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OF
HEALTH PLANNING METHODS

Prepared by AID - University of Pittsburgh
Contract No. 931 - 1103

by

Hector Correa, Ph.D.

with the assistance of:

Ms. Judith Sangl - Chapters 1 through 5
Ms. Patricia Lizanec and
Mr. Steve McBride - Chapter 6
Dr. Mohammed El-Torky - Chapter 7 and 8
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I - INTRODUCTION

Health planning is an effort to introduce rationality into the political and administrative processes of a society in order to obtain specified goals for health. Although there have been many improvements in planning techniques, these improvements alone are not sufficient to guarantee the achievement of the desired goals. Hence, problems must arise elsewhere in the planning process that account for failure of implementation and a shortfall in targets attained.

The purpose of the seven chapters that follow is to contribute to the development of an integrated theory of the health planning process which involves its political, technical, and administrative aspects, with the objective of formulating implementable plans.

To begin building a model of the planning process, the basis for understanding scientific models in general is described in Chapter II.

The concept of a model is introduced by presenting the steps required in constructing one: selecting the important aspects of the phenomenon being studied, classifying these variables as exogenous or endogenous, specifying the forms of these variables, and determining the cause-effect relationships among the variables. The

consequences of the aspects of reality excluded from the model, verification of the model and the actual process of constructing and verifying the model are also discussed.

In the third chapter, a conceptual model of health as a component of the social processes is presented. Four systems are defined which have outputs that influence the health status of the members of a society. An empirical index of health is established in order to analyse health by statistical methods. Statistical studies of factors that determine the level of health and their supply and demand are provided for illustration.

Planning for health is described in Chapter IV as a set of functions: decision-making, technical preparation of the plan, implementation and control. These functions are performed by five planning groups: high government officials, technicians, public administrators, private groups within the same country, and foreign governments and international organizations. A basic hypothesis for analysing the planning process is sketched, discussing how the organization and participation of the planning groups and the way in which the functions are performed influence the degree of achievement of the targets of the plan.

The fifth chapter introduces the use of quantifiable models in the performance of the technical function. The ideas about scientific models and their features presented in the second chapter are discussed in relation to the

technical function and the three models required for health planning. The various steps for performing the technical function are outlined and the end result - a published plan - is discussed and compared with the content of actual health plans.

In chapter six, the concept of choice between public health and individualized medical care is introduced. The advantages and disadvantages of both individualized medical care and public health measures are discussed. The idea of selecting the health programs which are most desirable for a community is operationalized mathematicaly by using linear programming. This technique is applied to the following three problems: mass screening vs. individualized care, prevention vs. individualized care, and nutrition and prevention vs. individualized care. A mathematical model is presented for each case.

In the seventh chapter, the optimal choice of health personnel is discussed. A description of the main characteristics of the different types of health personnel is presented. The possibility of substituting one types of health personnel for another is discussed. Examples of the complementary uses of health personnel provided are the simultaneous uses of doctors, nurses, and physician extenders. Examples of this latter type are the Barefoot Doctors used in China, and the traditional doctors practicing in many countries with little or no formal

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training. A linear programming model is introduced for the optimal selection of health personnel.

Planning for the number, size, and location of health facilities is discussed in Chapter VIII. Facilities are selected so that the need for them can be sitisfied using the resources available whenever possible. A description of and a comparison among the different types of health facilities are introduced. Factors which influence hospital utilization and the impact of hospital location on their utilization are also discussed. An integer programming model for the optimum selection of number, size, and locations of the various types of health facilities is presented.

II - BASIC IDEAS ABOUT SCIENTIFIC MODELS

II-1 INTRODUCTION

This chapter introduces the basic instrument to be utilized in the remainder of the manual - abstract models. It begins by assuming some conceptual framework on the part of the observer with which he forms analogies to the phenomenon being examined and describes the necessary steps in constructing an abstract model.

II-2 CONCEPT OF A MODEL

15;The concept of a model will be introduced by means of a step-by-step discription of the construction of one

First, it is assumed that the observer has some intuitive idea or mental image of the phenomenon he intends to study, which will be called a conceptual framework of the phenomenon. He does not approach the investigation with an empty mind - he has ideas, concepts, and expectations which are generally regarded as his "knowledge", "experience", or "scientific background". The existence of these ideas permits him to establish analogies between familiar concepts and the less familiar phenomenon being studied. This conceptualization

process can be described as follows:

> "When a man is faced with an empirical system of some kind he produces a mental system or an image in his mind which is an explanation of the empirical system he encounters. Empirical systems in the outside world are very complex and, as we all know, it is extremely hard to find out what is their true systematic nature. It is not surprising, therefore, that we argue by analogy from systems we know, to systems we think we do not know." (Sayasti and Mitroff, 1973:700).

Although reality is the basis of all data, different observers may perceive reality differently and would form different mental images of the same phenomenon. Differences may also arise from different epistemological approaches (methods of inquiry) utilized by observers.

II-3 STEPS IN CONSTRUCTING A MODEL

On the basis of his mental image, the observer selects examples of the phenomenon under study. For instance, in studying the phenomenon of health services, he might examine health services in several cities or regions of a country or in several countries. With the examples chosen, the following

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steps are then performed:

(1) The characteristic elements of the phenomenon which will be called "variables," are determined. For example, in examining a rural primary health care system, one would include the variables personnel, amount of equipment and drugs available, cost of service, average distance of clients from center, hours facilities are open, and so on.

(2) The different "forms" the variables can take are specified. For instance, the variable morbidity may be categorized as high, medium or low, or can be expressed numerically as rates per thousand of population.

(3) The variables are linked in cause-effect relationships.

Each of these steps will be studied below in detail.

The first step in abstraction is selecting the variables. The observer will select those variables that he considers relevant, depending on his mental image of the reality and on the point of view adopted. For example, the same observer would choose different variables if he were dealing with macro aspects of the health system (gross national product, total number of hospitals, doctors, etc., and total number of deaths and illnesses reported, for example) than if he were dealing with micro aspects (personal discretionary income, costs involved in visiting doctors and probability of infection from

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particular illnesses, for example) and different observers would likely choose different variables. A number of variables may not be selected, for many reasons. The observer may deem them irrelevant. Every observer has limitations in comprehending and defining a phenomenon. Also, not every variable can be included, since the purpose of the model is to simplify reality. The aspects of reality excluded from the model introduce a margin of error, and the consequences of this error will be discussed later.

For the second step, the observer will specify the various forms of the variables included, which may be either quantitative or qualitative. If different numerical values can be specified corresponding to different amounts or different magnitudes of degree or intensity, these are called quantitative variables. If the forms of a variable are classificatory, for instance, different types of diseases, or if the magnitude or the intensity of the different forms of a variable, for instance when the forms are good/bad, then one is dealing with qualitative variables. Numbers, though, may be assigned to qualitative variables, such as 0, 1, and so on for the purpose of distinguishing categories. This is not to be confused with actual numerical properties. The set of all the forms that a variable takes is called its range. Different ranges may be specified for the same phenomenon. If one range includes all the forms of another plus some additional ones, it is said to be "more refined" or to give more "precision" to the

variable.

One will also observe that not every form of one variable appears together with every form of any other variable. For instance, not every level of infant mortality appears together with every level of income. From observations of reality, one can determine which forms of the variables appear together; i.e., which variables are correlated.

Next, the observer links the variables in cause-effect relationships, stating that whenever a variable cause (exogenous variable) takes a specific form, a variable effect (endogenous variable) will also take a specific form. This relationship is the basis for the concept of explanation of a phenomenon i.e., a phenomenon is explained when, given a combination of forms of exogenous variables, one can determine the form that each endogenous variable will take. For example, health workers have observed that, with an increase in the number of vaccinations for a specific disease, that specific disease rate decreases, and concluded that the increment in vaccinations is the "cause" of the decrease in the disease specific rates, i.e., decreased morbidity rates are explained by increased vaccinations. It is the observer who links the variables in the causal relationship, and that link does not necessarily exist in reality.

There are several characteristics of the cause-effect relationship that should be discussed. First, a particular variable effect might have more than one cause. It is also

possible for one variable to be simultaneously a cause in one relationship and an effect in another. Finally, since the cause-effect relationship depends upon the point of view of the observer, the relationship might change if he alters his viewpoint. An example of different formulations of cause-effect relationships arising from different viewpoints will be presented. A radical perspective on health would maintain that the problems of the health care system are caused by variables outside the system; i.e., that the relationships in the health care system reflect the relationships in the society at large. On the other hand, a conservative perspective would view these same problems as a result of variables within the health care system. A case in point is the lack of care available to poor rural areas. A radical perspective may look to the distribution of wealth and power within society and the relationship of the rural sector to the urban sector for an explanation, while a conservative perspective might attribute the problem to a breakdown of market mechanisms in the health sector, resulting in shortages of doctors, etc.

Variables may be classified as either endogenous or exogenous. Those that are assumed to be causes only are called exogenous variables. This means that they influence the phenomenon being studied, but are not influenced by it. Endogenous variables are those that appear both as causes and effects or as effects only. For example, in a disease model

concerning malaria, the acreage of marshy land would be an exogenous variable, while in a model of family planning programs, population would be an endogenous variable. The exogenous variables are considered the explanatory variables, and the endogenous variables are considered the explained variables.

The same exogenous variables used in several varying causal chains may lead to different forms for the one or more endogenous variables, i.e., there are contradictory explanations for endogenous variables. Contradictory explanations should not exist in a model if, whenever the form of the exogenous variable is known, it is possible to determine in one and only one way the form of each of the endogenous variables. The relationships in a model are consistent and complete if, given the forms of all the exogenous variables, the forms of the endogenous variables can be determined.

Thus, we can see that a model has the following basic elements: (1) variables; (2) their classification as either endogenous or exogenous; (3) the causal relationships among them; and (4) the consistency condition.

