymakers find solutions to problems they encounter in designing and operating primary health care (PHC) programs.

This project's activities include: Funding and monitoring country studies; sponsoring workshops and conferences; conducting methodological and comparative studies; and disseminating the findings of sponsored research. PRICOR is particularly interested in research designed to overcome problems that limit the expansion of essential PHC services to high-risk populations in rural and peri-urban communities. Consequently, PRICOR has concentrated on operations research to find solutions to problems in four priority areas:

- Community health workers
- Community-based commodity distribution
- Community financing
- Community organization

Operations research provides a systematic approach to problemsolving. In operations research, rather than relying on the costly process of trial-and-error, a well-defined plan of analysis is used to select the best of several possible alternatives. A specific operational problem is first defined and analyzed. Alternative solutions are developed and evaluated to identify those that are most appropriate and feasible. Recommendations are then made for testing, or in some cases directly implementing, the best solution(s).

This is one in a series of five monographs on operations research that was prepared by PRICOR staff and consultants for researchers in the developing world who are interested in learning more about this approach and applying it to their own primary health care programs. The five monographs in the series are:

- Issue Papers
 1. Operations Research Issues: Community Financing
 2. Operations Research Issues: Community Health Workers
 3. Operations Research Issues: Community Organization
- Methodology Papers
 1. Operations Research Methods: A General Approach in Primary Health Care
 2. Operations Research Methods: Cost-Effectiveness Analysis

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ABBREVIATIONS USED IN TEXT

AID	Agency for International Development (USAID)
APHA	American Public Health Association
CHA	Community Health Auxiliary
CHW	Community Health Worker
MOH	Ministry of Health
OR	Operations Research
ORS	Oral Rehydration Salts
ORT	Oral Rehydration Therapy
PHC	Primary Health Care
PRICOR	Primary Health Care Operations Research
TBA	Traditional Birth Attendant
UNICEF	United Nations Children's Fund
VHW	Village Health Worker
WHO	World Health Organization

INTRODUCTION

Primary health care is gaining acceptance as a strategy for bringing basic health services to all people in developing nations who do not have access to such services at this time. Primary health care programs can have a significant impact on health by focusing on a limited number of health problems that are preventable by means of simple, relatively low-cost interventions.

Diarrhea, respiratory infections, malnutrition, and contagious diseases are among the most serious health problems in developing countries. They result in high rates of infant, child, and maternal mortality and morbidity, particularly in rural areas and in the surroundings of urban centers, where organized health services are most limited. Ironically, much of this suffering is avoidable, because a few primary health care interventions could dramatically reduce these problems if ways could be found to reach the target populations--particularly women and children--with such needed primary health care services as immunizations, oral rehydration therapy, growth monitoring, family planning, malaria prophylaxis, water supply, environmental sanitation, and antepartum and perinatal care.

In 1978, the International Conference on Primary Health Care was convened at Alma-Ata in the Soviet Union. At this historic event attended by representatives of 134 nations, primary health care was endorsed as a strategy for making fundamental health services universally accessible to the world's population. The Declaration of Alma-Ata defines primary health care as:

. . . essential health care based on practical, scientifically sound and socially acceptable methods and technology made universally accessible to individuals and families in the community through their full participation and at a cost that the community and country can afford . . . [Primary health care] addresses the main health problems in the community, providing promotive, preventive, curative and rehabilitative services accordingly . . . [it] includes at least: education concerning prevailing health problems and the methods of preventing and controlling them, promotion of food supply and proper nutrition; an adequate supply of safe water and basic sanitation; maternal and child health care, including family planning; immunization against major infectious diseases; prevention and control of locally endemic diseases; appropriate treatment of common diseases and injuries; and provision of essential drugs.(1)

Among those organizations helping to find ways to achieve this goal is the Agency for International Development (AID), which has supported numerous primary health care projects around the world. These projects, extensively documented in a recent American Public Health Association (APHA) publication, have demonstrated the efficacy of primary health care in reducing premature mortality and excess morbidity.(2)

The Agency for International Development has been particularly interested in finding ways to expand coverage of mothers and children in rural and periurban areas with such essential primary health care services as immunizations and oral rehydration therapy, among others. However, AID and other international donors have learned from experience that meeting this objective is not a simple matter.

Role of Operations Research in Primary Health Care

A number of operational issues need to be resolved before primary health care can become universally available. For example, the Alma-Ata Conference report noted that:

Enough is already known about primary health care for much of it to be put into practice immediately. However, much still needs to be learned about its application under local conditions, and during its operation, control and evaluation problems will arise which require research. These may be related to such questions as the organization of primary health care within communities and of supporting services; the mobilization of community support and participation; the best ways of applying (existing and appropriate) technology; . . . the planning for and training of community health workers, their supervision, their remuneration and their career structure; and methods of financing primary health care.(3)

Recognizing the importance of research into the operation of primary health care delivery, the AID Office of Health funded PRICOR to help primary health care program managers and policymakers find solutions to such problems through operations research. PRICOR has defined operations research as a problemsolving process consisting of three phases:

1. Systematic analysis of the operational problem;
2. Application of the most appropriate analytical methods to identify the best solution(s) to that problem; and
3. Validation of the solution(s).

Although operations research has not yet been widely used as an analytical and decisionmaking tool to improve health services in developing countries, it can be applied to examine a number of issues pertinent to primary health care service delivery.

For example, in planning for the use of community health workers, operations research can be applied to examine the advantages and disadvantages of completely different schemes for training, supervising, or supporting community health workers. It can be used to determine the best way to structure one or more aspects of a community health worker program, such as its relationship to the community, community health worker selection, specification of community health worker tasks, and so forth. Operations research techniques can also be used to help design new systems and to identify ways to improve existing systems.

This paper was prepared to help policymakers, program managers, and researchers identify problems in the use of community health workers that can be addressed by operations research. The paper is particularly relevant to those in developing countries who are actively involved in the planning or operation of primary health care programs that rely on community health workers. This includes primary health care program managers, investigators working with primary health care program managers, and health policy planners.

The specific objectives of the paper are:

1. To define community health workers and explain why this subject is an important research topic;

2. To identify key operational problems and issues in the use of community health workers that can be addressed by operations research;
3. To describe a general approach to operations research that can be used to study such problems; and
4. To describe a number of recent operations research projects on community health workers in primary health care to illustrate the application of operations research to this subject.

NOTES

1. "Declaration of Alma-Ata, "Primary Health Care, Report of the International Conference on Primary Health Care, Alma-Ata, USSR, 6-12 September 1978, jointly sponsored by WHO and UNICEF (Geneva: WHO, 1978), pp. 3-4.
2. Primary Health Care: Progress and Problems, An Analysis of 52 AID-Assisted Projects (Washington, DC: APHA, 1982).
3. WHO and UNICEF, Alma-Ata 1978, op. cit., pp. 71-72.

CHAPTER I
OPERATIONS RESEARCH ON COMMUNITY HEALTH WORKERS:
A RESEARCH PRIORITY

CHAPTER I. OPERATIONS RESEARCH ON COMMUNITY HEALTH WORKERS: A RESEARCH PRIORITY

ROLE OF COMMUNITY HEALTH WORKERS IN PRIMARY HEALTH CARE

Many national plans and policies for "Health for All by the Year 2000" envisage primary health care (PHC) as the crucial strategy to attain health improvement goals that are linked to socioeconomic development. Within many national strategies, the use of community health workers (CHWs) is seen as one of the major ways to implement primary health care. Community health workers are viewed as the key to attaining the acceptability, affordability, and accessibility of primary health care.

In addition to the term "community health worker," many other titles are used in different countries. They include village health worker, health promotor, health agent, health guide, and health visitor. What is common to these terms in most developing countries* is that they refer to workers who are:

- Indigenous to the settlement or the social class of those to be served;
- Trained to function at the auxiliary level of health care;
- Based in rural, and in some cases urban, communities;
- Trained to work closely with the communities they serve, so as to involve communities in the process of improving their own health;
- Charged with tasks such as
 - Education concerning prevailing health problems and the methods of identifying, preventing, and controlling them;
 - Promotion of food supply and proper nutrition, an adequate supply of safe water, and basic sanitation;
 - Maternal and child health care, including family planning;
 - Immunization against major infectious diseases;
 - Prevention and control of locally endemic diseases;
 - Appropriate treatment of common diseases and injuries;

*Analogous workers are also found in the health sectors of some industrialized countries, performing as "outreach workers" among disadvantaged rural and urban populations or among groups at special risk, such as mothers and children. Their role in such countries and programs tends to be less critical to national health improvement strategies than service by higher level health professionals. Therefore, the reader should be aware that the discussion of community health workers in this paper is primarily addressed to situations in developing countries.

- Promotion of mental health; and
- Provision of essential drugs; and*
- Prepared to facilitate access to other health services for more complex and unusual diseases and ailments.

In some national PHC strategies, community health workers function as part of a multisectoral or intersectoral scheme of rural socioeconomic development, interacting with schoolteachers, agricultural and rural development agents, and water supply-sanitation workers.

The justification for the use of community health workers is based on the recognition (or assumption) that:

- Coverage with minimum services can be achieved relatively rapidly because many community health workers can be trained faster and less expensively than more highly trained health personnel and can be distributed more easily to underserved areas, especially if they are recruited from the settlements where they are to serve;
- Acceptability of services is enhanced when offered by persons who are known to clients or, at least, are "the same kind of people as we are";
- Community health workers can encourage community participation in primary health care and facilitate the delivery of other related services to the population; and
- Community health workers, in contrast to specialists in various diseases and disciplines, can facilitate provision of integrated health care, can help link preventive and curative services, and can collaborate with agents and activities of other sectors.

OPERATIONAL ISSUES IN THE DEVELOPMENT OF EFFECTIVE COMMUNITY HEALTH WORKER STRATEGIES

Experiences with community health workers in a number of countries predate by several decades the rise of the PHC movement in the late 1970's. Many countries used auxiliaries in specific programs, such as malaria control, family planning, and smallpox eradication, but some used them in basic health service schemes. Several of these schemes were adaptations of older programs, such as malaria control; others used auxiliaries to extend the work of health centers through auxiliary-staffed health posts.

As the PHC movement gained momentum, many countries began pilot, or prototype, CHW demonstration projects, and several developed large-scale PHC programs centered on the use of community health workers. These experiences helped identify a number of operational issues that countries need to resolve to ensure the effective development of their CHW programs.

*These eight areas were identified in the Alma-Ata conference report as essential to primary health care.

These critical issues can be summarized by two broad questions about community health workers. They are:

1. What are community health workers expected to accomplish? On what health improvement objectives are they to focus? To what extent are they to accomplish these objectives? How do community health workers relate to such other PHC elements as mobile services, services at fixed facilities, commodities distribution, school-based services, environmental modifications, and local economic development programs?
2. What arrangements are most likely to enable community health workers to meet those expectations? How are community health workers to be selected, trained, supervised, supplied, supported, motivated, rewarded, and linked with other health services and with the community?

These two questions are strongly interrelated. Policy expectations set the boundaries within which programs are specified. But expectations depend upon being realistic about what is feasible. For example, literate community health workers have a greater potential to provide adequate services than illiterate community health workers. The refusal of professional staff to support or interact with community health workers limits the possibilities for treatment referral services and for a unified system of supervision. However, active and coherent social organization in villages opens possibilities for high utilization of CHW services and for CHW involvement in intersectoral development. Therefore, planners need to keep these two main questions in mind throughout the planning (and replanning) process.

For example, selection of community health workers requires decisions on the desired characteristics of the health workers; that is, age group, sex, social position, educational level, "trainability," residence, and experience, as well as on the process by which they are nominated, reviewed, and chosen. Those making decisions on selection criteria must keep in mind the acceptability of community health workers to those served and to community leaders, the tasks to be performed, the conditions of supervision, the feasibility of remuneration, and the possibilities for advancement.

Decisions on the mix of tasks that community health workers will perform involve choosing what educational, clinical, and distributional activities are needed. Decisionmakers must consider not only epidemiological and administrative priorities, but also the types of persons likely to be selected as community health workers, the attitudes and behaviors of the "health establishment" toward community health workers, the feasibility of supervision and supply support, the constraints on training, the presence and influence of traditional healers, and the balance of local and national aspirations and politics.

These examples make clear not only the number of choices to be made about CHW strategies, but also the inherent complexity of the decisions and the constraints affecting them.

Yet even though the use of community health workers is central to the PHC strategies of many developing countries, a number of issues related to the design of effective CHW programs remain unresolved. Few systematic studies have been done that would begin to provide the answers to these questions. Research in the field of primary health care has often consisted of descriptive or evaluative studies; seldom has it been focused on clear identification and resolution of important operational problems. Further, even though program managers and researchers can learn a great deal from programs and studies in other places, research is often needed onsite to solve local problems.

Operations research can make an important contribution to the solution of problems that have impeded the development of effective strategies for using community health workers in primary health care. Well-designed operations research can effect economies and save time in arriving at preferable strategies and tactics by narrowing the range of choices and eliminating unproductive field trials.

The following chapter describes a number of issues related to the use of community health workers in primary health care that are amenable to operations research. Chapter III describes a general approach for conducting operations research on such issues.

CHAPTER II
OPERATIONAL PROBLEMS RELATED TO COMMUNITY HEALTH WORKERS
IN PRIMARY HEALTH CARE PROGRAMS

CHAPTER II. OPERATIONAL PROBLEMS RELATED TO COMMUNITY HEALTH WORKERS IN PRIMARY HEALTH CARE PROGRAMS

A review of experiences in various developing countries with programs using community health workers indicates that there are certain problems that operations research can help resolve. This chapter provides a framework for identifying important research problems related to community health workers and the variables that need analyzing in the search for solutions.

The five sections of this chapter: 1) identify ten of the more common issues or "problem clusters" related to the use of community health workers in primary health care; 2) present a framework for viewing these problem clusters as a subsystem of interrelated components; 3) explain how to identify the key variables of a problem; 4) identify the controllable and uncontrollable factors that influence or constrain solutions to these operational problems; and 5) provide a technique for setting priorities.

COMMUNITY HEALTH WORKER PROBLEM CLUSTERS

In recent years, many developing countries have revised their health systems, policies, and strategies and given new emphasis to primary health care. Many include community health workers as a key element of primary health care. Countries differ, however, in the way they use, remunerate, supervise, and train health workers. Operations research is invaluable to making these strategic decisions about program structure, procedures, and resource allocation.

In deciding on the best use of community health workers, policymakers and program managers must often deal with some, or all, of the following ten sets of issues, or problem clusters. They are:

1. Development of a CHW program strategy
2. Community organization and support
3. Specification of CHW tasks
4. Selection of community health workers
5. Training of community health workers
6. Supervision of community health workers
7. Provision of incentives and other means of motivation
8. Provision of supplies and other logistical support
9. Linkages of community health workers with other resources
10. Monitoring and evaluation of CHW performance.

Each of these problems is a subject for operations research.

SYSTEMATIC ANALYSIS OF COMMUNITY HEALTH WORKER PROBLEMS

The nature of an operational problem in the use of community health workers will vary somewhat depending on whether the researcher is studying an ongoing system or trying to provide relevant data for designing a new system. For example, supervision of community health workers is a common problem, but the researcher will take a different approach in analyzing the supervision problem of an ongoing program than in analyzing the supervision possibilities for a new system. In either case, the general problem must be carefully described, smaller operational problems defined, and then priorities set for developing solutions. This approach to problem analysis is described in more detail in chapter III.

A review of relevant information that has already been prepared is helpful at the start of a major problem analysis effort. For example, evaluations, surveys, site visit reports, interviews with key informants, and observations often identify operational problems. Analysts will need to supplement these data with new information. Quade suggests an investigative reporter approach, interviewing people to answer the key questions about the problem: who, what, when, where, how, and why.