In the following sections, a more detailed presentation will be given of the variables appearing in a model and the relationships among them. Also the consequences of the aspects of reality excluded from the model will be discussed.

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II-4 VARIABLES IN A MODEL

The observer must keep in mind that the main reason for constructing a model is to simplify and systematize reality. Therefore, the number of variables that one includes should be manageable.

In the previous section, it was mentioned that variables take different forms. Specification of the forms of the variables may be made according to the nature of measurement, i.e., whether they are nominal, ordinal, interval or ratio. Nominal refers to a level of measurement which groups objects into classes so that all of those in a single class are equivalent with respect to some attribute. Examples include the variable sex, which can be classified as male or female, and the variable health services, which may be classfied as maternal and child health services, emergency services, surgical services, etc. In other words, they are slots for classification as mentioned previously. Ordinal measurement is possible when one can detect differing degrees of an attribute or property in objects, and thus the objects can be ordered or ranked. An example would be different degrees of disability - little, moderate and severe. Interval level measurement distinguishes different amounts of an attribute in objects and additionally discerns equal differences between objects. For example, one can say that there is a difference of 1 unit for every degree on the temperature scale, but one can not say that

the differences among good, fair, and poor categories are equal to so many units. The zero point is arbitrary, as on the temperature scale, and does not reflect absence of the attribute. Ratio measurement has all the characteristics of interval measurement and in addition has a true zero point as its origin. Examples would be weight and height. Measurement of morbidity and mortality as rates per thousands would be another example. Those variables which are nominal or ordinal level are qualitative; those that are interval or ratio level are quantitative. The characteristic that separates these two categories of variables is not inherent to the quantitative variables; it is simply that a method has been discovered to quantify the different forms that a particular variable takes.

Scientific models deal with both types of variables. However, the definition and analysis of qualitative variables is more difficult.

One element common to all phenomenon is time. Models which include time are known as dynamic models, and those which do not include time are known as static.

II-5 RELATIONSHIPS AMONG VARIABLES

Another element of a model is the causal relationships among the variables. The observer first asserts that a

cause-effect relationship exists between two or more variables and then determines the form of the relationship. It is usually possible to obtain some approximation of the form of the relationships among quantitative variables. For instance, in many cases it can be assumed that the values of the explained variable change in proportion to those of the explanatory variable, i.e., that there is a linear relationship between explained and explanatory variables. It is more difficult when qualitative variables are included in the model.

The condition of consistency requires that for each combination of forms of the cause variables there should be one and only one form of the effect variable. If the correspondence is not one to one, it is possible that the range of the cause or of the effect variables is over refined. For instance, a particular level of mortality, say 15 per thousand, may be associated with more than one level of per capita income, say $1000, $1250, and $1500. In order to establish a one-to-one correspondance, the several categories can be combined to form one, $1000 - $1500.

To satisfy the requirement for one to one correspondence it is possible to group several forms of variables into classes and define a new range for the variable that includes only these aggregated classes. Instead of using a numerical index of income, for instance, income classes could be defined such as high, medium or low. Frequently, this transforms a quantitative variable into a qualitative one.

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Once the relationships among the variables in a model are specified and their consistency verified, it is possible to use the model to study in the abstract the phenomenon it represents. However, one must consider the fact that the aspects of the phenomenon left out of the model influence its cause-effect relationships, which are discussed in the following section.

II-6 CONSEQUENCES OF THE ASPECTS OF REALITY EXCLUDED FROM THE MODEL

In constructing a model , the observer leaves out some of the aspects of the reality he is studying, due to human limitations in comprehending the phenomenon, in specifying and aggregating the variables, and exclusion of variables considered irrelevant by the observer. This somewhat arbitrary elimination from a model of some aspect of reality has important consequences.

First, the relationships among the variables in a model usually do not reproduce exactly the value of the endogenous variables. It is possible to specify the form of the effect variable only up to an error term i.e. ; it is not possible to state the specific form of the effect variable, but only a specified set that includes several alternatives. The

difference between the observed and the computed values is known as random error. Another consequence is that the aspects of reality excluded from the model characterize the form of the relationships.

The relationship between the variables in a model can be specified on two levels: with or without taking into consideration the aspects of reality not included in the model. When these aspects are not considered in the relationships, a general model is constructed which does not refer to any particular reality . in order to apply these general models, the aspects of reality left out of them must be included.

These observations show that another element in addition to the variables appears in the relationships between the variables in a model. This element is dependent upon the aspects of reality excluded from the model - parameters. For instance, nutritional level may be excluded form a model, but a given value for it would be assigned in order to calculate the other cause-effect relationships.

II-7 VERIFICATION OF A MODEL

The problem of verification is that of deciding whether or not the model describes satisfactorily the phenomenon being studied. In order to find out, it is necessary to specify the

link between the variables, taking into consideration the values of the parameters. When the values of the parameters and the terms of the exogenous variables are known, it is possible to determine the forms of the endogenous variables.

To test a model, the first step is to observe the forms taken by the exogenous and endogenous variables in reality. Next, the observed forms of the exogenous variables are used in the model. The relationships among the variables in the model make possible the determination of the forms of the endogenous variables. Thus two sets of forms of the endogenous variables are available: those observed in reality, and those obtained from the relationships among the variables in the model. These two sets of forms are compared. The model is verified and accepted, if for the observer's purpose these two sets of forms do not differ significantly. In this comparison, the existence of random errors should be kept in mind by using statistical techniques to test hypotheses i.e., tests of significance are used to ascertain whether the differences are due to chance - random error - or not.

Of course, it is the scientist who determines how close the agreement between the observed and derived forms of the variables should be. In some cases, he may feel that a very close agreeement is required, while in others this may not be necessary.

II-8 ACTUAL PROCESS

In practice, the sequence described for constructing and verifying a model is not feasible. It is very unlikely that all the data needed are available for evaluating the parameters of a model at the time the observer has defined the variables and the cause-effect relationships in it. Consequently, he must proceed in a stepwise fashion from one model to another. The first few models would utilize whatever information is available and also initial observations and estimations of the variable values, in order to discover and clarify the cause-effect relationships and to verify the model. If these prove successful, there may be a more systematic collection of data, and the additional data may suggest new variables and cause-effect relationships. So the process of constructing and verifying a model is reinitiated, and the model can be continuously refined and updated until the observer is satisfied.

II -9 SUMMARY

This chapter has described the process of analyzing reality and conceptualizing a particular phenomenon into an

abstract model. Any idea which is logically consistent constitutes a model, since models are the basis of systematic thinking. All the steps in building a model - selection of important aspects of the phenomenon being studied, their classification as exogenous or endogenous, and the determination of cause-effect relationships among the variables - are then included in any thinking process. The consequences of the aspects of reality excluded from the model, varification of the model and the actual process of constructing and verifying a model are also discussed.

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III OUTLINE OF A CONCEPTUAL MODEL OF HEALTH AS A COMPONENT OF THE SOCIAL PROCESSES

Before developing an empirical index of health and an input/output model of the health process, we will examine the place of health as a component of the social processes, by viewing some of the many inter-relationships that exist between them.

III-1 HEALTH AS A COMPONENT OF THE SOCIAL PROCESSES

Health, using the W.H.O. definition, is not just the absence of disease, but a state of complete physical, emotional and social well-being. Health contributes directly to human well-being and is one determinant of welfare. Good health permits participation in personal, family, social, and political activities. The direct consumption and investment value of health is measured in part by resources devoted to health care. Health care satisfies felt human needs and has important human support functions, whether it cures the disease or not. However, health has not always been considered important in the socio-economic planning process, given the bias toward investment in physical elements of economic growth.

The implication of this bias has been that "non-physical capital factors" such as health and education and other forms of human investment have been disregarded.

Ill health is thought to impose economic costs in the productive sector by (1) reducing the availability of labor; (2) impairing the productivity of employed workers and capital goods; (3) wasting current resources, particularly nutrients; and (4) impeding the development of natural resources, animal wealth and tourism potential. The availability of labor is reduced both by premature death and by absenteeism due to illness. Ill health affects the productivity of workers, since their strength, stamina and ability to concentrate suffer. Current resources are wasted by the costs of diagnosis and treatment and by the increased caloric needs of the population caused by fevers, helminthic and enteric diseases. A waste of resources also occurs when poor health conditions restrict settlement in areas with fertile land or other natural resources. The presence of onchocerciasis, malaria and sleeping sickness has restricted access and development in many areas.

There exists a complex inter-relationship between health and many socio-economic factors. The example of the relationship between health and education will be considered. "= For a child to utilize the schooling he obtains to the fullest extent, he must have good health. Likewise, an adult must be mentally and physically fit to use the knowledge and

skills he has acquired. Chronic sickness in a school-age population can lead to a decrease in the average years of education received, affecting the future quality of the work force. Chronic sickness and disability will affect the quality of the present work force, decreasing labor productivity. On the other hand, the extent to which health conditions can be improved depends on people's knowledge and attitude toward health practices. In turn, these standards of health and education depend on the social environment, especially the prevailing attitudes and institutions.

In fact, most of the diseases that are important from the point of view of public health importance in developing countries are basically socio-environmental in nature. Some examples of major health problems, that may be classified as "social problems with medical aspects" are:

(1) malnutrition;

(2) many communicable diseases such as gastro-intestinal conditions, including parasitoses, tetanus, tuberculosis and leprosy. Although a germ agent is part of the etiology, causation is multifactorial and these conditions would not be public health problems if socio-environmental conditions were different;

(3) anemia in non-industrialized countries. This is due mostly to factors related to the environment (external and internal): inadequate intake or

absorption of iron, and chronic blood loss for such reasons as hookworm infestation (Martin, 1976: 185).

Now that we have outlined some aspects of health as a component of the social processes, we will proceed to construct a model of the health process. One of the first steps is establishing an empirical definition of health which will be termed a health index.

III-2 CONCEPT AND EMPIRICAL INDEX OF HEALTH

In defining the concept of health, a distinction will be made between individual health and societal health. The essential characteristic in the process of health is its relationship with a natural range of physical and mental states of well-being, illness and death. Illness is assumed to be a state that reduces the health of an individual and eventually leads to death if it is not cured. The existence of diseases that cause a great deal of discomfort but do not involve any risk of death will be ignored in developing an empirical index at present time. An example could be some forms of mental illness.

Once the concept of individual health has been defined, one can proceed to specify the concept of social health by many

different methods. For our purposes, societal health will be defined as an average of the health status of the individual members of a society. To obtain this average, a health index for each individual must first be found that describes the position an individual occupies on the scale of well-being, illness, and death. The value of this health index represents the relative distance between the individual's state of health and death at a given point in time. It is measured by life expectancy, the average number of years an individual can expect to live (Mausner and Bahn, 1974: 198), given his present state of health. For example, if an individual is in a state of well-being so that his life expectancy is 50 years, his health index is 50. If he becomes ill, and subsequently his life expectancy is reduced, his health index is proportionately reduced. If the person returns to the initial conditions of well-being his health index will increase likewise. In order to prepare this individual health index, one would require knowledge of all the illnesses and diseases that a person will experience and the number of years that each one will subtract from his life expectancy. Or, at the time of an individual's death, one can evaluate precisely the health index as the number of years lived.

For purposes of illustration, we will assume that the health indices of the members of a society are known. Then, the health index for an entire population can be represented by one numerical term (a simple average) for the aggregate of all

individuals' health indices in that population. This average health index approach offers some operational advantages. Table III-1 shows the health index of a population of 100 persons, using the individual health indices of such a population.

Table III-1

Example of the Estimation of the Population Health Index

Health index<1>	Number of Persons	
(a)	(b)	(a x b)
40	60	2400
35	30	1050
1	10	10
Totals	100	3460

Health Index of Population = 3460/100 = 34.60

<1> average number of years of life

Source: Correa, 1968: 5.

An observer of the above population studying a span of life of 40 years would write down the number of people

who die at the end of the first year, which in this example is 10; next he will write down the number of those dying at the end of the 35th year, in this case, 30; and finally the number of people who die at the end of the 40th year, which is 60. At this point he will estimate the average number of years of life of the population - which is 34.60 years.

The great advantage of the average number of years approach is that this can be estimated without knowing the health index of the individuals who constitute the population. As a basis for these estimates, statistical data or mortality /$to750 rates by sex and age breakdowns, if available, are used. This average number of years is expressed in terms of life expectancy at birth as an index of health of a population. However, due to lack of statistical data and to difficulties in calculation, it is useful to have a rough approximation of life expectancy at birth which can be obtained by the formula

$$100/r$$

where r is the rate of mortality in the specific population. These mortality rates and life expectancies will be used as a basis for later analysis.

III-3 FACTORS WHICH DETERMINE THE LEVEL OF HEALTH OF A POPULATION

The factors that influence the health status of the members of a society can be classified along four dimensions:

(1) human genetics and intrinsic biological characteristics;

(2) physical and social environment;

(3) health care organization; and

(4) human behavior.

The first factor involves all the processes that occur within the body and affect health, such as genetic endowment, internal metabolic systems, mental aspects, and processes of development and maturation.

The second factor, the physical and social environment, is external to the individual and he exercises little control over it. The physical environment includes exogenous chemical, biological and phsycial factors such as air and water pollution, foods, noise, drugs, climate and so forth. The social environment is the entire array of social, cultural, economic and political patterns within the human community that influence health, such as shared belief systems, family structures, education, and economic status. The interaction of some of these factors with health was previously mentioned in discussing health as a component of the social processes.

Health care organization, the third factor, encompasses all institutions, providers and services

of a medical nature. The quantity, quality, arrangement, nature and relationship of people and medical resources comprise this element.

Human behavior, or "lifestyle", is viewed as all aspects of a person's decisions and habits which affect health and over which a person has substantial control. This includes decisons about diet, exercise, and cigarette and alcohol consumption.

Health status, therefore, is the end result of the interaction of all these dimensions. Within each dimension, there are both factors which militate against health and factors which defend health. For example, bacteria and parasites exist in the physical environment and serve to detract from the individual's level of health. Some of these agents require carriers such as insects, arthropods, and rodents, to deliver the disease agents to the host. The existence of these agents and carriers, in turn, depends on conditions in the physical and social environment such as climate, sewage and garbage disposal methods, water treatment facilities, types of housing, and health education. Malaria is one example of a disease in which all the four factors are present. Genetically, those individuals who possess the sickle cell trait are less susceptible to malaria. Factors dependent on the physical environment, such as temperature and

altitude, determine which species of mosquitoes exist, some of which do not transmit malaria. Topographical features affect the existence of breeding places for mosquitoes. Social environmental factors determine housing, education, insecticide availability and the like which can serve either to increase or decrease an individual's susceptibility to malaria. Health care organizational factors would determine whether preventive and curative services are administered. Lastly, aspects of human behavior would influence whether an individual would take prophylactic medicines, use bed nets or install screens in housing.

The disease agents only constitute the necessary conditions but not the sufficient cause for the disease to occur. Besides harboring of the disease agent, an individual must be susceptible to that disease. A partial list of agents which affect the susceptibility of individuals to disease is shown in the following diagram:

Diagram III-1

Agents Which Determine the Susceptibility of Individuals to Disease

```
          /
          |Genetic
          |
          |                          /
          |                /         |
          |                |         |Nutrition
          |                |General  |Housing
          |                |         |Dress
          |                |         |Shoes
          |Preventive      |         <Alcohol
          |and             |         | consumption
          |Therapeutic     <         |Tobacco
          |                |         | consumption
          |                |         |Medical
          |                |         | examination
          |                |         \
          |                |
Agents    <                |         /
          |                |Specific |Vaccination
          |                |         <Maternal &
          |                |         | child care
          |                \         \
          |
          |                /         /
          |                |Personnel |Medical
          |                |         <Ancillary:Nurses,
          |                |         |etc.
          |                |         \
          |Only            |
          |Therapeutic     <         /
          |Medical         |Equipment |Hospitals
          |Services        |Medication |Beds
          |                |(Drugs)   |Laboratories,etc.
          \                \         \
```

Source: Correa, 1968: 14.

The majority of the factors that defend or enhance health originate in the social environment (also encompassing health services) and their production

depends mostly on the economic conditions of the community.

These four dimensions constitute a conceptual framework which has been termed the "Health Field Concept" (Lee, 1977: 11), and it emphasizes the importance of lifestyle and the physical and social environment relative to health care organization. Health care services are not considered to be the greatest contributor to health, both at a national and individual level, although health planning has generally concentrated on this input. Utilization of this framework fosters a systems approach to the planning of health, giving adequate consideration to the influence of non-health factors.

Several assumptions are made: (1) that an individual, in order to demand and utilize agents which reduce his disease susceptibility, must know what these agents are and recognize his need for them; (2) that this knowledge depends on the level of education of the individual; and (3) that the individual's income determines his capability to express his need for these agents in the market.

This past section defined four systems with outputs that influence health, and the factors within each that serve to defend or militate aganist health. Next, we proceed to study these factors and their supply and

demand with the aid of of statistical methods.

III-4 STATISTICAL STUDIES OF THE FACTORS WHICH DETERMINE THE LEVEL OF HEALTH OF A POPULATION

In a statistical study of the health processes, two problems are to be considered: (1) estimating the influence of the health-determining factors on the level of health of a population; and (2) studying the supply and demand of such factors which defend the individual's health. The following diagram lists the variables which influence the level of health:

Diagram III-2

Dependent and Independent Variables Used in Statistical Analysis of Health Determining Factors

```
                 |Dependent:  index of health, i.e., crude
                 |            mortality rate and specific mortality
                 |            rate by age (d<i>)
                 |
                 |             /
                 |             |Determining factors  /
                 |             |of agents which      |Climate:
                 |             |attack health        | Temperature (T)
                 |             |                     |Urbanization:
                 |             |                     | Percentage of the
                 |             |                     < Population in
                 |             |                     | cities of 20,000
                 |             |                     | individuals or
                 |             |                     | more (U)
                 |             |                     \
                 |             |                     /
                 |             |                     |Nutrition:
Variables        <             |                     | deficiency of
                 |             |                     | deficiency of
                 |             |                     | capita (C);and
                 |             |                     | deficiency of
                 |             |                     | protein per
                 |independent: <                     | capita (P)
                 |             |                     <Housing:
                 |             |                     | percentage of
                 |             |                     | houses with
                 |             |Determining factors  | running water
                 |             |of agents which      | inside or outside
                 |             |defend or            | of house (h)
                 |             |protect health       |Number of persons
                 |             |                     | per physician (D)
                 |             |                     |Number of persons
                 |             |                     | per hospital
                 |             |                     | bed (d)
                 |             |                     \
                 |             |                     /
                 |             |                     |Education:
                 |             |Determining factors  | percentage of
                 |             |of the use of        < literate
                 |             |agents which         | population (E)
                 |             |protect human        |per capita
                 |             |health               | income (Y)
                 \             \                     \
```

Source: Correa,1968: 17.

With the first problem mentioned, lack of sufficient information on the use of such resources as physicians and hospitals is a problem in the statistical analysis of the level of health. An equation that can be utilized for statistical analysis for estimating the influence of health determining factors is:

$$d_i = a_{0i} + a_{1i}T + a_{2i}U + a_{3i}C + a_{4i}P + a_{5i}W + a_{6i}D + a_{7i}d + a_{8i}E + a_{9i}Y$$

where
T is temperature
U is percentage of urban population
C is deficiency of calories per capita
P is deficiency of protein per capita
W is percentage of houses with running water
D is the number of persons per physicians
H is the number of persons per hospital
E is percentage of literate population
Y is per capita income; and
d is the average mortality rate

Source: Correa, 1968: 21.