When beginning work on a study, the analyst should interrogate the sponsor and all other persons associated with the problem situation who seem likely to be able to help. In particular, he seeks answers to such questions as

1. How did the situation arise? Why is it a problem?
2. Who are the people who believe it to be a problem?
3. Why is a solution important? If an analysis is carried out, what will be done with it? Will anybody be able to act on the recommendations?
4. What should a solution look like? What sort of solution is acceptable?
5. Is it the right problem anyway? Might it not be just a manifestation or a symptom of a much larger or deeper problem? Would it be better to tackle this larger problem if there is one?
6. Analytical resources are always limited; at this stage does it seem that there would be a return from the study effort that would be justified, or would the analytic effort be better applied elsewhere?(1)

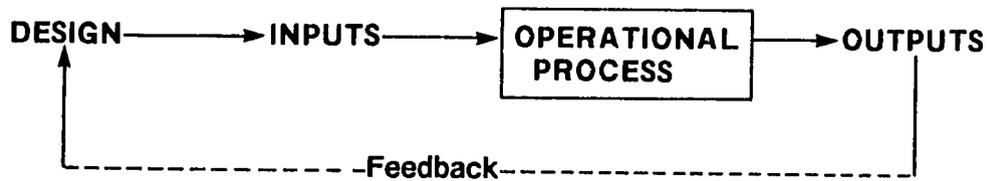
This type of problem analysis may be sufficient. But a more formal systems approach to problem analysis may be necessary in conducting operations research on community health workers in primary health care. In this approach, analysts view the overall strategy for using community health workers as a system that absorbs inputs according to their plan or design and then processes them to produce outputs. (See figure 2-1.) Johnson, et al., suggest that:

The best way to view [a] system is by describing the flow process, analyzing each segment, and investigating the relationships and contributions of the parts to the whole. In this way it is possible to direct attention and study to those segments which fail to optimize their contribution to the total system.(2)

The authors give this description of a system.

A system will be defined as an array of components designed to accomplish a particular objective according to plan. There are three significant points in this definition. First, there must be a purpose, or objective, which the system is designed to perform. Second, there must be a design, or an established arrangement of the components. Finally, inputs of information, energy, and materials must be allocated according to plan. . . . However, the emphasis in the systems concept differs slightly. Information, energy, and materials are classified in terms of whether they are used 1) to create the system or 2) to operate the system.(3)

Figure 2-1.--A Simple System



Operations research is concerned with identifying problems with the processes of a system and assessing possible solutions. The ten problem clusters listed at the beginning of this chapter serve as a starting point in the description of a system using community health workers. A relationship among these problem clusters is implied in the inventory, but analysis requires that the relationships be made explicit and defined in causal terms. For example, what is the relationship of health worker task specification to training?

Defining this relationship can be done through a diagram (or model) that illustrates how the CHW program functions as a process. Such a diagram is presented in figure 2-2, which illustrates the relationships among the problem clusters.

The diagram shows the ten problem clusters within a rectangle that defines the "boundaries" of the CHW system. The larger rectangle represents the environment within which the CHW system operates. This environment is made up of other health systems (private, social security, etc.), other socioeconomic sectors (agriculture, transportation, etc.), infrastructure (roads, communications systems), and natural forces (climate, terrain) that affect the system in one way or another.

The diagram shows the CHW system receiving resources and direction (PHC strategy and resources) on the left and processing those resources through community organization, task specification, and so forth, to result in CHW task performance, which in turn, should lead to improvements in health and other social outcomes.

Figure 2-2 is a general description of a CHW system and the key variables for a particular problem. It can be used to examine how a program is designed as well as how it actually operates. Operations research in a particular country should begin with a comparable description that shows the actual relationships among key variables in that country's PHC program.

Figure 2-3, for example, shows a CHW system that differs from the one in figure 2-2 in several important respects. In the latter example, the community health workers are government employees who report to Ministry of Health field units. The community does not participate in the organization of the program or in selecting and paying the community health workers. One of the health workers' principal tasks is to promote the program among community leaders. The PHC services are provided largely through the district field units.

The diagram can be a helpful problem analysis tool, since it can display the principal problem clusters and show how they are related to one another. Narrowing this simple model into a more detailed description of one or more problems allows the researcher to identify the relevant variables that need to be studied.

Figure 2-2.--Diagram of a CHW System

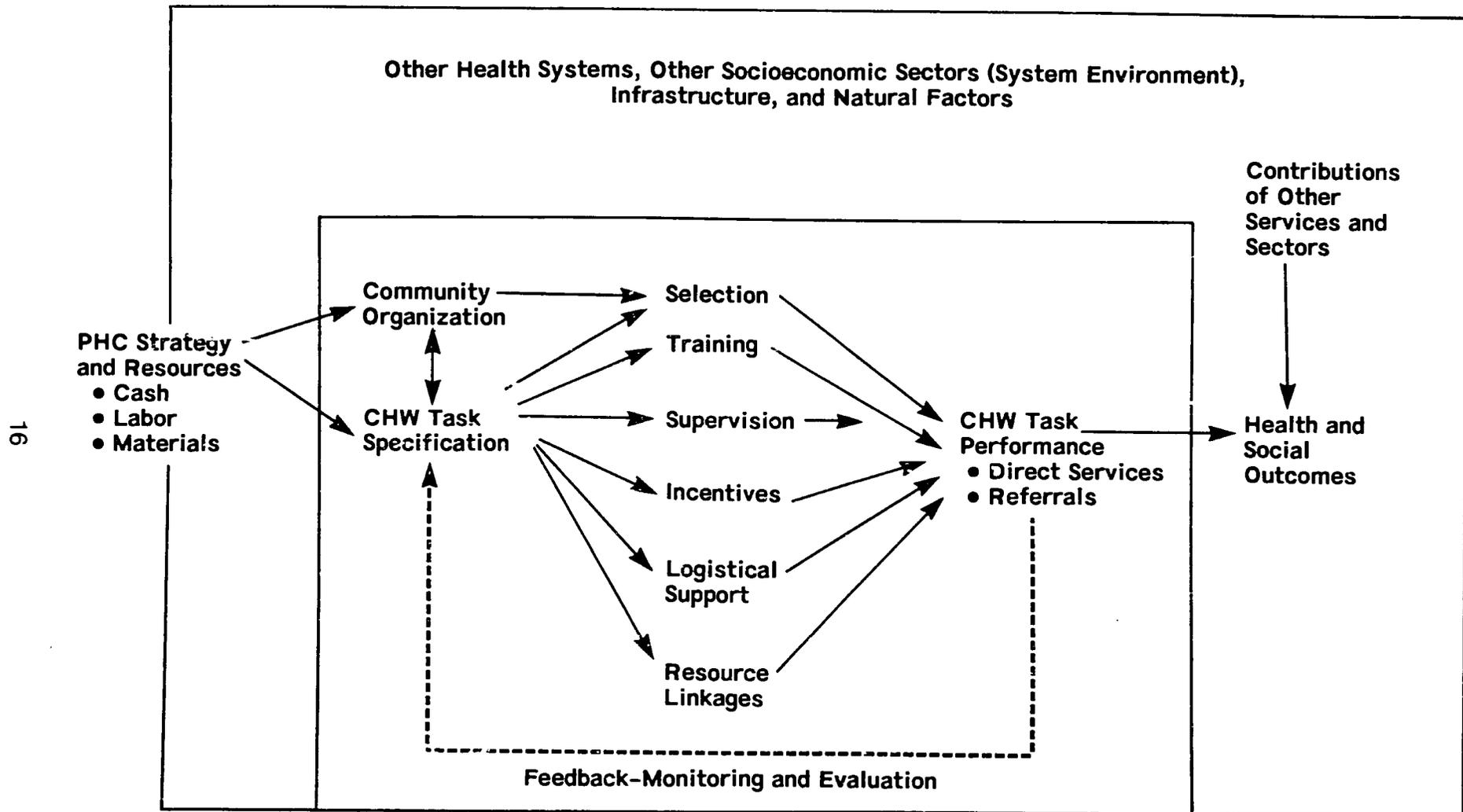
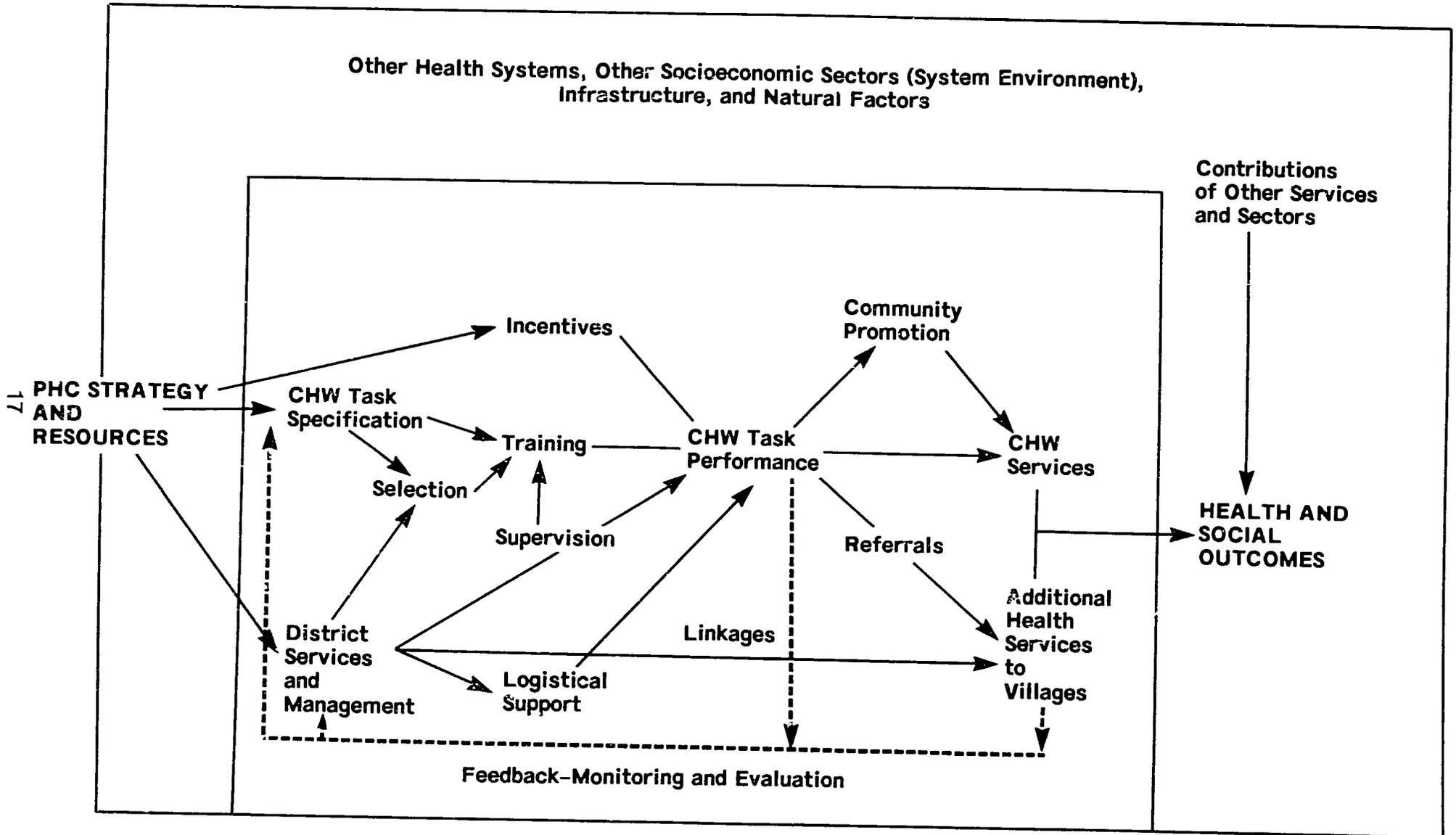


Figure 2-3.--Alternative Diagram of a CHW System



IDENTIFYING THE KEY VARIABLES OF A PROBLEM

When analysts begin to examine an operational problem they are usually confronted with a large number of variables which affect the system, and they must decide which ones are relevant to the problem. The most relevant variables that make up a problem can be divided into two categories: those that are controllable and those that are uncontrollable. The former are called decision variables because they are under the control of the decisionmaker (e.g., which tasks to assign CHWs, how to train them, what supplies to provide them).

There are several types of uncontrollable variables. One of the most relevant are the constraints. Constraints tend to limit the range of choices available to a decisionmaker. Some constraints are external to the system, for example, the weather, which may limit program activities to particular seasons. Other constraints are imposed by the system itself and can affect inputs (all CHWs must be men), processes (CHWs will be trained at district health centers), or the outputs (the CHWs will emphasize latrine construction). Sometimes uncontrollable variables expand the range of choice or favor a certain decision (e.g., the willingness of villagers to pay for the training of one of their members to become a CHW). Some authors call these "facilitating factors."*

Figure 2-4 lists common decision variables and constraints related to the problem of selecting community health workers. The solution to this problem is a function of the interaction of these two sets of variables. Thus, in looking for a solution to a problem, the operations research analyst must first identify the most relevant decision variables and the constraints and facilitating factors. Figure 2-5 lists additional constraints and facilitating factors.

The operations research approach to problemsolving is described in more detail in chapter III, but at this point, a brief example may help to explain the relationships among these variables and demonstrate why it is important to identify them.

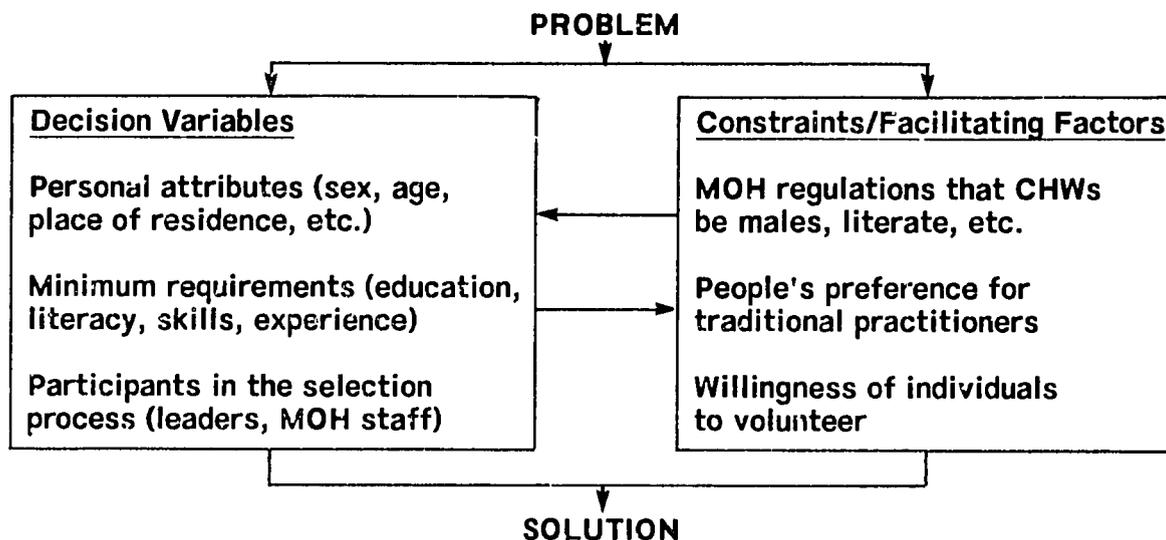
The analyst usually begins with an objective, a statement that describes what the solution should accomplish. If the operational problem is one of CHW selection, the objective of the solution might be stated as: to define a strategy for selecting community health workers who will be acceptable to their communities and capable of carrying out the defined PHC tasks.

Given that objective, the analyst needs to identify all of the relevant decision variables that can be manipulated to effect the desired change. For example, the program manager can alter the selection criteria (the age, sex, education requirements) for applicants, the selection process, and the participants in the selection process.