In an analysis of 16 developed countries and 15 underdeveloped countries by Correa (1968), the percentage of literate population is possibly the most important factor determining mortality rates.

III-5 STATISTICAL STUDY OF THE SUPPLY AND DEMAND OF AGENTS WHICH DEFEND HUMAN HEALTH

In this section we describe the technical problems found in the statistical study of the supply and demand of agents which defend the health of individuals, as well as a study of the relationship between level of health and agents which defend human health.

For the first, we confirmed the problem of the lack of sufficient data which would only refer to supply or demand. All of the available statistical information refers to the point of equilibrium between supply and demand, i.e., to the result of the interaction that occurs between these two forces. This complicates the problem because the determining factors of the supply which contribute to an improved level of health also influence their demand. For example, in considering the supply and demand of medical services, the educational level of the population, the rate of income, their health index, etc., influences simultaneously supply and demand. It is possible to solve this "identification" problem only with availability of statistical data which pertains only to either supply or demand. Unfortunately, such data is not available in many countries.

In order to obtain some idea of the relationship between supply and demand of medical services, with both level of

education and per capita income, one can perform two regression analyses with per capita income and per-centage of literate population as independent variables and number of inhabitants per physician as the first dependent variable and inhabitants per hospital bed as the second. The results of these two analyses by Correa (1968) using data for 106 countries show that income and per cent literacy have a marked influence on each dependent variable. However, looking at the coefficient of multiple regression indicates that these variables explain a small part of the variation in each dependent variable. Table III-2 provides a summary of the results.

TABLE III-2

Coefficients obtained in the statistical analysis of the factors which determine supply and demand of physician and hospital services

Dependent variables	constant	Coefficients of per capita income Y	Coefficients of per cent of literacy E	Coefficients of multiple regression
Habitants per physician (D)	26489	.276 (2.58)	-305.58 (57.6)	.51
Habitants per hospital bed (H)	1737	-0.64 (.18)	-17.14 (.13)	.44

Note: The first figure in columns 3 and 4 is the regression coefficient. The figures in parenthesis represent the standard deviation of the coefficient.

Source: Correa, 1968: 33.

III-6 SUMMARY

This chapter outlines some aspects of health as a component of the social processes by examining the many inter-relationships that exist among health, education, labor productivity, economic growth, etc. The value of investment in

health is recognized by a description of its economic impact. Then it proceeds to establish an empirical index of health at the individual and societal level in order to analyse health by statistical methods. The health index for a population is ultimately defined as life expectancy at birth.

Four systems are defined which have outputs that influence the health status of the members of a society. These are:

(1) human genetics/intrinsic biological characteristics;

(2) physical and social environment;

(3)health care organization; and

(4) human behavior.

Within each system, there are both factors which militate against health, and those that defend health. A list of agents which determine the susceptibility of an individual to disease is presented.

A discussion of statistical studies of these factors which determine the level of health and their supply and demand follows, with statistical studies by Correa (1968) provided as examples.

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IV A MODEL OF THE PLANNING PROCESS

IV-1 INTRODUCTION

This chapter presents a model of the planning process, following the ideas of the general model introduced in Chapter 2. Planning is analyzed from three perspectives: (1) by its outcomes; (2) by its formal elements; and (3) by the social groups involved in the process. These three points of view will provide the basis for a definition of the variables used in the analysis of health planning, to be dicussed later.

IV-2 OUTCOMES OF THE PLANNING PROCESS

The outcomes of the planning process can be classified as: (1) intended, and (2) unintended. Among the first, the most obvious is the achievement of the plan's objectives. Among the unintended outcomes, the following can be mentioned:

(a) collection of useful information, for instance, to prepare health plans; collection of data on the health status of the population and characteristics of the health delivery system;

(b) creation of useful administrative

organizations and improvement of existing ones;

(c) introduction of more rationality in the decision making process.

On the other hand, there may also be negative unintended consequences:

(a) increased centralization and bureaucratization in decision making, hindering the provision of services;

(b) legitimation of current political conditions.

Despite the importance of unintended consequences of planning, it will be assumed for the purpose of this Manual that the outcome of a plan is characterized by its intended consequences.

IV-3 FORMAL ELEMENTS OF THE PLANNING PROCESS

The formal elements of the planning process to be considered are: (a) the process being planned; (b) the functions that have to be performed with respect to the process in order to plan; and (c) the level of aggregation with which the process is considered. Each of these elements will be studied in detail below.

IV-3.1 PROCESSES BEING PLANNED

Planning always deals with one or several input-output processes. These processes receive some inputs from themselves or from other processes, and produce some outputs. For instance, the health system receives physical goods, such as medical supplies, hospital facilities, etc., and specialized labor of the health professions as inputs, and produces health services as output. It should be pointed out that the inputs from the health sector and other sectors might have outputs which will either have beneficial, neutral, or detrimental consequences for health. An example of a positive or beneficial input-output process within the health sector would be a periodic screening program for a certain disease, which leads to decreased disease-specific morbidity and mortality. An example of a negative input-output process from the agricultural sector is the building of the Aswan Dam, which provided more breeding places for snails, causing an increase in schistosomiasis.

IV-3.2 FUNCTIONS PERFORMED IN A PLANNING PROCESS

In order to plan an input-output process, four functions must be carried out: (1) the setting of goals for the output of the process being planned; (2) the technical preparation of the plan; (3) implementation; and (4) control.

For the first function, it should be pointed out that what constitutes a goal is determined by individuals' viewpoints and

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values, which were shaped by their particular environments. The preferences of the members of society should be reflected in all social goals. The manner by which individual preferences are aggregated and integrated into social goals is through the political process. This political mechanism is characterized by coalitions and their formation and delegation of power. The more attributes that individuals share - age, social, economic or ethnic - the more likely they are to have common values and set similar goals. Groups of such individuals will form coalitions to increase the likelihood that their common social goals are achieved, and these coalitions will yield the power of all their members. The preferences of those society members who have more power will weigh heavily in the determination of the societal goals of a coalition, including a winning coalition. Once goals are set for the process being planned, the technical preparation can begin.

The technical preparation of the plan involves determination of the minimum inputs required to attain the goals of the plan, of the actions and procedures to be performed to make these inputs available at the proper time and place, and of the feasibility of these actions and procedures. Actions and procedures can and should be summarized in a general time table which contains a list of actions that must be performed. Technical preparation is completed when feasibility of actions and procedures is verified.

A basic element of the technical function is a scientific model of the process being planned, which determines the inputs of the process and their relation to the outputs. This model will contain all the characteristics mentioned in Chapter II. As observed above, given the limitations of our knowledge, there is a margin of uncertainty in the relation between inputs and outputs. This model is what makes it possible to specify the inputs required to attain the goals of the plan.

During the plan's implementation, the third function, the general directions resulting from the technical preparation are translated into actual day-to-day decisions and actions. The fourth function, control, determines whether the actions required by the plan are performed, and whether these actions produce the expected results.

These functions must be considered simultaneously in any stage of the preparation of the plan, although they have been described sequentially above. This is to say that when goals are being set, one must give attention as to whether these goals are feasible, can be implemented and will produce the expected results.

IV-3.3 LEVEL OF AGGREGATION

The third formal element in planning is the level of aggregation in regards to content, time and space. A plan of the health services only would be at a lower level of

aggregation than a comprehensive plan which would include other sectors in addition to health, such as education, industry, environment, agriculture, etc. Long term planning would represent the highest aggregation in time, and international or national plans would represent the highest aggregation in space. In actual planning it is necessary to pass from aggregated to disaggregated plans. One assigns tasks and procedures from the highest to the lowest levels of administration, from the region as a whole to all of the political subdivisions, and specifying shorter time intervals than than in the overall plan. For instance, actions to be performed will be stipulated for provincial health officers for one year periods in all regions.

The four main functions previously described can combine among themselves on many levels. For example, the technical preparation of the plan and control may be both at the aggregate and disaggregate levels, while implementation may mainly be at disaggregate levels. decision making asembly refers to aggregated levels of content and space, but it is also involved in disaggregated levels in time, for instance, with respect to annual budgets.

IV-4 SOCIAL GROUPS INVOLVED IN THE PLANNING PROCESS

The planning functions just described are necessary for the planning process to be operative, but the performance of these functions alone is not sufficient. The persons who carry out these functions also influence the success or failure of the plan.

The social groups to be considered in the analysis of the planning process are: (1) the government of the country; (2) private groups in the same country; and (3) other governments or international agencies.

The government of a country seen as a planning group is further subdivided into: (1) high officials; (2) technicians; and (3) public administrators. High officials or policy makers would be members of the legislative and executive branches of government, such as members of Congress or Parliament, the president or prime minister and the other ministers or secretaries of state. Technicians or planning experts are those who carry out the technical aspects of the planning process and usually are attached to two organizations: (1) a national planning institution formed by a Central Board and a Technical Secretariat (e.g. the Plan and Budget Organization of Iran) and (2) planning bodies within the different ministries and departments of the governments. Public administrators are the planning group that has as its principal function the implementation of a plan. For example, provincial or state health and medical officers would be in this category.

The second planning group, i.e., the private individuals

or institutions, would include all those persons or organizations outside the government in the same country who have some impact on the health process or are affected by the health process. Some of the private groups have some specfic vested interest, such as medical, hospital, pharmaceutical, and insurance associations, and would make their preferences known by lobbying among the high levels of government. Others, such as consumers, are represented on many of the broad aspects of the health processes by national, regional or community level advocacy groups. Examples of advocacy groups are Common Cause and Ralph Nader's Health Research Group in the United States. These groups would also lobby among the government, presenting the views of its consumer members on health issues or providing research results to decision makers on behalf of the general public. If the public has elected representatives in the high levels of government, these officials would likely monitor public opinion to determine the preferences of their constituents.

Foreign governments and organizations and international agencies are those which are external to the country, but can affect the health processes in some manner. Examples of such organizations are the World Health Organization, Food and Agricultural Organization, Agency for International Development, and the Medical Assistance Program, CARE-MEDICO, and the International Bank for Reconstruction and Development. These organizations influence the planning process by giving

the weight of their prestige to some specific targets, by entering into international agreements, and by contributing loans and grants to the achievement of targets.

IV-5 DEFINITION OF THE VARIABLES TO BE CONSIDERED IN THE ANALYSIS OF PLANNING

Four sets of variables will be used for the analysis of planning. These four sets, derived from the three perspectives discussed earlier in this chapter, define (1) the outcomes of the planning process; (2) the planning groups; (3) the planning functions; and (4) the participation of the planning groups in the planning functions.

The variables relating to the outcome of the planning processes deal primarily with the question of whether or not the targets of the plan were achieved. It is possible to construct a quantitative index to evaluate the degree of achievement of the targets. This quantitative index would express the similarity between intended consequences and actual achievements.

The main variables relating to the planning groups are (1) their organization, the different forms of organization being the different forms of this variable; and (2) the characteristics of the persons playing roles in the planning

groups, such as their values, beliefs, social class, education, age, etc. Any plan is a result of the cooperation of the persons in the plannning groups, and the main variables associated with these persons are important in accounting for the characteristi s of that cooperation.

An important point is the legal and actual periods during which indivuals play roles in the different planning groups because of the influence their characteristics and ideas exert on the planning process. The period for which the plan is prepared should be synchronized with the period during which the members of the planning groups remain in these functions. For example, a change in the high officials of the government is likely to modify the planning process.

The planning functions can be regarded as input-output processes. The inputs and outputs of these processes are the variables that must be defined. The principal outputs are the targets of the plans for decision making, verification of the feasibility of these targets, and actions to be performed to achieve them for technical preparation, actions already performed for implementation, and corrective information and actions for control. The main inputs of the planning functions are the activities of the planning groups. The determination and observations of the different forms that these variables may take present serious problems that, for the most part, remain to be solved.

The final set of variables deals with the participation of

the planning groups in the planning functions. The varying degrees of participation (for instance, presence or absence; or above average, average, below average) are the forms of this variable.

IV-6 BASIC HYPOTHESIS FOR THE STUDY OF THE PLANNING PROCESS

The basic hypothesis for analyzing the planning process can be summarized as follows:

1) The characteristics of the organization of planning groups, and the degree of their participation in the decision making function determine the goals of the plan;

2) The characteristics of these goals and, again, the organization and participation of the groups, determine the technical description of the actions that must be performed in order to achieve the targets;

3) The characteristics of these actions and the organization and participation of the groups determine whether or not the actions are performed during implementation. Finally, the characteristics of these three functions determine the control function;

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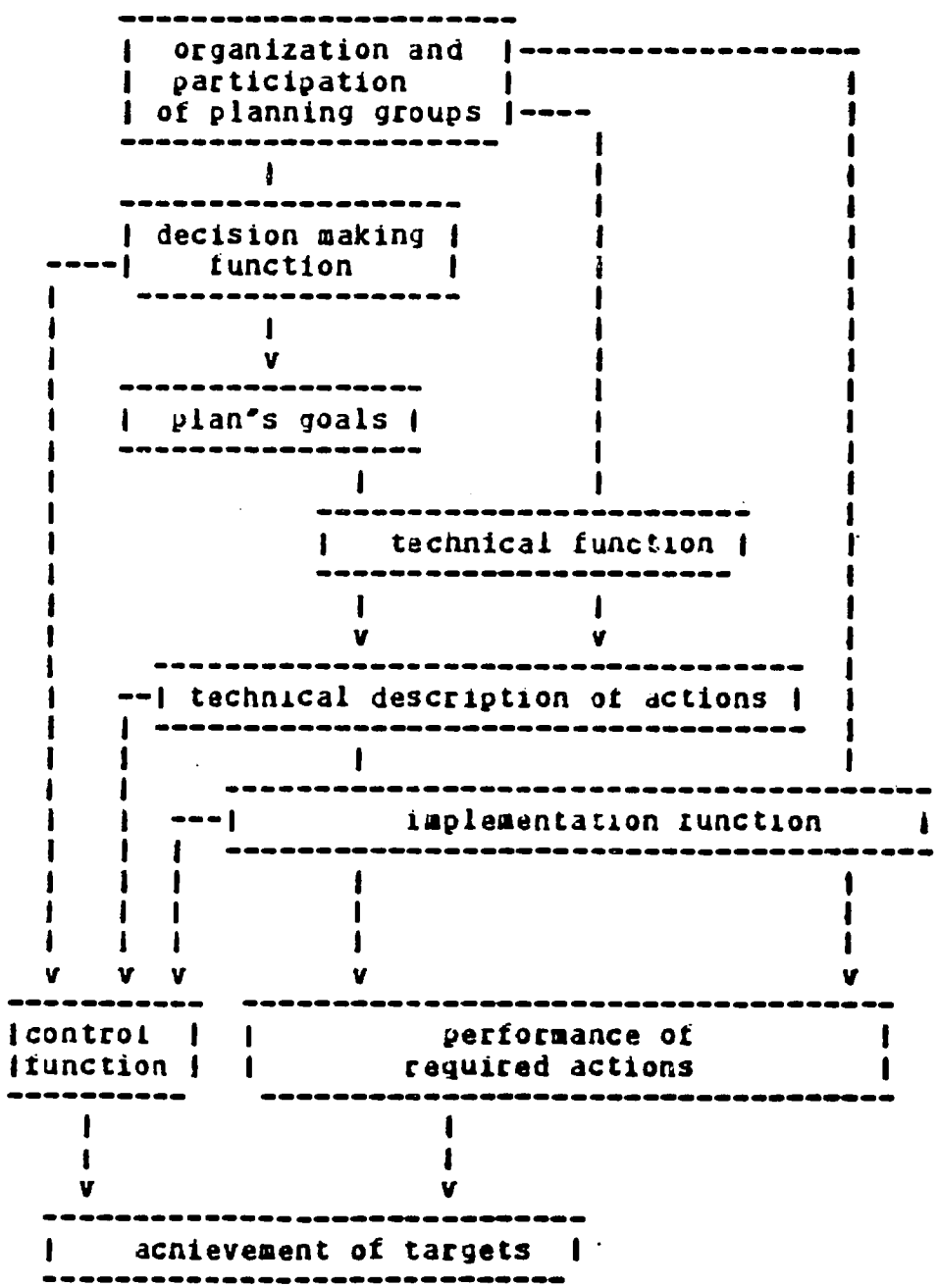
4) If the actions recommended by the technical function are performed, and the control function is developed appropriately, the targets of the plan will be achieved.

In summary, the hypothesis presented goes from the organization and participation of the planning groups, and the way in which the planning functions are performed, to the degree of achievement of the targets of the plan. This is schematically diagrammed as follows:

DIAGRAM IV - 1

Diagram of the Planning Process



Empirical verification of the basic hypothesis presents serious problems, due to the impossibility of observing certain variables, the lack of data on others, and on the characteristics of the hypothesis itself. These problems make it impossible to establish a clear link based on observed information between the organizations and participation of the planning groups, the performance of the functions and the success or failure of the planning process.

There is a missing link in the model between the actions recommended to achieve the targets and their performance. This appears at every step relating the organization and participation of the planning groups to the success of the plan by the performance of the functions of decision making, technical preparation, implementation and control. Once the actions required to achieve the targets are determined as output of the technical functions, its performance depends on the will and capacity of the persons designated to perform them. It is impossible to observe this will to act, and unlikely that the persons assigned the tasks would state they are unwilling to perform them, even if such is the case.

An indirect method should be found to determine whether the will to act exists. One possibility is to consider the actual performance or non-performance of the actions as an index. However, non-performance of the actions may not mean

lack of will, but rather lack of ability to act. Secondly, there is no record kept of the performance or non-performance of the actions required to implement the plan. So the possibility of testing the existence of the will to act must be abandoned.

Another missing link is that the performance or non-performance of the actions recommended does not guarantee the achievement of the targets. The targets might be achieved even without the performance of the actions, and, conversely, they might not be achieved even if the actions are performed. For instance, a particular target for a reduced birth rate might be realized without implementing family planning programs. On the other hand, operation of family planning programs may not cause birth rates to decrease. The main reason for this is that the method used to carry out the technical preparation of the plan has limitations. Random errors do not permit exact determination of the values of targets, but only an approximation of the range of values.

IV-7 SUMMARY

The model of the planning process can be used to study any planning process, including that used in private

industry or government. This general model is described according to the concepts presented in the second chapter.

Planning is examined from three perspectives: (1) by its outcomes; (2) by its formal elements; and (3) by the social groups involved. From the first perspective, planning is assumed to be characterized by its intended consequences, of which the most obvious is the achievement of the plan's objectives. Unintended consequences, both positive and negative, are not included.

With regard to the second perspective, the formal elements are: (1) the process being planned; (2) the functions that have to be performed ; and (3) the level of aggregation. Planning deals with one or several input-output processes. The four functions that must be performed to plan an input-output process are: (1) setting of goals for the output of the process being planned; (2) the technical preparation of the plan; (3) implementation ; and (4) control. The setting of goals is accomplished through a political process of aggregating and integrating individual preferences into social goals. Technical preparation is the specification of the inputs required to achieve the targets, and of the actions to make them available. During the technical function it should be verified that the actions needed are feasible. To specify the required inputs, a scientific model of the process being planned has to be used. Implementation translates the

directions obtained from the technical preparation into day-to-day decisions and actions. Control determines whether the required actions are performed, and whether these actions produce the desired results.