The analyst then assigns the value for each decision variable that will best achieve the stated objective. For example, what is the best age or age range for community health workers? Should they be male or female? What level of education would be best, given the objective of selecting individuals who will be acceptable and capable?

*For a discussion of the types of variables that are important in operations research, see the PRICOR monograph Operations Research Methods: A General Approach in Primary Health Care, by Stewart Blumenfeld.

Figure 2-4.--Some Variables Related to CHW Selection



The analyst must also identify all of the relevant constraints, the "givens" that limit the range of choice. For example, the Ministry of Health may require that all community health workers be literate males.

Facilitating factors favor certain choices, and the analyst must identify them. For example, if most community members want a male as their health worker, that is a facilitating factor in a system that requires that community health workers be male.

To summarize how these variables are related to one another, in selecting community health workers, an objective may be to select individuals who are acceptable to their communities. A constraint may be that the Ministry of Health decrees that all community health workers must be literate males. One of the decision variables would be the age range for health workers. The value of that decision variable would be the age or age range specified. An optimal solution to this problem, therefore, would be to find the value; that is, the age or age range of community health workers, that maximizes the acceptance by the community of the health worker, given the constraint that community health workers must be literate males.

Thus, the operations research analyst needs to state the objective and identify the relevant decision variables, constraints, and facilitating factors--those elements on which the research will concentrate to reach the optimal solution.

INVENTORY OF OPERATIONAL PROBLEMS AND DECISION VARIABLES

This section identifies the most common decision variables for each CHW problem cluster as an aid to identifying potential operations research topics related to community health workers. Where possible, it also identifies common constraints as seen in the relevant experience of CHW programs and studies on these problems. Unfortunately, the literature on these problem clusters is uneven. Much more is known about some problem areas, such as training and supervision of community health workers, than others, such as community organization and linkages of community health workers with other health resources. This lack of information indicates a need for more research on these problem clusters.

**Figure 2-5.--Common Constraints and Facilitating Factors
in the Use of Community Health Workers**

The following is a list of a wide range of factors that might be considered in identifying constraints and facilitating factors in the use of community health workers.

Geographic, Demographic, and Epidemiological Factors

Age distribution of the population
Spatial distribution of population and of settlements
Distribution of mortality and morbidity, by cause
Climate and topographic factors
Nutritional and health status

Political and Bureaucratic Factors

Role of government
Economic distribution policies
Social development priorities vs. priorities for economic development and defense
Balance of centralization and decentralization in administration
Patterns of intersectoral coordination; general administration vs. sectoral administration
Policy and planning decision processes
Articulation of health policies (if and how)
Budgetary commitments to primary health care, in comparison with other components of the health system

Cultural Factors

Religious or folk beliefs in relation to health
Community traditions
Role and utilization of traditional healers
Attitudes toward authority; toward government
Social relationships of the sexes

Economic Factors

Income distribution
Personal expenditures for health care
Urban-rural economic status
Occupational patterns
Interdependencies in economic organization and activities
Capacity for domestic manufacture of commodities for health programs

Health Sector Organization

Utilization of public vs. private health resources
Degree of governmental control over the health sector economy
Roles of professional organizations in decisionmaking
Spatial and social distribution of resources and services
Degree of institutional self-containment, independence
State of planning and management processes
Attitudes toward primary health care and community health workers
Financing patterns; e.g., social security
Status, roles, and traditions of training institutions; other training resources
International migration; medical, nursing, technical
Managerial roles and styles, e.g., autocratic, democratic

Social Factors

Concepts of property and property rights
Roles of women and children in the home, in production, in relation to health
Communal organization structures
Urban-rural lifestyle features
Populations in transition; e.g., in the urbanization process
Education levels; distribution by age group, class, and degree of urbanization
Literacy levels of various population groups

General Infrastructure

Transportation patterns and level of development
Communications systems; physical and social aspects
Public and university educational systems
Administrative systems; stage of development
Facilities; location patterns, practices in utilization and maintenance

1. Development of a CHW Program Strategy

Decisions about program development are usually made at middle or upper levels of the Ministry of Health. Because at higher levels of decisionmaking, political considerations often outweigh technical ones, a limitation of operations research on CHW program strategy development may be the political nature of decisionmaking itself. However, operations research can be useful for identifying decision options and assessing the feasibility of alternative CHW strategies in a rational and systematic way. Such analysis facilitates decisionmaking about which CHW strategy is most appropriate within the larger health system strategy, and may provide policymakers with persuasive evidence for adopting a particular course of action.

In developing a new CHW strategy or redesigning an existing one, fundamental policy decisions must first be made to specify the place of the CHW program within the overall primary health care strategy. Initially, policymakers must determine what the objectives of the CHW program are and how these relate to the larger primary health care system. These objectives, in turn, may depend largely upon the human, physical, and financial resources available for the development and ongoing support of a CHW program. Basic decisions about the CHW strategy to be used, such as the CHW's location, position in the health system, ratio of health workers to catchment population and to target population, are likewise dependent upon the objectives and resources available for the CHW program.

DEVELOPMENT OF A CHW PROGRAM STRATEGY

Common Decision Variables

- Objectives of the CHW strategy within the larger health system strategy: deliver primary curative and preventive services; provide health education; link community to health system through referral
 - Human resources available for the development and implementation of CHW strategy: central and regional personnel to plan and administer program; trainers; supervisors
 - Location/facilities available for CHW program: health centers; health posts; community development centers; other public location; based in home
 - Financing of the CHW program: external loans or grants; central government revenues; MOH development budget; state/municipal budgets; community financing
 - Position of the CHW in the health system: MOH employee/volunteer; departmental affiliation in MOH; full-time/part-time; member of a PHC team/works alone
 - Target population: children under 5; women of childbearing age; total population within x kilometers of health post
 - Coverage: size of population per CHW
-

2. Community Organization and Support

The issue of community organization for primary health care is itself a broad area for operations research, which is discussed extensively in a separate PRICOR monograph on community organization.(4) In the context of decisionmaking about a CHW program, the problem cluster of community organization includes the processes and structures through which members of a community can be mobilized to support and participate in the activities of community health workers.

The main operational issues in community organization for community health workers concern the role of and mechanisms for enabling community participation in planning for, selecting, training, financing, and supervising community health workers. Which mechanisms for approaching community members and groups to involve them in a CHW program work best, and under what conditions? What strategies should be undertaken to promote and sustain community utilization of community health workers? Should new groups be organized to support community health workers or existing groups asked to take on CHW-related responsibilities? These and other community organization issues are appropriate problems for operations research on CHW programs.

COMMUNITY ORGANIZATION AND SUPPORT

Common Decision Variables

- Community functions in CHW task selection and prioritization, selection, training, supervision and evaluation:

Task selection and prioritization: identify activities for CHW; rank CHW tasks by relevance to community needs; participate indirectly through needs assessment surveys

Selection: nominate CHW candidates; elect CHW; community health committee selects CHW; no role in CHW selection

Training: actively participate in design of training; attend CHW training as observers; no role in training

Supervision and evaluation: formal role in supervision/evaluation, with reporting; informal ongoing supervision/evaluation; meet periodically with CHW supervisor from health system; no role in supervision/evaluation

- Mechanisms for community participation in planning and priority-setting for CHW training, selection, supervision and evaluation: group decisionmaking techniques in community meetings, health committees, meetings with representatives from community organizations; election of health committee; focused interviews with community leaders, key informants; addition of health responsibilities to existing community organization(s)

- Type of community organization that can be involved in CHW program development and support: single-purpose (health)/multi-purpose (general development); newly created organization; existing organizations with other main objectives; large popular organization; committee with a few key individuals as members
 - Mechanisms for mobilizing community support and utilization of CHW program: primary health care orientation program for entire community/for community leaders; formation of local health and development committee; training of health committee members; literacy campaigns utilizing health themes; radio programs; loudspeaker; school health programs; sociodramas about health problems and role of CHW
 - Financial or contributory responsibility of community:
Objectives of community financing of CHW program: pay for all recurrent costs of CHW program; increase ownership or utilization of CHW program through limited cost-sharing; no community financial responsibility for CHW program
CHW program components to be financed by community: medicines; supplies; CHW incentives; CHW housing/meals; specific services; total primary health care services
Mechanisms for community contributions: fee for service; drug sales; personal prepayment; community or individual labor; community income-generating activities; donations; ad hoc assessments
Who contributes: everyone in the community; working families; beneficiaries only
 - Mechanisms for continuing CHW program promotion in the community: Regular meetings of health committee; periodic health campaigns; radio programs; reporting on CHW activities at community meetings
-

In rural areas of Korea, the lack of effective communication between the health workers and the community is an important factor inhibiting the provision of comprehensive health care services. A PRICOR-funded study is developing and testing strategies for using existing non-health community organizations as support structures for the delivery of primary health care. Decision variables include the types of organizations to be utilized and the roles that community leaders should play.

An operations research study in Uruguay seeks to organize neighborhoods in peripheral areas of Montevideo to improve environmental health and promote community participation in health activities. A health promotor program is being initiated with the help of health commissions composed of community members and staff from neighborhood clinics. The promotors and health commissions will work together to identify priority problems and intervention activities that the promotors will organize in the communities.

Constraints affecting community organization and support of CHW activities include attitudinal, economic, and physical factors. For example, previous negative experience with external attempts to alleviate common health problems in the community may have created resistance to such efforts. In these communities, self-help activities may be

more viable than those relying on external support. In sparsely populated rural areas, distance between homes inhibits activities requiring frequent contact among community members. For many communities, the potential for cash support of health workers may be limited, leading to a preference for in-kind contributions.

There are also factors which favor certain decisions. For example, efforts to mobilize community support could take advantage of such natural opportunities for gathering people together as market or religious activities.

3. Specification of CHW Tasks

The general functions and characteristics of the community health worker are usually determined by central-level policymakers during the development of the CHW program strategy. But beyond the basic decisions about what type of worker will be utilized and where based, the specific activities or tasks that the health worker is expected to accomplish need to be decided upon. The actual list of tasks and the priorities for completing them require consideration of community-felt needs, morbidity and mortality data, expectations of the health system, and the capabilities of potential CHW candidates.

SPECIFICATION OF CHW TASKS

Common Decision Variables

- Who will determine CHW tasks: health care professionals; community leaders/representatives; CHW candidates; health committees; central/ regional primary health care planners and program managers
 - Mechanisms for integrating the priorities of different participants in task specification: interactive group consensus techniques; ranking using influence weights; non-interactive group processes (using questionnaires, etc.)
 - Balance of promotive, preventive, and curative tasks: proportion of community health worker's time that should be allocated to each type of activity
 - Priorities/sequencing of tasks: for each task identified, level of priority and frequency with which task should be performed in relation to time, target population, etc.
 - Mode/location of service delivery: home visits; clinic-based; visits to outlying communities; presentations to community groups; school visits
 - Data collection/reporting tasks to be carried out: registration of births, deaths; case reporting of specified diseases (active/passive); routine service statistics; frequency of reporting
 - Degree of standardization in tasks from community to community: no standardization; standardization of essential tasks with time for other locally determined activities; completely standardized tasks for all CHWs
-

The operational questions of who should be involved in CHW task specification and what mechanisms can be used to integrate their views will depend upon local situations. The experience of many CHW programs has been, however, that when communities are not somehow involved in the determination of CHW tasks, support and utilization of CHW services is likely to be poor.

The development of a simple model for setting priorities for CHW activities to improve their responsiveness to community and professionally determined needs is the subject of an operations research study being conducted by the Coordinated Public Health Services of the State of Mexico. Health auxiliaries are using community forums to identify and rank health problems by such criteria as frequency, seriousness, possibility for prevention or treatment, and community's concern about the problem. Staff will then develop a planning model to help the auxiliaries set service priorities.

Another operations research study in the Philippines will identify nutrition interventions that can be integrated into the primary health care services delivered by barangay health workers.

As part of a study to develop community financing schemes through cooperatives in Bolivia, cooperative health committees will select primary health service packages that promoters will carry out in their communities.

The question of which tasks a community health worker can effectively perform must consider numerous factors, such as the health worker's level of education, the type and length of training that can be provided, the community's health needs, and the size of the population to be covered by each worker. The degree of flexibility in training will determine how easily tasks can be tailored to meet local needs. This becomes especially important in countries where geographically diverse regions may have very different patterns of morbidity.

Logistical and political constraints may affect the selection of specific tasks, such as immunizations, which require adequate refrigeration at the health post, and in some cases, government regulations permitting community health workers to administer injections. Tasks outlined for the community health worker may also be constrained by the community's perception of which activities are appropriate for the status and role of the health worker.

In the Maryland County project in Liberia, for example, the village health worker was originally seen by health planners as a change agent who would promote general development in the community. Change was slow to occur because, among other factors, the role of catalyst and leader in development matters was considered the task of an older member of the community and the community's perception of the health worker was that of helper, not leader.

4. Selection of CHWs

The selection of community health workers involves the determination of eligibility or selection criteria and the process by which these criteria are applied to the recruitment, evaluation, and final selection of CHW candidates. The choice of selection criteria is closely related to the requirements of the health system role and tasks specified for the health worker. In addition, local cultural values and perceptions of a health worker's social role and status may have strong influence on the personal qualities appropriate for the community health worker. Who participates in the selection process and the procedures used to choose among candidates have direct implications for the acceptability and legitimacy of the community health workers selected.

Evidence in Costa Rica, Botswana, Thailand, and Guatemala indicates that community involvement in selection is essential if communities are to support and utilize CHW services.⁽⁵⁾ The principal operations research issues in CHW selection are thus concerned with how and by whom the steps in the selection process are carried out, including deciding on the desired characteristics of the community health worker and the mechanisms to be used for candidate nomination, review, and selection.

CHW SELECTION

Common Decision Variables

- Participants and their roles in CHW nomination, review, and selection: community members; central/regional/district health personnel; community leaders; community health committee; non-health community organizations; local political/religious authorities; specially formed selection committee with representatives from community and the health system
 - Mechanisms for nomination, review, and selection:
 - Nomination: public recruitment meetings; presentation of interested candidates for preliminary screening; recommendation by community leaders or health committee
 - Review: interviews; written tests of knowledge and/or personality characteristics; physical exam; demonstration of skills; structured questionnaires
 - Selection: numerical score on examination; secret/open ballot; predetermined criteria weighted by importance
 - Minimum capabilities of CHW candidates: education level; literacy; skills; experience
 - Personal attributes of CHWs: sex; age group; health status; place of residence; economic level; social role/status; language; marital status; occupation
 - Final selection criteria and importance of each: acceptability to the community; maturity/sense of responsibility; ability to learn; interest in community work; likelihood of remaining in job; evaluation from candidate review
-

5. Training of CHWs

Among PRICOR-funded research projects on community health workers, the most frequently studied problem cluster, either as a single operational problem or in combination with other problem clusters, is training. One explanation for the prominence of training as a problem for operations research on community health workers is that training is often perceived as the program input having the greatest impact on CHW performance, particularly in the short run.

CHW TRAINING

Common Decision Variables

- Training content: congruence with knowledge, attitude, and skill objectives specified for CHW; relevance to problems faced in communities; adaptability to local needs and circumstances; participants in design of training content
 - Training methods: distribution of didactic and practical elements of training; lecture; demonstrations; clinical practice; field work in community; audiovisual training techniques; work groups; provisions for practice while in trainee status; role-playing; storytelling
 - Training materials: standardized/locally produced manuals; language and level of sophistication of materials; diagrams and pictures; CHW kits and equipment
 - Location: central/regional/district/community level; health center or hospital; school or other training facility
 - Trainers: specialized/basic personnel; staff from central institution; district health staff; CHW supervisors; experienced community health workers; non-health staff from other development sectors
 - Duration/timing: total course time; distribution in single or multiple blocks; time of year course held; how often course held
 - Class size: number of trainees per instructor or per training team
 - Evaluation of training: written tests; oral exams; observation of trainees; supervision of field practice; group discussion about what was learned in each session; post-training evaluation of CHW performance; trainer evaluation of training process
 - Provisions for additional/refresher training: frequency/location of additional training; incorporation into ongoing supervision; opportunities for community health workers to exchange experiences with other community health workers through CHW "staff" meetings with supervisor; central/ regional mini-courses
 - Training of replacements/new community health workers: regularly scheduled courses; minimum number of trainees required before course for new community health workers held; apprenticeship of replacement CHW with retiring CHW
-

Also, because the preparation of auxiliary personnel has usually been exclusively a function of the health system, training contains a large number of variables which are readily under the control of researchers or program managers. These variables include those relating to course content (such as topics covered, training methods used, specific knowledge, attitude and skill objectives); delivery (site, duration, trainers, class size); and followup (evaluation, refresher/additional training, training of replacements). Operations research can be used to design a new training program or improve an existing one by identifying the best values for these variables.

PRICOR-funded operations research studies to improve CHW training are underway in several countries. In the Philippines, alternative training strategies for barangay (village) health workers are being developed, based on a study of ongoing programs and of trainer characteristics and their relationships to barangay health worker performance.

Operations research can also be used to determine the most cost-effective way to train health workers in order to improve coverage of preventive and promotive health programs. In Haiti, alternative training models for traditional birth attendants will be tested to determine if focused training on selected tasks is more cost-effective than training in a broader range of activities.

A PRICOR-funded study in the Dominican Republic is looking for the best combinations of class size, type of trainers, and location of training to determine the most cost-effective way to train rural promoters to deliver oral rehydration therapy and malaria prophylaxis.

In Papua New Guinea, an important decision variable in designing a new primary health care program is who should be trained--new or "experienced" health workers.

Although training courses frequently involve many decisions that are under the control of researchers, the value of some decision variables may be fixed at certain levels, making them constraints. For example, budget restrictions may limit the number of days for which trainers and trainees can be paid per diem. Often, training alternatives are constrained by the number of available trainers and the reliance on standardized materials and curriculums when trainers with minimal preparation are used. Other typical constraints might include the time of year when training can be held (to avoid peak periods of agricultural activity or rainy weather) and the skill and knowledge objectives of training (which depend on the specified CHW tasks and selection criteria).

6. Supervision of Community Health Workers

The relation of appropriate and continuous supervision to CHW effectiveness is frequently emphasized in the growing primary health care literature. Despite the recognition of supervision's importance, inadequate attention is usually given to developing a viable supervision strategy in the design of CHW programs. Shortages of qualified personnel and transportation are often cited as major obstacles to providing adequate supervision. Furthermore, supervision, when carried out, is frequently restricted to conventional monitoring and control functions, with little emphasis on supportive, motivational, and educational ones. Limitations on the resources available for supervision and the need for improved patterns of supervision more responsive to CHW problems and needs make the identification of ways to maximize the effectiveness of supervision a particularly appropriate area for operations research.

CHW SUPERVISION

Common Decision Variables

- Level of resources committed to CHW supervision: transportation and per diem budgeted for supervision; ratio of first-line supervisors to community health workers; delineation of supervisor activities in job descriptions and work plans
 - Characteristics of first-line supervisor: technical/administrative capabilities; amount of training in supervision skills; experience with community work; residence; position in health system hierarchy
 - Characteristics of CHW-supervisor link: authoritative or participative; frequency and duration; location; direct or indirect; separate activity or combined with other activities, such as clinical work
 - Role of the community in CHW supervision and evaluation: formal or informal; specific tasks to be supervised by community; accountability of CHW to community; sanctions available to community
 - Type and balance of supervision activities: legitimizing CHW role; clarifying CHW responsibilities to community; motivation; educating and counseling; technical assistance; linking CHW and community to external resources; monitoring and control; evaluation
-

An operations research project in Ecuador will identify the supervisory method that minimizes the costs of supervision while achieving certain minimum levels of expected performance. The model will determine the optimal number of immediate and intermediate supervisors needed to fulfill supervisory objectives, which include the percent of supervisory time to be spent in the field vs. at the health post and the minimum number of supervisory contacts per promotor.

In Tanzania, operations research is being used to determine the most appropriate supervisor characteristics (technical, interpersonal, sense of commitment, etc.) and activities to enhance CHW performance and service outcomes.

A study underway in Nigeria is examining a series of variables reflecting both characteristics of the supervisor and the nature of the supervisory link to determine which factors enhance supervisory performance and, in turn, the performance of community health workers.

Constraints on effective supervision are often economic in nature. Shortages of functioning vehicles, gasoline, per diem funds, and the closing of unpaved roads because of weather conditions are reasons frequently cited for failure to make programmed supervisory visits. In primary health care systems where systematic supervision is not planned but, rather, is carried out on an ad hoc basis, supervisors may not be adequately prepared to provide the administrative or technical support needed by the community health worker.

Who carries out supervision of community health workers may result in certain constraints on the supervisory strategy. Where CHW supervision is done by nurses who may have a low status in the health system, lack of supervisory control over the resources needed to carry out responsibilities may be a problem. Distances between the supervisor and the health workers and lack of transportation are also serious obstacles, particularly in remote areas.

7. Provision of Incentives and Other Means of Motivation

While in the past, primary health care planners and program managers often expected the spontaneous participation of community health workers, high attrition rates and increasing demands placed on health workers have drawn attention to the importance of providing adequate incentives to primary-level health workers. The provision of incentives to community health workers may have various objectives: recruit qualified candidates; promote job satisfaction; motivate performance; encourage particular activities. Depending on different local cultural and economic factors, CHW incentives may take many different forms and have multiple sources. Care must be taken to ensure that the nature of and mechanism for providing the incentive are appropriate to the motivational effect desired.

For example, payment of a stipend during training may attract qualified individuals to become community health workers, but will probably not influence their decision to stay on the job after training is completed. Operations research on the provision of CHW incentives is concerned with identifying the kinds of incentives that are most appropriate, ways to mobilize sources of CHW support and remuneration, and mechanisms to provide incentives on a sustained basis.

PROVISION OF INCENTIVES AND OTHER MEANS OF MOTIVATION

Common Decision Variables

- Type of CHW behavior/activity to be motivated: joining (recruitment); improved performance; staying on job; specific activities to be emphasized
 - Type of incentive/reward to be provided: monetary; symbolic (uniform, insignia, equipment); land; in kind; prizes; status; exemption from military service; free medical care; possibilities for advancement
 - Sources of remuneration: government; community financing; fee-for-service
 - Mechanisms for providing incentives: decision by supervisor/health committee/local leaders; timing of reward; relation of reward and meeting targets
 - Provisions for ensuring continuity/regularity of incentives: make CHW position part of civil service; establish ongoing income-generating activities to finance CHW incentives; establish schedule for CHW rewards; make a particular community organization responsible for provision of CHW incentives
-

In Bolivia, where the dropout rate of rural health workers is high, an operations research study is seeking the most appropriate incentives, and the means to generate these, that will induce health workers to remain in their communities. Preliminary evidence suggests that economic factors related to the agricultural occupation of the health workers are primarily responsible for this phenomenon. Key decision variables to be examined will be sources and levels of remuneration needed.

Dropout of rural health motivators has been identified as a serious obstacle to primary health care in Swaziland. A survey of these health workers indicated that most feel they should be given a stipend at least double the current level. Moreover, because of budgetary difficulties in the Ministry of Health, many rural health motivators have not received stipends for several months. The Ministry of Health is concerned that very little supervision and accountability exist for the present stipend, since great variation has been observed in performance among health workers. Strategies for providing incentives, therefore, will have to contain a strong component of accountability.

Constraints affecting the provision of incentives are most often economic, but may also be attitudinal. Communities may be limited in their ability to make cash contributions; in-kind support may be feasible and effective in such circumstances. The nature of the services provided by the community health workers could inhibit the willingness of community members to support them if the activities carried out are not those people are willing to pay for. Similarly, the perception that the primary care services of the community health worker are a government responsibility and not a community one can limit potential for community support.

8. Provision of Supplies and Other Logistical Support

The extension of primary health care services through the use of community health workers has contributed to the increased use of basic health services. This greater demand for drugs, equipment, and supplies has placed increasing pressure on health systems' logistics and support mechanisms. Shortages of drugs and supplies have disrupted CHW activities in many countries and resulted in loss of CHW credibility. Ensuring that efficient procedures for ordering, distributing, and storing essential drugs and supplies are in place and functioning is thus a critical component of CHW effectiveness.

Operations research problems relating to supplies and logistical support for community health workers include: selection of appropriate drugs and supplies for use by health workers; establishing procedures for procurement, distribution, and inventory to ensure adequate supplies; maintenance of equipment and vehicles; transportation of personnel and referred patients; and financing supplies and logistical support.

PROVISION OF SUPPLIES AND OTHER LOGISTICAL SUPPORT

Common Decision Variables

- *Selection of supplies/drugs: for routine/nonroutine use; quantities to be available at different service levels; initial stock to be provided per CHW or per population size*
- *Procurement procedures: issue fixed quantity to CHW at regular intervals; order on demand according to established procurement schedule; make provisions for emergency orders; establish measures to assist CHW with ordering/inventory activities*

- Supply distribution and storage strategy: availability of drugs/supplies and storage facilities at central/regional/district level; means of transportation; accountability; lag time between orders and receipt of supplies; commercial channels for distribution
 - Provisions for transport of supplies, emergency referrals and direct service personnel: health system vehicles; public transportation; private vehicles
 - Provisions for maintenance and repair of equipment/vehicles: full or part-time mechanic at central/regional/district level; commercial channels
 - Provisions for financing drugs/supplies: sale at cost; fee per consultation, including cost of drugs/supplies; subsidized drugs for certain members of population; revolving funds; purchase and sale of drugs/supplies by community organization; prepayment schemes; commercial sales of drugs/ supplies
-

In Ecuador, rural health promoters have indicated that lack of supplies is their number one problem. An operations research study is being carried out to develop administrative procedures that would efficiently handle the steps in supply logistics to support the promoters. Current purchasing, distribution, and storage procedures and the fluctuations in demand for supplies by health promoters are being analyzed for various regions of the country. Objectives for the solution to the supply problem are to minimize the time between ordering and receipt of supplies, shipping costs, and costs of ordering and storing supplies.

An operations research study in the Dominican Republic will identify approaches to ensure the supply of oral rehydration salts on a national scale. Principal decision variables will be channels for distribution, including both public and private sectors, price structure, and subsidization mechanisms for those who cannot afford to purchase the salts.

Common constraints are related to the nature of the supplies (such as shelf life, storage requirements, amenability to bulk purchases, etc.) and demand (e.g., seasonal variations, consumer preferences, morbidity patterns). The capabilities of the health worker may also be constraints, depending on the inventory and ordering skills required. Budgetary limitations in the Ministry of Health and shortage of foreign exchange to buy imported drugs or supplies may restrict alternative solutions. However, because supplies are tangible goods that are often highly valued by community members, solutions to a logistics problem may be facilitated by individuals' willingness to pay for certain items used by community health workers.

9. Linkages of Community Health Workers With Other Resources

Just as improvements in health depend on socioeconomic and political factors outside the formal health system, the effectiveness of community health workers is related to and enhanced by other health and nonhealth development efforts. Coordination of CHW activities with those of other development sectors, for example, may better address community needs by focusing efforts on priority problems. Ties with other elements of the health care system are essential if community health workers are expected to refer patients with problems they are unprepared to handle.

Areas of cooperation with other health resources in the community--such as traditional healers, pharmacists and private physicians--should also be explored, since these persons often hold positions of status and influence. Finally, linkages with the various groups and individuals important to the life of the community may be needed for the community health worker's role and activities to be accepted. Identifying ways to link community health workers with such resources in and outside the community is an area for operations research.

LINKAGES WITH OTHER RESOURCES

Common Decision Variables

- Linkages with other elements of the community: community/religious/ political leaders; non-health community organizations; recreational clubs; unions/cooperatives
 - Linkages with other elements of the health care system: criteria and procedures for referral and followup of patients needing more skilled care; role of CHW as entry/triage point of health system
 - Relationships and areas of cooperation with other community health resources: private physicians; traditional healers; traditional birth attendants; pharmacists/herbalists
 - Linkages and areas of coordination with agents/organizations from other government development sectors: education; agriculture; water/sanitation; rural development; military
-

10. Monitoring and Evaluation of CHW Performance

An important component that is often overlooked is an accurate and reliable monitoring and evaluation system. Most PHC programs have some sort of information system and conduct some evaluations periodically, but many of these do not produce information that is useful for decisionmaking. If CHW performance is to be improved, a clear and simple monitoring and evaluation system should be included.

MONITORING AND EVALUATION OF CHW PERFORMANCE

Common Decision Variables

- Users of the information: will the primary users be central level, regional, or local decisionmakers; should different information be provided to different users?
- Topics for monitoring and evaluation: which components should be monitored routinely (training, supervision, services provided) and which should be evaluated with special studies?

- *Scheduling: how often should data be collected and reported for the monitoring system; how often and in what order should the evaluation studies be conducted?*
 - *Personnel: who should conduct the monitoring and evaluation (CHWs, their supervisors, community members, outside experts, a combination); should some personnel be responsible for data collection and others for analysis and reporting; should different personnel be responsible for different monitoring tasks or evaluation studies?*
 - *Nature of monitoring and evaluation: should the systems be centralized or decentralized; computerized or not; standardized or flexible; based primarily on registration and service statistics or surveys and experiments?*
-

Relationships Between Constraints and Problem Clusters

Even though differences among countries make it difficult to generalize about the relationships between the uncontrollable factors and the clusters of problems identified in this chapter, one view of such relationships is presented in figure 2-6. Factors in the left-hand column contain decision variables on solutions to the problem presented in the columns on the right.

Which of these factors--or others--are pertinent in a specific operations research project will depend on the scope and focus of the research problem that has been identified, on the relationship of the factors to the decision variables in the problem, and on the actual importance of the factor in the country study.

SELECTING THE OPERATIONAL PROBLEMS FOR STUDY

Each problem within a problem cluster is a potential topic for operations research. When there are more problems than time and resources available to study them, priorities need to be set. This is one time when the user of the research, the decisionmaker, should become involved.

Generally, the decisionmaker and researcher should study those problems that are most critical to solving the overall problem; i.e., those that are likely to have the greatest impact on the operation. When factual data are available to rate each problem objectively, then this is a relatively straightforward procedure. Those problems with the highest values (scores, weights) would receive the highest priority.

However, many such decisions must be made based on opinions and informed judgments, and sometimes a number of decisionmakers have to be involved. Several techniques have been developed to aid this sort of decisionmaking. Each involves setting criteria by which to "grade" each problem. For example:

1. Most significant (greatest obstacle to health worker performance);
2. Greatest uncertainty (have no idea what the solution might be); and
3. Greatest probability (of finding solutions quickly).

Assuming a group will set the priorities, a very simple technique is to ask the members to rate or rank each problem on these criteria. Other simple techniques that could be used, such as the Delphi and the Q-Sort, are described in the PRICOR monograph, Operations Research Methods: A General Approach in Primary Health Care.