The level of agggregation, the third formal element, is considered with regard to content, time and space. It is observed that the four main functions can combine among themselves on many levels.

For the planning process to be operative, the performance of the four functions just described alone is not sufficient; the persons who perform these functions affect the success or failure of the plan. The social groups that are presented are: (1) the government of the country; (2) private groups in the same country; and (3) other governments or international agencies. The government of the country is further subdivided into: (a) high officials; (b) technicians; and (c) public administrators.

The planning process was analyzed according to variables defining: (1) the outcomes of the planning process; (2) the planning groups; (3) the planning functions; and (4) the participation of the planning groups in the planning functions.

A basic hypothesis for analyzing the planning process is given, along with a diagram describing how the organization and participation of the planning groups and the way in which the functions are performed influence the

degree of achievement of the targets of the plan. Problems of verifying this hypothesis are also discussed.

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"The Implementation Function in Planning", Chapter 9, pp.89-96; and

"The Control Function in Planning", Chapter 10, pp.97-99,

V TECHNICAL FUNCTION IN HEALTH PLANNING

V-1 CONCEPT OF THE TECHNICAL FUNCTION

The planning process, as mentioned earlier, can be analyzed as an input-output system. Health planning has as its output the health of the members of society, and the various inputs are those that were described in Chapter III. These inputs themselves are outputs of subsystems in the society, each having its own inputs, eventually including some physical resources and some actions.

In health planning, the technical function is basically the use of a scientific model of the health processes outlined in the second chapter for the following purposes:

(1) to aid in determining, first, the goals of the outputs of the health system and subsystems that contributute to it, and then the targets for those outputs. A goal becomes a target when it is verified that the necessary inputs for its achievement are available.

(2) to determine the levels that the inputs of this system and subsystems should reach to attain the goals and targets; and

(3) to verify that the input levels can and will be attained.

Since these objectives are carried out for each system and subsystems in the process being planned, a series of aggregation and disaggregation steps is involved. This makes it possible to proceed from the output of the aggregate systems to those of the subsystems and vice versa.

V-2 OVERALL VIEW OF SCIENTIFIC MODELS IN THE TECHNICAL FUNCTION

In health planning, the system to be planned is health in society, and the subprocesses defined by it. At least three types of models are necessary to perform the technical function:

(1) An holistic model of health for the entire society, the output being health and well-being, and the input processes being the social and physical environment, medical services, behavior of members of society, and human biology, in which the interactions between output and inputs and among the inputs themselves are considered;

(2) A model of each process whose output contributes to health, for instance, a model of the health services processes in which the main variables type of services,

personnel and distribution of personnel, health care facilities, etc., appear; and

(3) Models of each of the divisions of the processes considered in (2); for example, a detailed model of preventive services.

The concept of a model and its features were introduced in the second chapter. It was mentioned there that a scientific model does not have to include only quantitative variables or relations expresssed as mathematical equations. Qualitative models are frequently used by high government officials and by public administrators to make decisions. However, because of available information, most of the subsequent analysis will examine quantitative models rather than qualitative ones.

The endogenous variables in a scientific model include the outputs of the process. The forms of these output variables are expressed by the goals of the planning process. For example, output for preventive health services may be expressed as the number of children to be immunized for particular diseases, the number of lactating mothers and infants to be given supplemental foods, and so on. The exogenous variables include the inputs of the process, i.e., the resources and actions that determine the levels reached by the endogenous variables. Some of the exogenous variables are subject to control by government officials and public administrators, while some are not. Those which can be controlled are called instruments.

It is useful to distinguish the behavioral relationships that are included in a model. For example, a consumption function may describe how people alter their consumption of health care services when there are changes in their income or level of education. These relationships are important in the technical function because they are often used to describe behavior in the private sector.

The first problem faced by technical planners is to choose or construct an appropriate model of the process for a specific country. Once this is completed, the second step is to collect data and use statistical methods to estimate the values of the parameters. Then it is possible to utilize a model for the purposes of the technical function.

V-3 SELECTION OF MODELS TO BE USED

The construction or selection of models in the technical function in planning and the construction of one for purely scientific purposes do not differ in any basic respect. There are differences concerning the persons involved in designing and using the models and the purposes of the models (academic vs. administrative orientation).

The main objective of models for scientific analysis is the explanation of a process or the investigation of its characteristics, and is not usually concerned with the actions that government officials or public administrators have to

perform in order to direct the process studied.

However, models for planning have to serve as the basis for action and control of the performance of government officials and administrators. The three main groups, officials, public administrators, and technicians, would agree on this point, but disagreement among them would likely occur because of their different points of view and social characteristics. For example, high officials and public administrators would prefer variables closer to their experience, such as those dealing with actual political subdivisions of the country and organizational subdivisions of the government, rather than some artifical ad hoc subdivisons created by the technicians for scientific purposes. They might also fail to comprenend the detailed relationships among the variables defined in a health model, or to understand complete models of that process, because they are used to dealing with smaller, more manageable, aspects, while the technicians take an overall view for granted. On the other hand, hypotheses that the officials deem acceptable and actually use as guides for their actions might not satisfy the criteria of the technicians. However, the solution of the conflicts among these groups is important to the success of the planning process. The model selected should satisfy a minimum of the requirements of all the groups involved.

Since models in the technical function are to be used as a basis for action, values of the parameters have to be known.

As a consequence, when selecting a model, one must consider availability of data required for parameter estimation, the possibility of obtaining them in a certain amount of time, or the possibility of using parameters estimated for similar countries, depending upon the time and resources available for data collection and upon the consequences of using unreliable information.

V-4 STATISTICAL DATA REQUIRED

Empirical information is required for both qualitative and quantitative models. However, there is little experience in the collection of purely qualitative information for use in planning, and this section will be restricted to the analysis of quantitative statistical data.

The characteristics of a scientific model will determine the characteristics of the data required. The data are observations of the values taken simultaneously by independent and dependent variables. Usually many sets of these simultaneous observations are required, corresponding to different times or places; i.e., time series or cross section data. Since the relationships between cause and effect variables are hypotheses regarding the change in the effect variables brought about by the changes in the cause variables, these changes can only be studied if many observations are available.

Usually, some data which were previously collected by a statistical office or another administrative department are available at the time when the parameters of a model are going to be evaluated. Since these offices have collected the data for administrative purposes not directly related to planning, the data often are not well suited to planning purposes and might have to be adapted. Additionally, the data would have to be examined for its reliability and consistency, and possibly modified for use in the model, such as forming aggregates that can be identified with the variables of the model. The data that are not available at the time when the parameters are being estimated must be collected by the technical secretariat in many cases, because the statistical offices may not have the extra personnel and other resources needed for this special collection.

V-5 DIAGNOSIS AND FORECAST

Aggregating and integrating the desires and interests of members of a society with respect to health goals through the political process does not produce information that can be used to specify the resources needed to achieve them in the technical function.

The first step toward concrete goals is diagnosis of the present health conditions, which is divided into evaluation and explanation of future conditions. In evaluation, the values of

the variables in the model of the particular country for which the health process is being planned are compared in several of its regions or with the values in similar countries if values are not known, or if better estimates are not available within the country itself. In the explanatory part of the diagnosis, the causes for the values taken by the endogenous variables in the model are determined, i.e., the values taken by the exogenous variables. During the diagnosis, the information contained in the model must be interpreted properly. Where required, one should take into consideration qualitative variables usually left out of the model. The second step is the forecast with the objective of determining the most likely future evolution of the endogenous variables identified in the process being planned. The forecast is obtained by projecting the past trends of the exogenous variables. If there is some doubt that the past trends will continue in the future, a forecast based on additional considerations can be made.

These procedures make it possible to judge whether the values for the goals obtained through the political process are reasonable for the actual health situation. For example, the outcome of the political process through which individual preferences are aggregated into social goals may be the demand for the installation of cardiac care units in certain hospitals, but an analysis of health conditions might show that a small percentage of the population would actually utilize such a service.

Diagnosis and forecast are steps controlled mainly by technicians. If the results of these procedures are not communicated to the high levels of government and public adminnistrators, these will not be used in setting goals for the health plans, and make goal setting difficult. Using these results alone, however, results in the setting of goals without taking into consideration those formulated through the political process. In fact, it can be easy for technicians to replace other planning groups in setting goals for the health plan that may reflect only the interests of this one group. For instance, the technicians, with their usually higher educational levels, may favor curative, hospital based health investments, while the needs of the majority of the public may demand investment in preventive health services. However, after a period of time with no input from other groups in setting goals, problems may arise. For example, if the technicians' choice of goals does not meet the approval of the administrators, these may choose not to implement the plan, since their interests have been neglected. The private sector and the consumers may likewise be dissatisfied, and withdraw critical support of the plan, resulting in its failure.

V-6 CONTRIBUTION OF THE TECHNICAL FUNCTION TO THE DETERMINATION OF TARGETS FOR THE PLAN

During the determination of goals for the health

processes, little attention is given to their feasibility, or to the various methods by which they can be achieved. Consequently, they are deemed tentative.