B. Problem Clusters

Figure 2-6
Relationships Between Constraints
and Decision Variables
in CHW Problem Clusters

A. Constraints	CHW Strategy	Community Organization & Support	CHW Selection	CHW Task Specification	CHW Training	Incentives and Motivation	Supervision	Linkages	Supply-Logistics	Monitoring-Evaluation
Age distribution of the population	X			X						
Spatial distribution of population/settlements	X	X	X	X	X		X	X	X	X
Distribution of mortality/morbidity by cause	X	X	X	X	X		X	X	X	X
Climate/topographic factors	X	X		X	X	X	X		X	X
Nutritional status	X			X	X			X	X	
Role of government	X	X	X	X		X	X	X	X	X
Economic distribution policies	X	X				X		X	X	
Social development priorities	X	X				X		X		X
Centralization/decentralization balance	X	X			X	X	X	X	X	X
Intersectoral coordination; relations	X	X	X	X	X		X	X	X	X
Planning/decision processes	X	X				X		X		X
Articulation of health policy	X	X		X		X		X		
Budgetary commitments to PHC	X	X	X	X	X	X	X	X	X	X
Religious or folk beliefs related to health	X		X	X		X				
Community traditions	X	X	X	X	X	X	X			
Role/utilization of traditional healers	X	X	X	X	X	X	X			
Attitudes toward authority: toward government	X	X	X	X	X	X	X			X
Social relationships of the sexes	X		X	X	X		X	X		
Concepts of property and property rights	X	X		X			X	X		
Roles of women and children	X		X	X	X	X	X			
Communal organization structures	X	X	X			X	X	X		
Urban-rural lifestyle features	X	X	X	X	X	X	X	X	X	
Populations in transition	X	X	X	X	X	X	X	X		
Education levels/distribution	X	X	X	X	X	X	X	X		X
Literacy levels of the population	X		X	X	X		X		X	X
Income distribution	X	X		X		X	X		X	
Personal expenditures for health care	X			X		X			X	
Urban-rural economic status	X	X		X		X		X	X	
Occupational patterns	X	X	X	X		X	X	X		
Economic interdependencies	X	X				X		X		
Domestic manufacture of commodities for health	X			X				X	X	
Transportation patterns and level of development	X	X		X	X		X	X	X	
Communications systems - physical/social	X	X		X	X	X	X	X	X	X
Educational systems	X		X		X		X	X		
Administrative systems - stage of development	X	X	X	X	X	X	X	X	X	X
Facilities - locations and practices	X	X		X	X		X	X	X	X
Public vs. private distribution	X			X		X	X			
Degree of control over health sector economy	X	X	X	X	X	X	X		X	
Professional organization: decisionmaking role	X	X	X	X	X	X	X			X
Spatial and social distribution of resources	X	X	X	X	X		X		X	
Degree of institutional self-containment	X			X	X		X	X	X	
State of planning and management processes	X	X		X	X	X	X	X	X	X
Attitudes toward PHC and CHW's	X	X	X	X	X	X	X	X		
Financing patterns; social security, etc.	X	X		X		X	X		X	
Training institutions and resources	X		X	X	X		X			X
International migration - medical, nursing, etc.	X			X	X		X			
Managerial roles and styles	X	X		X		X	X	X	X	X

*Marked boxes indicate which of the constraints in a given row (A) is likely to affect the decision variables in the problem clusters in a column (B).

NOTES

1. E. S. Quade, Analysis for Public Decisions, 2d. ed. (New York: Elsevier Publishing Co., 1982), p. 69.
2. Richard A. Johnson, Fremont E. Kast, and James F. Rosenzweig, The Theory and Management of Systems (New York: McGraw Hill, 1963), p. 90.
3. Ibid., pp. 91-92.
4. Arthur Goldsmith, Barbara Pillsbury, and David Nicholas, Operations Research Issues: Community Organization (Chevy Chase, MD: PRICOR, 1985).
5. Virginia Ofosu-Amaah, National Experience in the Use of Community Health Workers (Geneva: WHO Offset Publication No. 71, 1983).

CHAPTER III
DESIGNING AN OPERATIONS RESEARCH STUDY
ON COMMUNITY HEALTH WORKERS

CHAPTER III. DESIGNING AN OPERATIONS RESEARCH STUDY ON COMMUNITY HEALTH WORKERS

PRICOR defines operations research as a systematic, problemsolving process for use in planning, consisting of three phases: problem analysis, development of solutions, and testing of those solutions. This chapter describes that process briefly, with examples of ways this approach can be applied to operational problems in the community health worker (CHW) component of primary health care (PHC) programs. Summaries of PRICOR-funded projects on community health workers can be found in the appendix. The PRICOR monograph, Operations Research Methods: A General Approach in Primary Health Care, by Stewart Blumenfeld, provides a more detailed description of operations research methods.

Operations research can make management decisionmaking easier and more rational. It can reduce reliance on costly trial-and-error approaches through the use of systematic procedures for selecting the "best" course of action. PRICOR staff and advisers have developed a practical operations research approach that incorporates the essential features of traditional operations research yet remains flexible enough to be applied to the significant operational problems identified in the last chapter. That general operations research approach is summarized in figure 3-1.

Figure 3-1.--Steps in a General Approach to Operations Research

PHASE I: PROBLEM ANALYSIS

1. Define the problem.
2. Analyze the problem, divide it into smaller operational problems, and collect needed data.
3. Set priorities and select the problems for study.

PHASE II: SOLUTION DEVELOPMENT (for each operational problem)

1. Specify the objective for the solution to each problem.
2. Identify the controllable (decision) variables and uncontrollable factors (constraints and facilitating factors) of each problem.
3. Select and construct an appropriate model for solving each problem.
4. Collect required data.
5. Use the model to develop the optimal solution(s) for each problem.
6. Conduct sensitivity analysis of each solution.

PHASE III: SOLUTION TESTING AND EVALUATION

1. Design the test of the solution(s).
 2. Conduct the test and collect needed data.
 3. Evaluate and modify/adjust the solution(s).
 4. Merge the resulting information.
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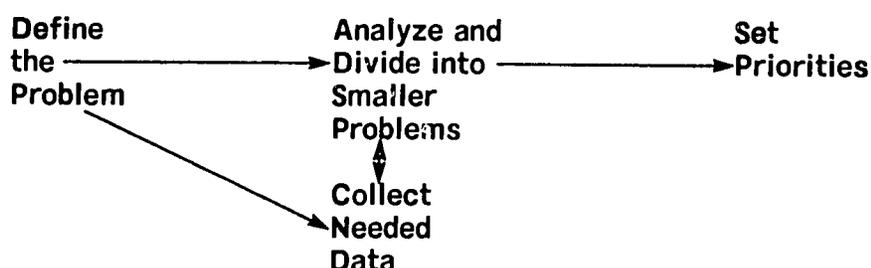
The steps in this process are described briefly in the following sections and are illustrated with an example based on a PRICOR-supported operations research project.

As operations research is an iterative process, the steps are not necessarily sequential, and depending on the nature of the study, some may be repeated several times and others may not be undertaken at all.

PHASE I: PROBLEM ANALYSIS

The steps in this phase are illustrated in figure 3-2 and described below.

Figure 3-2.--Steps in Problem Analysis



Step 1. Define the Problem

Problem analysis usually begins with the identification of a discrepancy between what should be, and what is, occurring. For example, villagers should be supporting their health workers, but they are not; essential drugs should be available in the rural areas, but they are not. Information identifying a problem could come from observations, evaluation reports, discussions with program managers, and other sources.

Example: An African country has, over several years, introduced CHW services into selected areas, using a variety of approaches for CHW selection, training, functions, supervision, and support. The National Social Planning Council has decided that these ad hoc approaches should be replaced by a consistent national strategy for primary health care. No studies have been made, however, that would enable decisionmakers to select among the approaches that have been used or to combine elements of the different programs into a new strategy. A task force of program managers, field officers, supervisors, and researchers is organized to systematically study this problem and to work out recommendations to the planning council.

Step 2. Analyze the Problem, Divide It Into Smaller Operational Problems, and Collect Needed Data

Problem analysis often begins with a systematic description of the problem to define such things as its scope, magnitude, seriousness, characteristics, and probable causes. Some problems, such as "What should community health workers do?" are too big to study all at once. They need to be broken down into more manageable problems, such as those listed in chapter II on specifying health worker tasks.

One way to proceed in problem analysis is to describe how a community health worker program should work, thinking of it as a system of related parts. The system may be ongoing or one that is being designed. Figure 2-2 in chapter II presented a general, graphic representation of a CHW system. The model shows that the system's contribution to PHC goals depends not only on the smooth functioning of its parts (selection, training, supervision, etc.), but also on other factors in the environment (seasonality of diseases, health care provided by private practitioners, costs of pharmaceuticals, etc.). The general CHW system can be described in this graphic manner, and each of its component parts, or subsystems, analyzed to identify significant operational issues or problems.

For example, what criteria should be used to select community health workers? What tasks should health workers perform? How frequently should they be resupplied? Sometimes several components can be grouped for analysis; for example, selection and acceptance. Sometimes--as is often the case with supply--several different analyses may be required in one component.

Researchers need to collect and analyze data to describe the operational problems accurately. Since data collection can be costly and time consuming, analysts should examine existing data first and then draw up a list of the remaining data that need to be collected. Many researchers collect data for problem analysis and solution development at the same time. The data may come from a variety of sources, including PHC records, statistical reports on household expenditures, observations of health-seeking behavior, surveys of service utilization, and case studies of other CHW programs.

Example: The task force gathers descriptive information on PHC programs and examines a sample of records from the various operating schemes. It also interviews supervisors, community health workers, and village leaders about the difficulties and accomplishments of each program. Using this information, the task force develops an overall description, complete with diagrams, of the PHC system (see figure 3-3). The diagram that concerns the CHW component is shown in figure 3-4. The general problem is seen as how to restructure the PHC system so as to increase the utilization and the impact of CHW services.

In the process of developing its description of the system problem, the task force became aware of four components of the CHW program that were mentioned most frequently as presenting difficulties: the criteria and processes of CHW selection, the length and type of site used for training, the process of CHW supervision, and the provision of logistical support in the face of limited resources.

Step 3. Set Priorities and Select the Problems for Study

Sometimes a number of problems will emerge from the analysis. Obviously, they cannot all be studied at once; priorities need to be set. The analyst can do this in a number of ways. One is to identify those problems that are expected have the greatest effect and study them first. Another is to identify the logical sequence of decisions. For example, decisionmakers must first determine which services the community health workers should provide before deciding how they should be trained.

Example: Further consultation with informed officials indicates that among the four operational problems, two are of low priority. The selection problem appears to be less critical than first thought, and although the logistical system is important, the country's current economic difficulties make it unlikely that any changes could be implemented in the near future. There is general concern with the patchy supervisory practices, and it is unclear which of several training schemes, varying in length from 3 to 9 weeks, is most

Figure 3-3.--Description of a Primary Health Care System

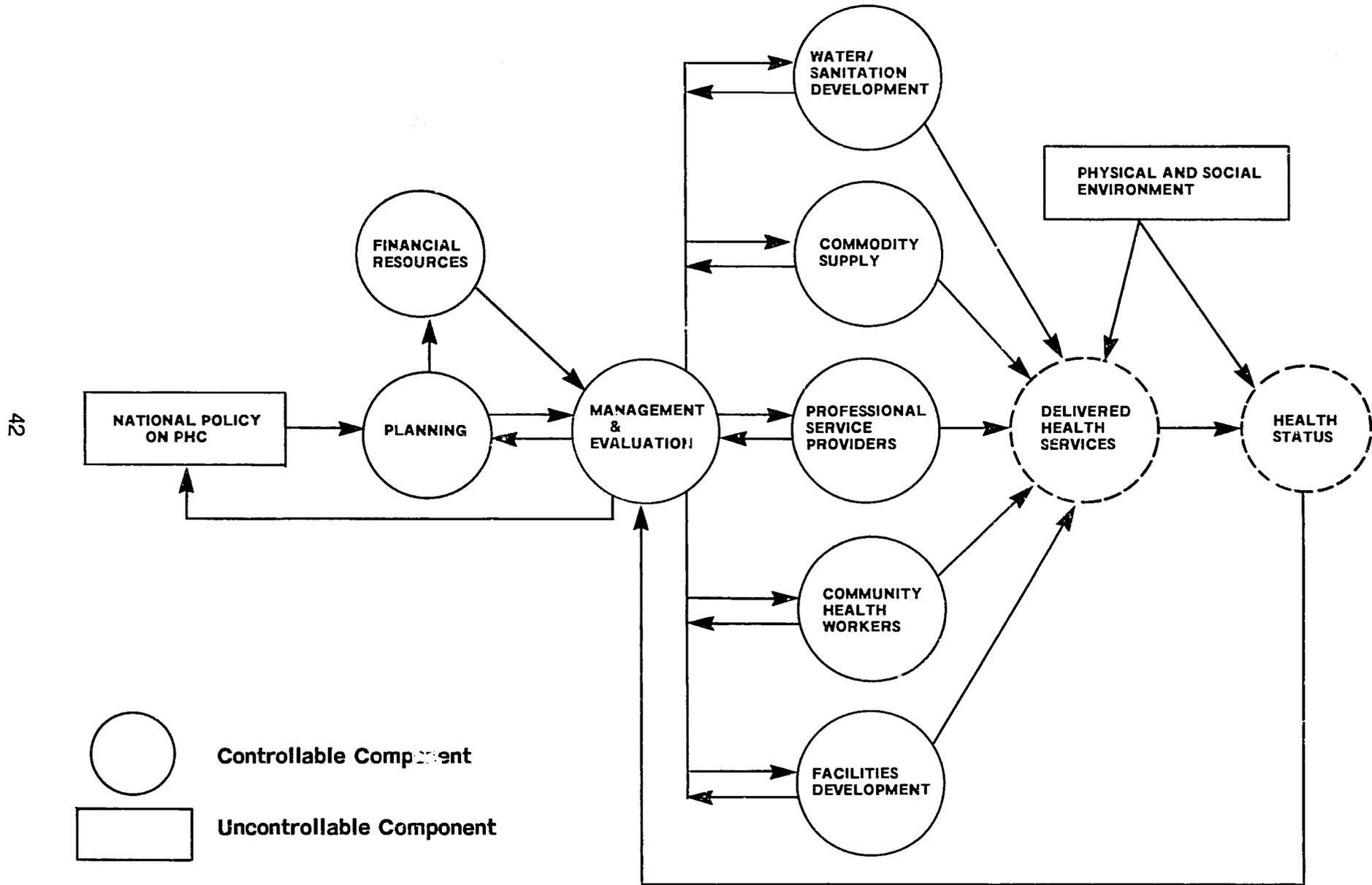
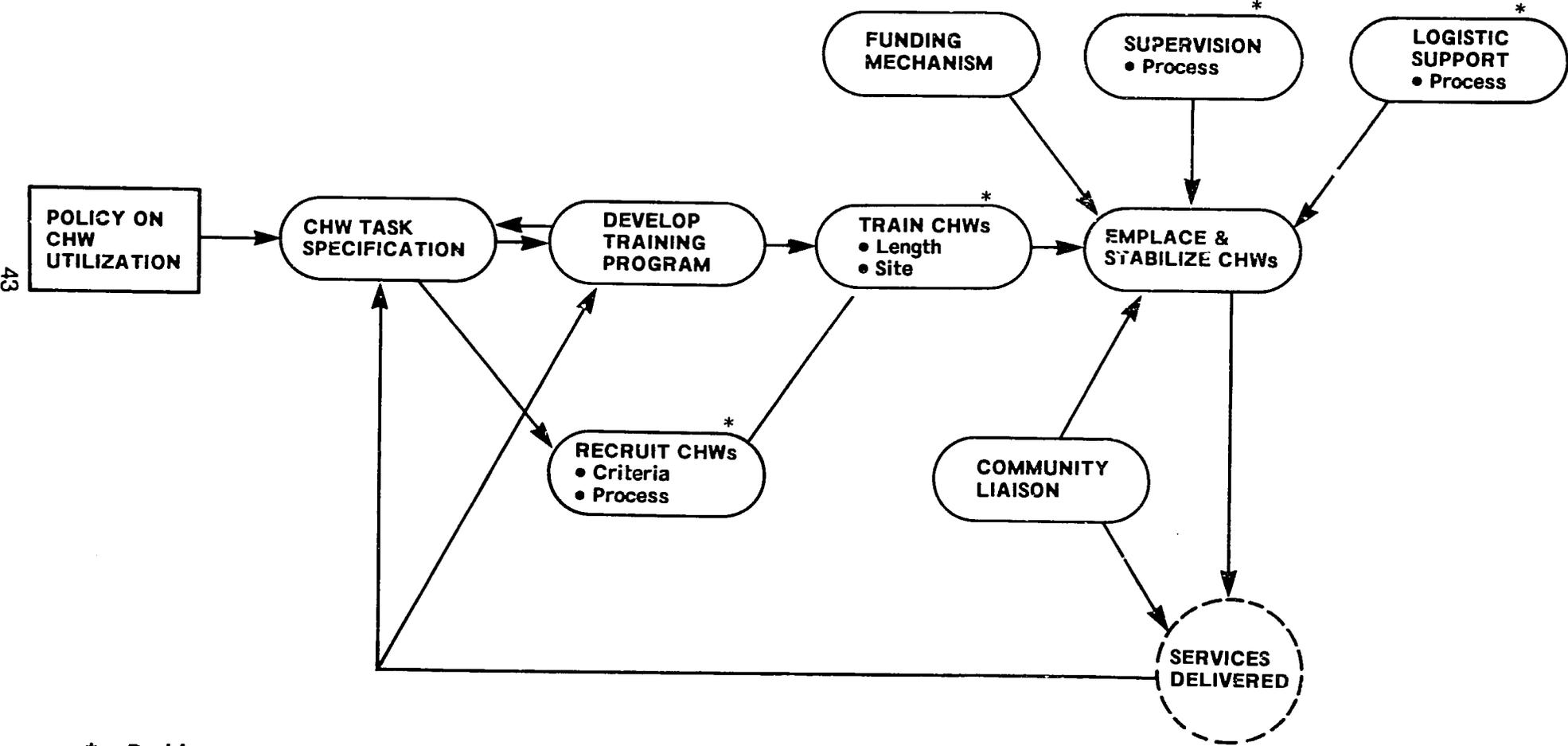


Figure 3-4.--Community Health Worker Subsystem



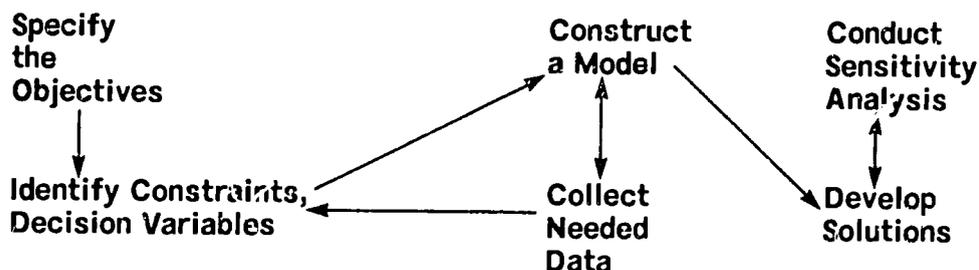
* = Problem areas

effective. Thus, the task force selects training and supervision as priority operational problems. Because it realizes the type and intensity of supervision affects the training required, it decides to analyze the supervisory system first.

PHASE II: SOLUTION DEVELOPMENT

The steps in developing a solution for each operational problem are illustrated in figure 3-5 and described below.

Figure 3-5.--Steps in Solution Development



Step 1. Specify the Objective for the Solution to Each Problem

To begin the solution process, the analyst must specify the characteristics of the desired solution in terms as quantitative as is feasible. If the operational problem is one of training, the objective might be stated as: to define a strategy for training auxiliaries to perform (tasks) by (date) in (region). If the operational problem has been defined as one of acceptance and utilization of CHW services, the objective might be: to have an average of (percent) of the families using CHW services after (months) from the start of the program in the villages of (region). Objectives in operations research are usually of two types: 1) Those that retain things of value (input minimization, e.g., minimize cost); and 2) those that obtain things of value (output maximization, e.g., maximize coverage). One cannot attempt to achieve both objectives at the same time (i.e., one cannot concurrently achieve highest output and lowest input).

For example, one might set as the objective for the solution to a malaria problem: select the best mix of malaria control activities that will maximize the reduction in the prevalence of malaria in children under 10 years of age. In operations research terminology, such a statement of the characteristics of the solution is called the objective of the solution.

Example: For the operational problem of supervision, the task force works out the following objective: to identify one or more schemes of supervision (problem) that will ensure the specified quality of CHW performance of eight specific tasks, as measured by the utilization of services and adoption by villagers of recommended health practices (objective). The eight tasks are: oral rehydration therapy, malaria prophylaxis, malaria treatment, DPT and polio immunization, pneumonia treatment, latrine construction, latrine maintenance, and nutrition monitoring.

Step 2. Identify the Uncontrollable Factors (Constraints and Facilitating Factors) and Controllable (Decision) Variables of Each Problem

The performance of a program can be represented by a simple equation:

$$P = f(C, U)$$

which means that performance (P) is a function (f) of a set of controllable (C) variables and uncontrollable (U) variables. Such an equation is sometimes called the objective function. Often, the objective for the solution is to maximize the (P) of this objective function.

The controllable variables are also called decision variables. The decision variables are those that are under the control of the decisionmakers and for which they must set a "best" value. For example, a decisionmaker may have to decide on the fee to set for CHW services, the frequency of supervision of health workers, and the best persons to train the health workers. All of the decision variables for which values have to be set must be identified.

One important type of uncontrollable variable is the constraint, the "givens" that analysts must take into account when developing a solution. For example, government regulations may forbid the sale of certain drugs by community health workers. Constraints limit the range of choice and, for that reason, should be identified.

Uncontrollable factors that are positive are called facilitating factors; they favor certain choices. For example, if most community members are willing to pay community health workers for their services, this is a facilitating factor. Constraints and facilitating factors have values, or magnitudes, and analysts must also determine these. For example, how much are community members willing to pay community health workers for PHC services?

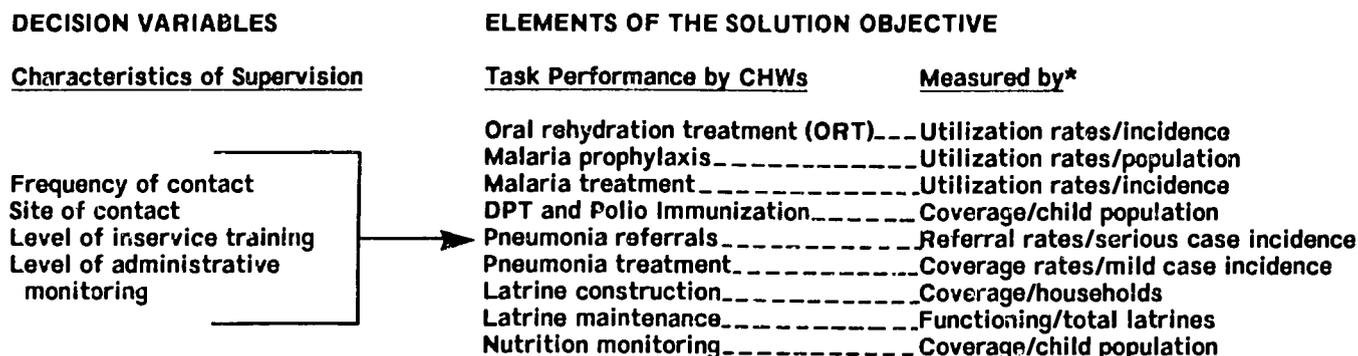
A simple illustration of how these variables are related to one another follows. In supervising community health workers, a constraint may be that funds are limited to a certain amount for supervisors' travel. One objective may be to maximize the number of community health workers visited during each trip. One of the decision variables would be the duration of each trip. The value of that decision variable would be the number of days each trip would last. An optimal solution, therefore, would be to find the value that best meets the objective, given the constraints; that is, the duration of each trip (in days) that maximizes the number of community health workers visited, given the limited funds available for supervisory travel.

Example: The task force identifies the following factors as being beyond the control of the program managers: the salary grade for supervisors that has been set by the National Personnel Board, the amount of funds available for supervision, the number of community health workers assigned to each supervisor, the educational level of supervisors, the disinclination of urban health workers to serve in rural areas, and the amount and type of health professional staff available to back up the supervisors.

The task force then identifies those issues that are subject to the control of the program managers. The principal decision variables are listed in the left-hand column of figure 3-6, which also shows the CHW tasks to be performed and the indicators of CHW performance that are to be used to measure performance.

Figure 3-6.--Decision Variables and Elements of the Solution Objective

(Problem: CHW Supervision)



***For a comprehensive list of effectiveness measures for primary health care services, see "Appendix B: Calculating Effectiveness" in Jack Reynolds and K. Celeste Caspari, Operations Research Methods: Cost-Effectiveness Analysis, PRICOR, 1984.**

Step 3. Select and Construct an Appropriate Model for Solving Each Problem

Operations research uses a wide range of data analysis procedures to arrive at solutions to problems, but its distinctive feature is the development of solutions through the use of models. Models are representations of reality expressed in symbols that may be graphic (maps, diagrams, flowcharts) or mathematical (a cost-effectiveness equation, a supply-demand equation, a linear program).

In operations research, the analyst selects or develops a model that fits the problem being studied and then uses it to find the best, or optimal, solution to the problem. The model allows the analyst to enter different values for the controllable variables, so as to find the best solution given the constraints. For example, an analyst might use a supply-demand curve to identify the fee for CHW services that would result in the highest utilization possible yet produce enough revenue to cover the cost of the services.

This process of modeling is far more rapid than conducting field experiments, and far less expensive as well. These are its principal advantages; but there are limitations, too. Models only approximate reality, and thus program planners must construct them carefully, because inappropriate or unrealistic models will necessarily produce unrealistic results. Complex mathematical models usually require specialists and computers. However, a number of simple techniques are useful. Using maps (themselves models of geographic realities) together with "rules of thumb" to determine the geographic area that each CHW supervisor should cover is a modeling approach. A time chart used to schedule CHW tasks is a model. Simple equations to compute the quantity of drugs to supply to each health worker is also a form of modeling. These and other relevant models, including flowcharts, decision trees, and matrices, are described in the PRICOR monograph, Operations Research Methods: A General Approach in Primary Health Care.

Example: The task force decides that two modeling techniques are appropriate for solving the supervision problem. The first will generate alternative "supervision packages" made up of different combinations of the principal decision variables (frequency of contact, site, amount of in-service training, amount of administrative monitoring). The second will estimate the relative cost-effectiveness of each package.

To generate the packages the task force will have to rely on expert opinion. First, the task force will use a technique known as oval diagramming to show how the decision variables relate to one another (see figure 3-7).

An oval diagram is a graphic way to show the relationships among variables. The arrows show the direction of a cause-effect relationship, and the pluses and minuses show whether the effect is positive or negative. For example, budget limitations (a constraint) limit the number of supervisory contacts, but supervisory contacts make in-service training possible. Question marks are used when it is unknown whether an effect is positive or negative.

Then they will obtain the viewpoints of knowledgeable individuals, including district administrators, supervisors, community health workers, and others to verify these relationships, to establish weights that indicate the relative importance of each variable, and finally, to identify feasible values for each decision variable. For example, feasible values for the frequency of supervisory contacts might be monthly, bimonthly, or quarterly, but not weekly (could not afford it) or semi-annually (too long between visits). The task force will develop a matrix that displays the weights and feasible values for each decision variable (see figure 3-8). It will then convene a representative group of experts to develop several supervision packages from this matrix, using a consensus-building approach known as the Nominal Group Technique. The group will estimate the expected effectiveness of each package to meet the solution objective. The task force will then compute the costs of each package and assess the relative cost-effectiveness.

Step 4. Collect Required Data

Each model has certain data requirements. If some of the needed data are not in hand, they would have to be collected. As in phase I, data could come from a variety of sources, depending on the needs.

Example: In addition to collecting opinion data for the oval diagramming work, the task force collects baseline data on the several supervisory schemes and on CHW performance from direct observations, service records, and a sample of village households. The economist collects cost data for the costeffectiveness analysis.

Step 5. Use the Model to Develop the Optimal Solution(s) for Each Problem

Once the required data have been collected on the decision variables, constraints and facilitating factors, the analysts can use their model(s) to develop and evaluate several possible solutions. By using different (but always realistic) values, the analysts can assess the likely effect of each solution on the objective. The solution that best meets the objective, given the constraints, is the "optimal" solution.

Example: Applying the collected information, the task force prepares the oval diagrams and matrices, and convenes an expert group which, using the Nominal Group Technique, develops several supervision packages for each geographic area and estimates the expected effectiveness of each (see figure 3-9).

**Figure 3-7.--Partial Example of an Oval Diagram
Used in a Supervision Problem**

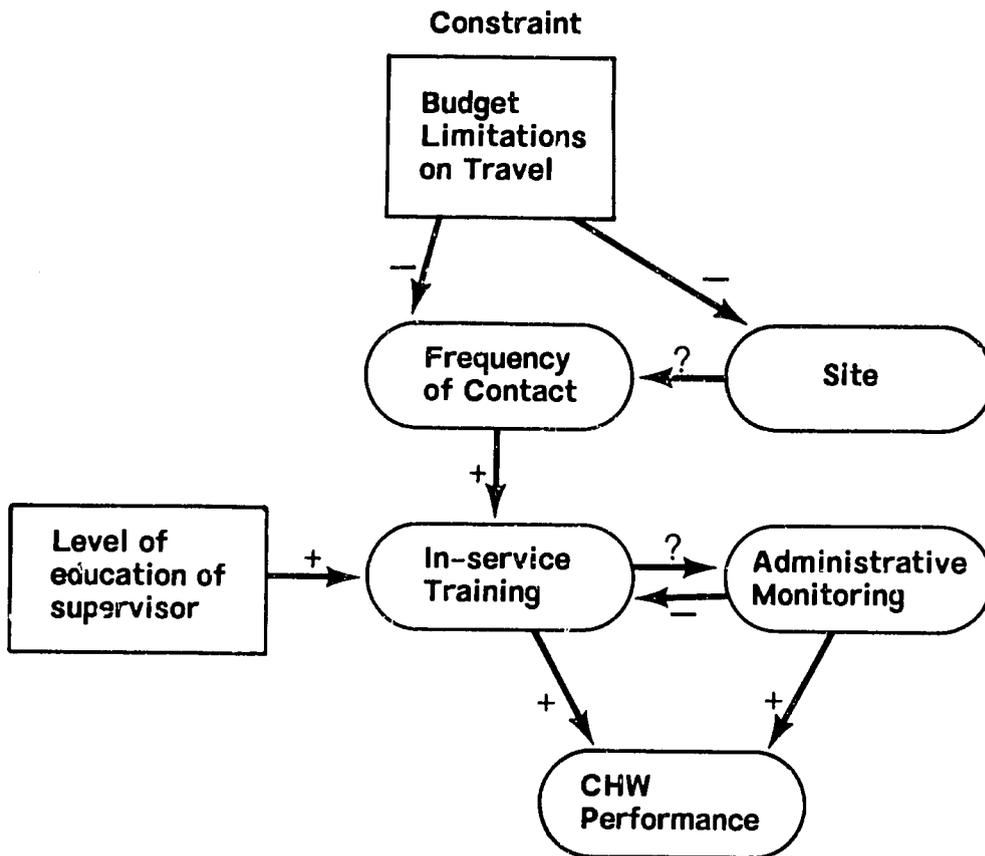


Figure 3-8.--Sample Matrix for Displaying Weights and Feasible Values for Decision Variables

<u>Decision Variables</u>	<u>Weight</u>	<u>Values</u>
Frequency of contact	10	Weekly , biweekly, monthly, bimonthly, quarterly, semi-annually
Site	4	Community, district, regional, national
In-service training	8	100% 80% 60% 50% 40% 20% 0%
Administrative monitoring	3	0% 20% 40% 50% 60% 80% 100%

Figure 3-9.--Sample Supervision Packages Resulting from Nominal Group Technique

- Package A:** Monthly supervisory contacts, onsite, emphasizing administrative monitoring with semi-annual in-service training offsite for all the CHWs in the area. Estimated effectiveness = .80.
- Package B:** Bimonthly supervisory sessions with all the CHWs in the area, emphasizing in-service training and some administrative monitoring. Estimated effectiveness = .75.
- Package C:** Quarterly in-service training offsite for all CHWs in the area, and onsite visits for administrative monitoring on an as-needed basis. Estimated effectiveness = .65.