For these goals to be attained, the inputs of the process must combine in a certain manner in relation to quantity, time and space. Some actions are necessary to provide these inputs. A scientific model of the health process aids in determining all the resources required, the actions that need to be performed so that the resources are made available, and the manner in which the resources should be combined. For example, one must combine the resources of personnel and vaccines and perform particular actions to deliver these resources to the target population in order that an immunization campaign be successful. All these relevant variables are specified in the model. In many cases, it is found that the required resources are not available because they are being used for alternative, more important objectives, or that the persons required to perform the necessary actions cannot or do not wish to perform them. Knowing these limitations, it is necessary to specify goals that can be achieved with what is available. Alternative possibilities are studied both going from the goals to resources and actions and from resources to goals. This process ends when a consistent set of goals, resources, and actions is found in the sense that the resources can be used and the actions will be performed, and as a consequence, the goals will be achieved. Thus the goals become the targets of

the plan, and the resources and actions are determined simultaneously.

V-7 AGGREGATION AND DISAGGREGATION

The step from goals to targets includes disaggregation and aggregation in two aspects: content of the process being planned and the governmental organizations involved in planning. The disaggregation in content goes from a general view of health to one of the particular processes, such as preventive services, curative services, etc., and then from each one of these processes to their subprocesses and inputs. Disaggregation in organization is the step from the high levels of government dealing with the aggregate view of health to the lower levels dealing with particular health processes, such as the administrative units, dealing with the preventive services, curative services, etc., and then to even smaller administrative units, reaching finally the level of the individual health functionary and the acts he is supposed to perform. The aggregation goes from the resources and actions in the departments and sections at the lower levels up to the goals of health as a whole as considered by the high levels of the government.

It is possible to divide these processes into four main steps:

(1) Overall targets of health are determined that

are consistent with the inputs for health and the general policies that can be carried out. For this step it is necessary to have an integrated model of health which would include health as a function of all its inputs and the interaction among these inputs, and the contribution of health to social well-being.

(2) A progressive disaggregation is performed. In this step, the levels required of all the inputs for health and the general policies to be carried out as determined in the first step become induced goals. These induced goals and scientific models of each of these processes make it possible to reinitiate at a disaggregate level the comparisons of goals with forecasts, and to study the resources and actions required. If the goals induced from the aggregated analysis appear reasonable when compared with the forecasts and are consistent with resources and actions, the analysis is completed at the disaggregate levels. The goals then become targets and the necessary resources and actions become second order induced goals. If consistency is not achieved, the goals have to be modified. The overall targets may even have to be modified. Examples of such second order induced goals are the outputs that medical education, immunization campaigns, environmental sanitation programs, and health education programs, etc. should have to reach targets of

reduced morbidity and mortality;

(3) The third step is that of aggregation that goes from actions and sources to goals;

(4) The fourth step is a comparison of the results of steps one and two with step three. When there is complete agreement between steps one, two and three, the technical preparation of the plan is completed.

For the first step, close interaction is needed among the technicians, the high levels of the legislative branch and the high levels of the executive branch. For the last two steps, interaction between technicians and members of public administration is required.

V-8 TIME USED IN PERFORMANCE OF TECHNICAL FUNCTION

It is suggested that only a short period of time be used to perform the technical function, for two reasons: (1) synchronization of the period of the plan with the period served by the high government officials so that those who make the decisions about the goals of a plan are directly related to implementation; and (2) repetition of the technical function during implementation and control which requires the results for guidance of government actions.

V-9 FINAL OUTCOME OF THE TECHNICAL FUNCTION

The final outcome of the technical preparation of a plan should be a timetable of actions to be taken, including : (1) a description of each action on both aggregate and disaggregate levels; (2) the time in which each one should be performed; and (3) who should perform them.

Since the plan is an instrument for action, it should be presented in such a way as to facilitate and encourage its use. This can be accomplished by presenting it (1) in small subdivisions, one for each organization responsible for the implementation of a part of the plan; and (2) without highly technical, lengthy details of the diagnosis and forecast of the processes planned, making it readable for those involved in its implementation.

V-10 CONCEPT OF IMPLEMENTABLE PLANS

The final outcome of the technical function can be called the published plan. This published plan will be considered implementable if there is a strong possibility of performing the actions required to achieve the targets by the levels of government responsible for their performance. The ability to take care of the implementation of the plan depends upon the following factors:

(1) Capacity as determined by public opinion,

laws, regulations, and internal organizations;

(2) Availability of physical, financial, and human resources;

(3) Will, knowledge and ability of individuals in the levels of government responsible for plan 4ch/ implementation.

The process of implementable plans is, in principle, similar to the process of preparation of technically sound plans. This involves attempts to determine whether the goals of the plan are consistent with the capacity, will, knowledge and ability of the high levels of government and of the public administration. Present inconsistencies have to be corrected by modifying the goals of the plan. In the future, discrepancies can be avoided with modification of the characteristics of the high levels of government and the public administration, in addition to modification of the goals of the plan. The preparation of implementable plans is a part of the technical preparation of the plans, emphasizing the government and administration responsible for its implementation, rather than the resources required to reach the targets.

V-11 CONTENT OF ACTUAL HEALTH PLANS

Although a plan should be a timetable of actions, health

plans in many countries of Latin America and West Africa, and of Iran, for instance, do not include any clear norms of action. A review of health plans published for the Republic of Liberia (1967-1976), Sierra Leone ((1965-1975), Niger (1965-1974), Gabon (1966-1980), and Mali (1966-1976) reveals the following contents:

(1) health situation;

(2) health organization and administration;

(3) health resources (physical and personnel);

(4) description of other health related activities;

(5) health budget in relation to other government expenditures;

(6) appraisal of the health problems;

(7) determination of relevant priorities;

(8) plan of action; and

(9) definition of plan and budget.

The "plan of action" gives a broad statement of objectives, but does not specify the actions that are required at all levels to attain the goals of the plan. In addition, background information for each country is provided, describing geography, natural resources, national economy, the political and administrative organization, and social and health legislation. Health plans contained in the general social and economic development plans for Colombia (1970-1973), Venezuela (1970-1974), Argentina (1971-1975) and Iran (1973-1978) describe the broad objectives and goals of the health sector,

outline the basic policies and guidelines for the sector, and give details of the number of hospital beds, number of physicians, and other physical and human resources, of the training programs for technical personnel, and of the budget allocations for the various health programs. In general, they are more resource-oriented than action-oriented, i.e., they are directed more to the physical and human resources required than to the actions needed to make them available and to the individuals who should perform them. They contain primarily diagnoses of the health conditions of the countries and forecasts of the health processes to be planned, but no indication of the targets or the actions needed to attain them.

V-12 SUMMARY

The technical function in health planning is viewed conceptually as a scientific model of the health processes which assists in determining:

(1) The goals of the health system and its subsystems and the targets for those outputs;

(2) The levels that the inputs of this system and subsystems should reach to attain the goals and targets; and

(3) That the input levels can and will be achieved.

The ideas about scientific models and their features introduced in the second chapter are discussed in relation to the technical function and the three models required for health planning. The various steps for performing the technical function which include selection of models to be used, collection and adaptation of statistical data, diagnosis and forecast, aggregation and disaggregation, etc. are outlined.

The final outcome of the technical preparation of a plan is described as a timetable of actions to be taken and the possibility of the implementation of the health plan is considered. Finally, the content of actual health plans of several countries is provided and its lack of action orientation noted.

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VI CHOICE BETWEEN PUBLIC HEALTH AND INDIVIDUALIZED MEDICAL CARE

VI-1.- Introduction

The instruments available to health planners to improve the health of a population can be classified into two main categories: individualized health care and public health services.

The term "health care" refers to treatment, of a single patient, whether it be through a public clinic or by a private physician after the onset of a disease in order to cure that disease or to reduce its undesireable effects. Although the individualized medical care option may sometimes provide services to those other than the victim, e.g., counseling to the parent of a sick child, for the most part the services are restricted to the patient himself, and are disease specific.

The advantage of individualized care is that health personnel, supplies, and financial resources are concentrated only on the afflicted, in the hope that all who contract a disease will be treated, regardless of the specific nature of the disease. The drawback of this approach is that the cost of disease treatment, particularly high in later stages of a disease, may prohibit adequate treatment of all victims. In addition by allocating resources to individualized treatment, diseases that could have been prevented or detected and treated in early stages may result in deaths or in the

spread of infection .

The term "public health" will be used to describe any disease control program which aims to provide services to an entire population or sub-population in order to minimize illness or death within that group, regardless of the current health status of members of that group. The services included in the public health category can be divided into two types: prevention and mass screening, each of which can be disease specific or non-specific.

Prevention, as the name implies, attempts to avoid the appearance of a disease through action taken before its onset. A disease specific prevention program, such as the U.S. Swine-flu program of 1975-76, aims to eliminate potential cases through a particular prevention device, such as vaccination. On the other hand, non-specific prevention programs attempt to control diseases simultaneously through environmental measures, such as rodent or garbage control, or host improvement steps, e.g., nutrition supplementation or personal hygiene education programs.

The major advantages of a prevention program are that if successful, deaths are minimized by reductions in the morbidity rates, and health resources are spread over the entire population. Therefore, all citizens benefit from the decrease in the number of cases of the disease, and subsequent deaths are avoided without costly treatment,

wage loss and general suffering.

Prevention programs, however, also have disadvantages. Prevention costs, although minimal at the individual level, may be quite substantial when the measures are applied to the entire population. These costs may be so high that they consume resources to the extent that treatment of those for whom public health measures have failed may not be possible. In addition, because prevention programs are usually specific to one disease or group of diseases, investment of money in them may result in the total disregard of victims of other diseases that may not be appropriate for preventive measures.

For diseases for which prevention options are non-existent or ineffective, the other public health option, mass screening, may be an appropriate method of disease control. Through its use, public health officials attempt to lessen the effects of a disease upon its victims through detection in its early, sometimes symptomless stages, in which, on the one hand, treatment is often more effective and less expensive, and on the other hand, the spread of infectious disease throughout the population can be avoided. Screening programs can be used for a single disease such as tuberculosis or cancer, or for a number of different diseases. One such multiple disease approach is the EDSPT (Early Screening for

Prevention Detection and Treatment) program which is currently in operation under the sponsorship of the U.S. Department of Health, Education and Welfare. In this program, participating low- income children are examined at specified intervals to detect any signs of illness and, if needed, treatment referrals are provided.