Figure 3-10.--Example of a Cost-Effectiveness Model for Assessing Supervision Packages

SOUTHERN AREA

	Estimated Costs	Estimated Effectiveness	Estimated Cost-Effectiveness
Package A	\$ 10,500	.80	\$ 13,125/1
Package B	9,600	.75	12,800/1
Package C	8,400	.65	12,923/1

The economist computes the cost of each package for each geographic area. The task force, together with selected experts, then analyzes the estimated costs and effectiveness of each package.

Figure 3-10 shows that package A is the most expensive and the most effective for the southern area, but has the highest cost per unit of effectiveness of the three alternatives. Package B appears to be the most cost-effective of the three, but the differences between A, B, and C are so slight that other criteria must also be taken into account in making a selection.

The task force convenes the nominal group to process this information and select the best supervision package for each area. They discuss each package, then individual group members rate each on a scale of 1-10. They tabulate the scores for each package and present the results to the group. They repeat this process two or three times, until they reach a consensus and select the package for a particular area. The task force and experts repeat this process for each geographic area. Package A is selected for the central and northern areas, package B for the southern, and package C for the eastern area.

Step 6. Conduct Sensitivity Analysis of Each Solution

The solutions that emerge from the procedures described above should be subject to "reality" testing to ensure that they are reasonable, politically and culturally acceptable, and compatible with solutions developed for other operational problems (e.g., remuneration of community health workers). Sensitivity analysis allows the analyst to see how the results might change if the objectives, decision variables, or constraints were changed, for example, by 5 or 10 percent. (Note that this is a "paper" exercise, not an actual field test of the solution. After indicated adjustments, the researchers are ready to recommend the "best" solution to the decisionmakers.)

Example: The research team checks the tentative results with the National Social Planning Council, which believes that all of the supervision schemes would be acceptable. The economist recomputes the costs using higher estimates for inflation and transportation costs. It is clear that each scheme will work as long as inflation does not exceed 50 percent in the next year.

This sensitivity analysis, however, leads to two unexpected results. First, analysts find that if the budget could be increased by 6 percent, the outcomes are likely to improve by 20-25 percent. Second, the more detailed analysis of the three schemes leads them to a new alternative that combines different features of the three. They decide to recommend that the decisionmakers consider this revised scheme at two different funding levels, to be implemented in all areas of the country.

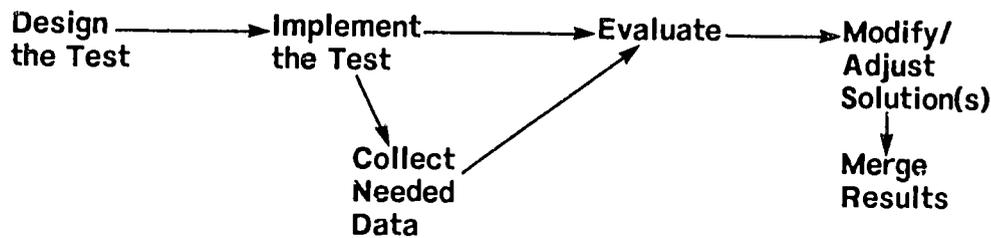
PHASE III: SOLUTION TESTING AND EVALUATION

The steps in this phase are illustrated in figure 3-11 and described below.

Step 1. Design the Test of the Solution(s)

Once the decisionmakers select the solutions they prefer, an actual test or trial may be required to validate the solution(s). The test may be of one or several possible solutions, and it may be designed in several ways: as an evaluation study with controls, as a pilot or demonstration project to test feasibility, or as a modification in program operations to be evaluated and adjusted over time.

Figure 3-11.--Steps in Solution Testing and Evaluation



For example, a field test may involve the comparison of two different schemes to train community health workers, based on measuring their posttraining performance on the job. Or just one training scheme, judged to be the best, may be implemented, evaluated, and--as difficulties are experienced--adjusted. Whatever the form of the field test, however, it has to be designed carefully to ensure that the findings will be accurate and that the results will be generally applicable to other settings in the country or region.

Example: The decisionmakers accept the task force's recommendation on the structure of the supervisory schemes, but are unwilling to increase the budget without more evidence. They decide, therefore, to conduct a field test that will both demonstrate the feasibility of the strategy and determine the effects of different funding levels.

The test is designed as a quasi-experimental study in which two groups of districts will implement the revised supervisory strategy, but at two different funding levels. The group with the higher funding level will have fewer community health workers per supervisor and supervision will be more intensive. The districts are carefully selected to ensure the comparability of the communities, and they are selected in different regions of the country to help ensure that the scheme is workable on a nationwide basis.

Step 2. Conduct the Test and Collect Needed Data

The tests are then implemented according to the evaluation protocol. Data on actual performance, including CHW performance, services utilized, population covered, costs, and other key indicators are collected to evaluate the solutions.

Example: The field test, as designed, is carried out in eight districts, two in each of the four regions. Approximately 2 months are required to conduct in-service training of supervisors, to adjust supervisory assignments, and to establish data collection procedures. Once the test is implemented, a task force member oversees the test in each district for the first 2 weeks, and then at intervals thereafter, to ensure that the test's conditions are met. Reports on cost and performance are received and reviewed monthly by the task force. After 5 months of trial, the task force is prepared to present final recommendations to the decisionmakers.

Step 3. Evaluate and Modify/Adjust the Solution(s)

On the basis of the findings from the test, the theoretical solutions are modified or adjusted. If the modifications are significant, further testing is required. Conclusions and recommendations are reported to the decisionmakers.

Example: In the course of the test, the task force has discovered the need for minor modifications in procedures. It introduced these changes in all the test districts at the end of the second month. By the end of the third month, it is able to report that the selected supervisory scheme is feasible and more effective than any of the earlier arrangements.

The findings on the two funding levels are somewhat equivocal, however, because more intensive supervision makes little difference when the community health workers are well trained to begin with. From a cost standpoint, it is less expensive to pay for more supervision and economize on training, but greater dependability and effectiveness result when community health workers are better trained. The task force decides to recommend the lower funding level for supervision, even though greater expenditures for training are a consequence. The decisionmakers accept this recommendation.

Step 4. Merge the Resulting Information

Sometimes several changes in the system are made at the same time. If this happens, the researcher must "put the system back together" to assess the effect of changes made in one part of the system on the rest of the system. For example, would a change in training require a change in the supervision scheme? The analyst must merge the various changes to ensure that the system as a whole will continue to function productively.

Example: Because the task force first analyzed and found solutions to the supervision problem, it can now identify some "givens" for the other problem components of the CHW system: selection, training, and logistics. From the data researchers have gathered, they have learned about the level of self-reliance required of community health workers, which has implications for CHW selection criteria, the extent of training required, the characteristics of the CHW-supervisor relationship, recordkeeping by community health workers, and the feasibility of supervisors being involved in logistical support activities. The task force can now proceed on those planned studies.

A FINAL NOTE

Certain problems do not lend themselves to following the above steps in exactly the order described. For example, analysts may need to collect data before selecting an analytical model. The steps and methods may overlap, or a number of steps might be repeated. Analysts may also research a number of operational problems simultaneously. Thus, these steps should be seen as a general guide to the process of operations research and should be employed with flexibility.

APPENDIX

**SUMMARIES OF PRICOR-SUPPORTED STUDIES OF COMMUNITY HEALTH
WORKERS IN PRIMARY HEALTH CARE**

APPENDIX: SUMMARIES OF PRICOR-SUPPORTED STUDIES OF COMMUNITY HEALTH WORKERS IN PRIMARY HEALTH CARE

This appendix summarizes a number of studies that PRICOR has funded and illustrates several ways that operations research can be used to study problems related to the use of community health workers in primary health care.

TANZANIA: Role of Supervision on Village Health Workers' Performance

The Government of Tanzania has developed a program to introduce village health workers (VHWs) into selected rural areas where primary health care has been lacking. Village health workers have been assigned in 55 districts, but a number of operational problems have occurred. There have been deficiencies in financial resources; qualified health personnel; health facilities, equipment, and supplies; transportation; communication; and especially, supervision of personnel. The purpose of this study is "to identify one or more 'optimal' supervisory schemes." Three principal issues to be addressed are:

1. The relationships between supervisory mechanisms and VHW performance and service outcomes;
2. Cost-effectiveness of supervisory schemes in relation to VHW output; and
3. Effectiveness and cost-effectiveness of dividing supervisory functions between community members and health professionals.

There are two phases in the project. In the first phase, a prescriptive study will be conducted to specify the "best" supervisory scheme(s). Three kinds of data will be needed to do this: 1) a description of the supervisory system; 2) VHW performance; and 3) primary health care service outcomes. Data will be collected to describe the current and desired system, VHW performance, and service outcomes. Then, a linear goal programming model will be formulated to identify the optimal supervisory scheme for meeting specified performance levels and service outcomes.

The most promising schemes will be field tested in phase II to assess their actual impact on VHW performance and PHC service outcome. Additional data will be collected to assess the relative cost-effectiveness of the various supervisory schemes. This project will be carried out over a 20-month period by staff of the University of Dar es Salaam, with technical assistance from two U.S. consultants. For more information about the project, contact Dr. Fariji Mtango, Department of Epidemiology and Biostatistics, Muhimbili Medical Center, University of Dar es Salaam, Dar es Salaam, Tanzania.

ECUADOR: Rural Primary Health Care Delivery Utilizing Health Promoters

This is a 24-month study of the primary health care "promotor system" currently operating in Ecuador. The promotor (community health worker) is the essential, strategic element in Ecuador's program to extend primary health care coverage to its rural population. Although 300 of these promoters have been trained and returned to their communities, coverage has not been increased significantly.

The purpose of this study is to analyze the existing promotor system and devise improved ways to train, supervise, and support health promoters. The study was requested by the USAID Mission in Ecuador in response to a need expressed by the Ministry of Public

Health for assistance in studying ways to improve the current system. USAID and the Ministry of Health selected the Fundacion Eugenio Espejo to conduct the study on their behalf.

There are two phases to the research. Phase I is a systematic analysis of the current promotor system to both describe the actual system (as opposed to the one planned on paper) and identify operational problems within that system. Since little is known about actual operations, data will be collected from several sources, including interviews, observations, and surveys to fill in these gaps.

A preliminary systems analysis suggested to the research team that three problems are the most significant: training, provision of materials, and supervision. This was confirmed by an informal survey of promotores and MOH officials.

In phase II, these three problems (training, supervision, and logistics) will be examined in detail to identify possible solutions, and appropriate operations research models will be employed to develop and assess the solutions. Once all of the solutions have been developed, they will be field tested through a quasi-experimental design.

For more information, contact Dr. Ramiro Echeverria, Fundacion Eugenio Espejo, Avenida Atahualpa 333 y Ulloa, Quito, Ecuador.

HAITI: Role of Traditional Birth Attendants (TBAs) in Maternal Health

This study will seek to develop and test alternative ways to train and utilize traditional birth attendants so as to reduce the high rate of maternal morbidity and mortality in the Cite Simone area of Port-au-Prince, one of the city's poorest neighborhoods. During the preliminary analysis, two components were identified that seemed particularly in need of study: training and referral policies.

During the first phase, the research team will conduct a systematic analysis of the TBA subsystem and develop alternative models. The principal steps planned are: 1) identify the priority tasks or interventions that traditional birth attendants should perform that will be directly related to the principal causes of maternal and perinatal mortality and morbidity; 2) select the tasks and skills that will be emphasized in the shorter alternative training program; 3) consider and select alternative training approaches (e.g., competency-based, simulation, etc.) that would be expected to result in optimal TBA performance; 4) review and, if appropriate, revise referral policies for traditional birth attendants; 5) identify and estimate the cost of various TBA system components and establish the cost accounting procedures to be used in tracking costs in phase II; and 6) where possible, estimate the cost-effectiveness of various alternative program models.

Phase II involves a 15-month field test of the alternative models, including a followup survey of pregnant women to assess the effectiveness of each approach. The study will be carried out over a 21-month period by investigators on the staff of a nonprofit organization providing health services to the area.

For more information, contact Dr. Carlo Boulos, Complexe Medico Sociale de la Cite Simone, P.O. Box 1666, Port-au-Prince, Haiti.

BRAZIL: Mobilization of Traditional Healers for Primary Health Care Delivery

In their research proposal, the investigators stated that "the mobilization of traditional healers and their existing systems of medicine for the delivery of oral rehydration therapy holds the key, we believe, to actually reaching poor rural families and extending primary health care to the grassroots level. Hence, the operational objectives of this project are to: 1) determine how best to mobilize and integrate traditional healers into the official health system to clinically manage diarrheal illnesses and to deliver oral rehydration therapy; and 2) identify the optimal health delivery structure that integrates popular and professional spheres of care for the ready distribution of oral rehydration therapy." The investigators proposed a methodology that combines the general approach to operations research with a number of classical anthropological and sociological techniques.

Phase I will be a systematic analysis of the operational problem, involving a comprehensive description of the existing health delivery system, particularly as it relates to child health, and a baseline survey of poor households to assess their familiarity with and utilization of oral rehydration therapy.

The second phase of research will involve developing a wide range of alternative solutions to the problem, beginning with a "brainstorming" session to identify and to develop a wide range of plausible strategies and a systematic analysis of the strengths and weaknesses of each approach. Pilot, or demonstration, projects will be set up according to a field test protocol in two comparable communities to field test the "best solutions."

The project is scheduled for 24 months and will be carried out in Fortaleza, Brazil. For further information, contact Dr. Marilyn Nations, Box 485, Division of Geographic Medicine, School of Medicine, University of Virginia, Charlottesville, VA 22908, or Dra. Maria Auxiliadora de Souza, Maternidade Escola Assis Chateaubriand, Federal University of Ceara, Fortaleza, Brazil.

MEXICO: Productive Capacity of the Community Health Auxiliary in the Health Microregions of the State of Mexico

The Coordinated Public Health Services of the State of Mexico (CPHS) is responsible for the health care of the majority of the state's population who are not covered by social security institutions. In recent years, CPHS has placed increased emphasis on primary health care as the main strategy for addressing community health problems. In 1978, CPHS began to recruit and train community health auxiliaries (CHAs) to carry out basic preventive and curative PHC activities. Each of the 1,793 community health auxiliaries is responsible for 3,000 population in a microregion.

The operational problem is that the services provided by the health workers are not always congruent with the services desired and needed by the communities. The objective of this study is to increase the effectiveness of health workers by: 1) analyzing current practices to determine the degree of congruence between what health workers do and what they should be doing; and 2) developing a planning and priority-setting tool that health workers can use to increase the degree of congruence.

Problem analysis will be based on data from a survey and observation of health worker practices, interviews with chiefs of microregions, analysis of 1983 household survey data, and community meetings in selected microregions to identify local needs and

service demands. A modification of the Werner-Bower* model for setting service priorities will be used in the study communities to help select service packages to be provided by the health workers. A planning model will then be developed to enable the health workers to plan and schedule their services. Finally, CHA training and support needs will be identified.

A quasi-experimental test of the models will be carried out over a 6-month period in prototypical microregions and control communities. The study will be conducted by CPHS over an 18-month period with technical assistance from Mexican and U.S. consultants.

For more information, contact Dra. Ana Ramos, Servicios Coordinados de Salud Publica del Estado de Mexico, Avenida Independencia 1009, Toluca, 50000 Mexico.

NIGERIA: Increasing the Productivity of Community Health Workers Through Supervision in Ife, Ijesha Areas

Childhood malnutrition and infectious diseases are the two major health problems contributing to high infant mortality and morbidity in the rural area of Ife/Ijesha in Oyo State. One of the critical factors contributing to this continued problem is low coverage of the population with PHC services, despite the fact that several community health workers have been trained and deployed in these areas. There is evidence that CHW productivity is low because of poor supervision. Thus, the thrust of this research is to systematically analyze the reasons for poor supervision and to develop a practical solution that will be economically and culturally acceptable to health decisionmakers, supervisors, the communities, and the community health workers.

The researchers will develop a mathematical model of supervision to identify those variables highly correlated with effective supervision and then develop one or more supervision models for testing. Data required to develop this model will come from Federal and State Ministry of Health reports and interviews with community health workers, supervisors, and selected community households. A matrix will be developed to analyze the relative costs, acceptability, and coverage that would result from alternative supervisory approaches. Selection of a final solution will be done by a small group consisting of representatives from all groups involved in the study. The selected solution(s) will then be field tested for a 6-month period using a quasi-experimental, control group design.

The study will be conducted by the University of Ife in collaboration with personnel from the Federal and State Ministry of Health. For more information, contact Dr. E.O. Ojofeimi, Department of Community Health and Nutrition, Faculty of Health Sciences, University of Ife, Ile-Ife, Nigeria.

SWAZILAND: Development of Appropriate Methods for Sustaining Community Health Workers

Rural health motivators are a key element in bringing primary health care to rural people in Swaziland. Recently, they have not received their monthly government stipend, and this has led to significant attrition. The operational objective of this study is to identify the most appropriate ways of sustaining the rural health motivators that will be dependable and based on community participation in their selection, supervision, and compensation.

*See David Werner and Bill Bower, Helping Health Workers Learn, Palo Alto, Calif.: Hesperian Foundation, 1982.

The first phase of this 22-month study is an analysis of the problem. The researchers will use several operations research techniques, including a system definition matrix to describe the current system and identify information gaps for which data will need to be collected. The components of the system will be described in an oval diagram, which will be used to show the relationships of the rural health motivators to the community and health care system.

The second phase of the study will be the identification of alternative solutions to the problem. An interaction matrix will be developed for each potential solution. These matrices will help the research team show the relationship between the components of each proposed solution and the objectives sought. The most feasible solutions will then be presented to the communities for their review.

The most appropriate solutions will be selected on the basis of consensus among community members, chiefs, and health professionals. The selected solutions will then be field-tested for a 9-month period and modified, if need be, based on field evaluation.

For more information, contact Ms. Catherine Connolly at the Social Science Research Unit, University of Swaziland, Kwaluseni, or Mrs. Bertha Dlamini, Swaziland Institute of Health Sciences, Ministry of Health, Swaziland.

LIBERIA: Testing the Effectiveness of Adolescent Schoolchildren As Health Promoters in Rural Liberia

This is a 2-year study to identify the best way(s) to use adolescents as promoters of primary health care. Among the issues to be explored are: 1) the most appropriate PHC tasks for adolescents to carry out; 2) how best to train adolescents in such tasks; 3) how best to supervise them; and 4) who should be selected as trainers and supervisors of adolescents.

The study will be carried out in three phases: 1) identification of essential components and problems of a program to use adolescents to aid village health workers in PHC work; 2) identification of optimal solutions to issues and problems; and 3) field testing of the proposed solutions in rural Liberia through a quasi-experimental design with before and after measures of health behavior among control and treatment groups.

More information on this project can be obtained from Ms. Janet Moore, Cuttington University College, Box 277, Suacoco, Bong County, Liberia, or Dr. Paul Wall, Division of Behavioral Science Research, Carver Research Foundation, Tuskegee Institute, Alabama 36088.

NIGERIA: Community Participation in Stabilization of Village Health Workers

In rural areas of southern Gongola State, 22 village health workers were trained in 1979 to work in village health programs. After 2 years, all but 7 had stopped working. The objective of this study is to examine the current VHW system in an attempt to identify causes of attrition and possible solutions.

The study will be conducted by staff of the Christian Reformed Church of Nigeria (CRCN). Interviews will be conducted among village health committees, village women, and village health workers. Case studies will be undertaken on other church primary health care programs in Nigeria and in Chad. A 1-year field test of possible solutions will be carried out and followup evaluations conducted to assess the effectiveness of the approach.

Contact Dr. Herman Gray or Mr. James Ciroma at CRCN, P.O. Box 30, Central Rural Health Program in Wukari, Gongola State, Nigeria, for more information.

PHILIPPINES: Role of the Barangay Health Worker in the Provision of Nutrition Services Within the Primary Health Care System

Malnutrition is still a persistent problem in the Philippines--four out of five Filipino children continue to be under or malnourished. The new primary health care program of the Ministry of Health includes nutrition services as an integral component; however, the role of the barangay (village) health worker in the delivery of nutrition services has not been clearly defined. This research project will attempt to define that role through:

1. Assessment of the nature and content of the current activities of the health workers, focusing on their training in nutrition services;
2. Determination of the extent to which nutrition training and services meet community needs;
3. Modification and revision of the current nutrition program to better meet needs;
4. Testing of revised nutrition strategies that incorporate both preventive and rehabilitative aspects; and
5. Evaluation of the outcome of the revised strategies on utilization of nutrition services.

The research will be carried out over a 2-year period by the University of the Philippines in collaboration with the National Nutrition Services of the Ministry of Health. For more information, contact Dr. Carmencita Salvosa-Loyola, Department of Nutrition, Institute of Public Health, University of the Philippines, P.O. Box EA460, Manila, Philippines.

PHILIPPINES: Alternative Training Strategies for Barangay Health Workers in Primary Health Care

Training of barangay health workers is considered a vital component of the PHC system. This project will study the current health worker training program and develop solutions to anticipated problems in the design and delivery of training. The study consists of three phases.

Phase I will begin with an examination of ongoing training programs in four sites: Metro Manila and Central, Northern, and Southern Luzon. The research team will look at training program design, the trainers, trainees, and other relevant factors that facilitate or hinder barangay health worker learning and performance.

In phase II, alternative training strategies will be developed, using a number of training mixes, based on the results from the phase I analysis. Among the decision variables to be considered are training content, health worker selection criteria, and mode of training.

The developed training mixes will be field tested and their effects evaluated in phase III of the research. The entire project is scheduled to take 2 years and will be conducted by the University of the Philippines in collaboration with the Ministry of Health.

Contact Dr. Leticia S.M. Lantican or Professor Thelma F. Corcega at the College of Nursing, University of the Philippines, Padre Faura Street, Ermita, Manila, Philippines, for further information.

URUGUAY: Neighborhood Health Services and Community Participation

The purposes of this project are to identify and test alternative methods for selecting, training, motivating, and supervising health promoters. The study will begin with a survey of health and sanitary conditions in six marginal urban areas of Montevideo. This information will be used to identify priority activities for health promoters to undertake to stimulate community members to adopt better sanitary practices and utilize available health facilities. Community leaders will participate in the identification of these priorities, in the selection of promoters, and in the development of their training and supervision systems.

Next, promoters will be trained in four of the six communities. The impact of the promoters will be monitored and assessed at the end of the project by repeating the community survey.

The study will take place over a 17-month period and be conducted by staff from the Centro Latinoamericano de Economía Humana (CLAEH), with technical assistance from a U.S. consultant in operations research. Contact Dra. Obdulia Ebole at CLAEH, Cuareim 1220, Casilla de Correo 5021, Montevideo, Uruguay, for more information.

JAMAICA: Productivity of Primary Health Care Teams

As the Ministry of Health embarks upon a program of strengthening primary health care during a time of budgetary restraint, it has concern about the productivity of PHC workers and the relationship between the time they spend in certain activities and the coverage of the population with essential services. This study addresses the question: What are the most important productivity problems, and what would be the most effective solutions?

During phase I, the study team will conduct a systematic analysis of those factors affecting productivity and their interrelationships using both existing data and data generated from special surveys to be conducted. During phase II, a study group consisting of the principal investigator, systems analysts, Ministry of Health decisionmakers, and operating field professionals will consider and analyze solutions to these problems.

Solutions developed will be both parish and country specific. A final report will detail the operational problems identified and the advantages and disadvantages of possible alternative solutions.

The 17-month study is being conducted by the University of the West Indies, with assistance in systems analysis from Price-Waterhouse. For more information, contact Mrs. Patricia Desai, Department of Social Preventive Medicine, University of the West Indies, Kingston, Jamaica.

SUGGESTED READINGS

Many of the references used to prepare this paper are not readily available. The following is a brief list of relevant articles and books on community health workers that are generally available.

Community Health Workers

World Federation of Public Health Associations, Training Community Health Workers, American Public Health Association, Information for Action Issue Paper, Washington, DC, 1983.

David Werner and Bill Bower, Helping Health Workers Learn, Palo Alto, CA: Hesperian Foundation, 1982.

Lori Vanderschmidt, Thomas Frostman, John McCollum, and Ascher Segall, Developing Competent Health Workers: A Handbook For Designing Education and Training Programs, Center for Education Development in Health, Boston University, 67 Bay State Road, Boston, MA 02215, 1981.

Operations Research

Stewart Blumenfeld, Operations Research Methods: A General Approach in Primary Health Care, Methodology Paper No. 1, PRICOR, 5530 Wisconsin Ave., Chevy Chase, MD 20815, 1985.

Peter Delp, et al., Systems Tools for Project Planning, International Development Institute, Indiana University, Bloomington, IN, 1977.

F. Grundy, and William A. Reinke, Health Practice Research and Formalized Managerial Methods, Public Health Papers No. 51, Geneva: WHO 1973 (also available in French and Spanish).

GLOSSARY

This glossary was compiled to aid the reader in understanding the meaning given to certain terms used by PRICOR.

ALTERNATIVE: An opportunity for choice between two or more solutions, one of which--but not more than one--may be chosen.

COMMUNITY: A group of people having common organization or interest or living in the same place under the same laws.

COMMUNITY FINANCING OF PHC: The mobilization of resources by a community to support, in full or in part, basic preventive and curative health services for its members.

COMMUNITY HEALTH WORKER: A person indigenous to the community who provides basic preventive and curative health services to members of the community. Also called village health workers. These include promoters, community health auxiliaries, health agents, health guides, health visitors, among others.

COMMUNITY ORGANIZATION FOR PHC: The processes or structures for achieving community participation in primary health care.

COMMUNITY PARTICIPATION: The involvement of community members in the planning or implementation of community activities.

COMPONENT: A part of a system.

CONSTRAINT: A requirement or restriction on a system that reduces the freedom of decision.

CONTROLLABLE FACTORS: (See decision variables.)

COST-EFFECTIVENESS: A technique for comparing the costs and the effectiveness of alternative ways of achieving the same objective.

CRITERION: A characteristic, rule, or test by which an object or event is judged.

DECISION: The act or process of choosing among alternatives.

DECISION VARIABLE: A variable in a decision problem that can be controlled by the decisionmaker.

DEMAND: The type and quantity of service or commodity wanted or requested.

DEPENDENT VARIABLE: The variable being predicted or explained (the "effect" in a cause-effect relationship).

EFFECTIVENESS: The degree to which program or system objectives are achieved. Usually, outcomes are compared to some standard, such as the objectives that were set originally. For example, the program reached 90 percent of its target.

EFFECTS: The changes in knowledge, attitudes, and behavior (practices) among individuals, families, or communities as a result of a program, project, or activity.

EFFICIENCY: The achievement of objectives without wasting resources; the relationship of output to input. For example, in two programs that use the same amount of resources, program A, which screens 10 mothers/day, is more efficient than program B, which screens 5 mothers/day.

EVALUATION: A judgment of worth. In practice, a process for making judgments about selected objects, processes, or programs by comparing them to specific value standards (e.g., objectives) for the purpose of deciding among alternatives.

FACILITATING FACTOR: An uncontrollable factor that favors certain choices (e.g., people's willingness to pay for primary health care).

GOAL: A desired impact. In primary health care, a state of health that is desired or expected to be achieved through an activity, project, or program; for example, to reduce infant mortality.

IMPACT: A change in the status (e.g., health, standard of living) of individuals, families, or communities as a result of a program, project, or activity. For example, a reduction in infant mortality by 15 percent.

INDEPENDENT VARIABLE: A variable that is used for predicting or explaining other (dependent) variables (the "cause" in a cause-effect relationship).

INDICATOR: An observable phenomenon that is substituted for a less observable phenomenon (e.g., weight according to age in a child as an indicator of health/nutritional status).

INPUT: The types and quantities of resources (labor, money, material, etc.) used in a program, project, or activity; sometimes called effort.

INTERVENTION: In health, an activity aimed at modifying a train of events so as to produce a more desirable outcome. For example, measles vaccination is an immunologic intervention between virus and host.

MATRIX: A mathematical or graphical representation in two dimensions of the relationship between a number of variables.

MEASURE: A number assigned to an object or event. Measures can be expressed as counts (45 visits), rates (10 visits/day), proportions ($45 \text{ primary health care total visits} / 380 \text{ total visits} = .118$), percentages (12 percent of the visits made) or ratios ($45 \text{ visits} / 4 \text{ CHWs} = 11.25$).

MODEL: A simplified representation of the real world. In operations research, models are usually graphic (maps, diagrams, flowcharts) or mathematical (formulas, equations).

OBJECTIVE: An effect that is desired or expected to be achieved by an activity, project, or program (e.g., to increase the use of growth charts by 50 percent).

OBJECTIVE FUNCTION: A statement or equation which expresses the relationship between the actions that a decisionmaker may take and the outcome of those actions or between the decision variable and the objective of the solution.

OBJECTIVE OF THE SOLUTION: A statement of the characteristics of an acceptable solution, usually expressed in quantified terms; for example, maximize the number of children that can be immunized with a particular program budget.

OPERATIONAL PROBLEM: A specific question, issue, or dysfunction in an operating system that limits the attainment of system objectives. It is a problem within the operating system as opposed to an environmental, health, or other nonsystem problem.

OPERATIONS (or OPERATIONAL) RESEARCH (OR): The application of science to the solution of managerial and administrative problems; a systematic, problemsolving process consisting of three phases: problem analysis, development of solutions, and testing of those solutions.

OPTIMIZE: To operate a system so that the system criterion is at its optimum value. For example, to minimize costs or maximize utilization.

OPTIMUM: The best, or more favorable, value that can be achieved given the constraints.

OPTION: An opportunity for choice between two or more courses of action.

OUTCOME: The results of a program or activity, usually its effects or impact, but may also include outputs.

OUTPUT: The types and quantities of goods and services produced by an activity, project, or program. For example, 750 packages of oral rehydration salts distributed.

PRIMARY HEALTH CARE: A strategy for making basic health services universally accessible to the world's population.

PROBLEM: (See operational problem.)

PROCEDURE: A series of predetermined tasks or actions to carry out an operation, such as a physical examination.

PROCESS: A linked series of actions or operations that are directed to a specific purpose, such as a health education session.

PROGRAM: A set of organized activities designed to reach a goal.

SENSITIVITY ANALYSIS: An analysis that shows how a solution is affected by changes in one or more of the variables that influence it.

SUBSYSTEM: A system within a larger system.

SYSTEM: A set of discrete, but interdependent, components designed to achieve a set of goals.

SYSTEMATIC ANALYSIS: Analysis carried out following orderly procedures.

SYSTEMIC ANALYSIS: The identification of the components that make up a system and an assessment of their interrelationships.

SYSTEMS ANALYSIS: A generic term to cover the application of a wide spectrum of methods (including OR) to problems or entities that are conceptualized or modeled in the form of systems.

UNCONTROLLABLE FACTORS: Factors that are not under the control of the decisionmaker.

VALUE: Estimated or assessed worth; in OR, the number assigned to a decision variable, such as the price set for ORS packages.

VARIABLES: The factors of a decision problem whose value may change.