Like prevention, early screening programs distribute resources throughout the population, but also can be very costly. Screening programs, which have become very popular since World War II, for the most part have been unsuccessful because of these high costs and because of low detection rates.

With an unlimited availability of health personnel, facilities and financial resources, health plannners could most appropriately utilize all public health and individualized treatment options so that all disease within a society could be reduced as far as current medical knowledge would permit. However, health resources, like those in any other area, are limited; this limitation eliminates the possibility of reducing disease to the ideal minimum. In the absence of unlimited resources, the health authorities' most reasonable course of action is to use the resources available to implement the combination of alternatives that maximizes health benefits. In summary , and in applying the ideas above to health planning and policy making, the best combination of

public health and individualized medical care that can be obtained within the resources available must be selected.

In order to rationally choose the best combination of program alternatives, the health planner must identify the objectives sought by the alternatives, the benefits of each program, i.e., how much they contribute to the achievement of objectives and the costs, or the amount of resources used in the attainment of those benefits.

As observed, the health plannner must first identify the objective sought by each alternative. The basic objective of every health program is the improvement of well-being. From this point of view it can be said that before cost factors are considered, prevention programs that avoid disease should be preferred to early detection programs that minimize disease impact after its onset, and that early detection should be preferred to simple cure of advanced cases. It should be observed, however, that once the cost factors of the alternatives are considered, the actual choice of the programs might differ from that of the original preference ranking. This is particularly true if the health of all the members of the community is to be considered.

The reason for this can be seen with an example. In a costly prevention program the scarce resources available might be sufficient only to protect a small segment of the community from disease. However, if a large number of the

un-protected persons are likely to contract it, and if all resources have been expended in prevention, many members of the community may suffer severely due to non-treatment. Clearly, therefore, the choice cannot be made solely on the basis of preference; the cost of alternatives must also be taken into consideration.

Intuitvely, the health planner with resource constraints should choose the individual treatment option for diseases with low morbidity and infection rates and with treatment costs that are low in comparison with the costs of prevention. He should opt for prevention when its costs are low and morbidity and infection rates and treatment costs are high, and for screening when the differential cost between early and late treatment is significant so as to warrant an extra investment in a screening program.

There is some possibility of using the above observations as a basis to construct the numerical indices needed for selecting the health programs which are most desirable for a community. With this objective, we could select the most appropriate program in such a way so as to minimize the number of cases within the resources available. Another possibility would be to minimize the number of disability days caused by a disease.

The indices just mentioned, however, would be only rough approximations, because they would not take into

consideration the severity of the disease and its ultimate outcome. A different problem for the use of the number of sick days produced by a disease is the lack of reliable information.

Another objective that can be seen as an extension of each of the above indices, and that can be considered the common end of all health programs, is the minimization of deaths.

In addition to its clear and intutive meaning, the main advantage of using the number of deaths as an index of health service efficiency is the availability of some of the statistical data needed for its use. One of the disadvantages is that all deaths are not equally important; for instance, the death of a father of a family represents a larger social loss than the death of an infant. This type of limitation, however, can be avoided with an appropriate system of weights. Another limitation is that such an index excludes losses due to morbidity alone. This limitation is particularly important when a choice between acute and chronic disease has to be made, since the former might produce immediate deaths while the later, mainly years of suffering. Despite the disadvantages listed, for want of a better index, the minimization of deaths will be used as the objective of the different health programs.

The intuitive ideas just presented can be

operationalized with mathematical methods for decision makers. Below, the simplest, most commonly used of these methods, namely linear programming, will be applied to the following three problems: mass screening vs. individualized care, prevention vs. individualized care, and nutrition and prevention vs. individualized care. A mathematical model and a numerical example will be presented for each case.

VI-2. Mass Screening

VI-2.1.- The Model

The purpose of the early-screening model is to find the optimal number of people to participate in a disease screening program and/or treatment programs in order to minimize deaths due to the disease, given various costs and resource constraints. In developing the model, several simplifying assumptions are made. First, the problems associated with the passage of time are not embodied in the model. Second, it is assumed that all occurences of a disease are detected between the time of inception of the disease and the time of death. Other assumptions will be mentioned in the following paragraphs.

The total number of people in the target population susceptible to the disease is denoted P. Thus,

$$N1 + N2 = P$$

where N1 indicates the number of people that, according to the results of the model, should be in the screening program, and N2 denotes the number that should not be in the program.

If we assume that occurences of the disease appear randomly throughout the target population, we can say that persons both in and outside of the prevention program are equally likely to contract the disease. Thus,

$$b*N1 + b*N2 = B*P$$

where b indicates the occurence rate of the disease in the target population, and as a consequence, b*N1 is the number of persons that are affected by the disease and that should be in the screening program. The other items in the equation have similar meaning.

Below it will be assumed that all cases of the disease are eventually detected. If E indicates total number of early detections of the disease and L denotes the total number of late detections, we find that

$$de1*b*N1 + de2*b*N2 = E$$

and

$$(1-de1)*b*N1 + (1-de2)*b*N2 = L$$

where de1 is the early detection rate in the program, and de2 is the early detection rate outside of the program. Thus, (1 - de1) and (1 - de2) are the proportions of cases detected at a late stage in the disease's development.

Depending on limitations in resources, not all people

contracting the disease will be able to be treated. Thus,

$$M1 + M2 = E$$

and

$$M3 + M4 = L$$

where M1 and M3 indicate the number of early and late detected cases, respectively, which are treated. M2 and M4 denote those early and late detected cases which are not treated.

The total costs of detection and treatment must satisfy the following constraint:

$$c1*N1 + c2*M1 + c3*M3 <= R$$

where c1 is the cost per person participating in the program, c2 is the cost of treating cases which are detected early, c3 is the cost of treating cases detected late, and R denotes the total resources available for treatment and detection.

The number of deaths caused by the disease is a function of the number of persons treated and the mortality rates associated with the patients' condition upon entering into treatment. Thus,

$$T = M2 + M4 + t1*M1 + t3*M3$$

where T is the total number of deaths and t1 is the mortality rate of cases detected early and treated, and t3 is the mortality rate for cases detected late and treated. We assume that those persons who are not treated will die, i.e., the mortality rate equals 1. In summary, the model

is:

$$\text{Minimize } T = M2 + M4 + t1*M1 + t3*M3$$

Subject to:

$$N1 + N2 = P$$

$$de1*b*n1 + de2*b*n2 = E$$

$$(1-de1)*b*n1 + (1-de2)*b*n2 = L$$

$$M1 + M2 = E$$

$$M3 + M4 = L$$

$$c1*N1 + c2*M1 + c3*M3 <= R$$

VI-2.2 Choice Between Mass Screening and Treatment in Breast Cancer

Breast cancer is the leading type of cancer in incidence and as a cause of death among American women, with an occurence rate of 60 per 100,000(2). However, one in 13 women will develop it sometime during their lifetime(3). When discovered at the early localized stage, the five-year mortality rate is .16, but when detected after spread to the axillary lymph node the rate increases to .44(3). The average economic losses to a victim with a "less severe cancer," taken in this case to be an early detected one, are $18,000, and similar average losses for victims of "more severe" or later detected

cancers are $40,000. These economic losses include not only treatment costs, but expected wage loss as well(4). Because of the significant difference in both treatment costs and mortality rates, screening seems to be warranted.

The American Cancer Society and The Breast Cancer Institute have jointly sponsored a number of detection demonstration projects to test the feasibility of breast cancer screening. The early published results report that of all breast cancers detected by the program, 77% are still in the early stages as compared to the 45% rate of early cases among women with cancers detected by all other means other than the program(3). The cost of screening is $16 per woman(4).

The information above is summarized in Table VI-2.1 and can be used to apply the model in Section VI-2.1.

The results obtained from the application of the model are presented in Table VI-2.2. They show, with the data used, that to minimize the number of deaths of breast cancer patients, treatment and not mass screening for early detection should be emphasized.

TABLE VI-2.1

data

breast cancer screening program

Parameter	Description	Value
	total number of women in target population	15,000,000
de1	proportion of total cases in program detected early	.77
de2	proportion of total cases not in program detected early	.45
t1	five-year mortality rate of early detections with treatment	.16
t3	five-year mortality rate of late detections with treatment	.44
c1	cost per woman screened	16.00
c2	cost of treatment to cases detected early	18,000
c3	cost of treatment to cases detected late	40,000
D	occurence rate of breast cancer	.0006
R	resources available (10**6)	250

TABLE VI-2.2

variables to be determined

breast cancer screening program

N1	number of women in program	0
N2	number of women not in program	15.0 million
M1	number of cases detected early and treated	4050
M2	number of cases detected early and not treated	0
E	total number of early detections	4050
M3	number of cases detected late and treated	4427
M4	number of cases detected late and not treated	522
L	total number of late detections	4950
E/L	early detection/late detection	.81
T	deaths due to cancer	3119
M	deaths per 1 million target population	208

Most data are subject to statistical error, and most parameters are likely to vary, even if only slightly, from time to time. Keeping these factors in mind, it is important to evaluate the effect of changes in the parameters on the results of mathematical procedures. Because of the variability of data, only results that do not change with small or medium adjustments in the parameters should be implemented. Tables VI-2.3 through VI-2.8 show the results of sensitivity analyses in the breast cancer problem.

In Table II-3 the effect of reducing the cost per woman in a mass screening program is studied. By reducing the cost per woman screened from $16 to $10, no changes result when the total resources amount to $250 million. At $6 per woman, however, more lives are saved if enough resources are allocated to the program to screen all women (N1= 15 * 10 ** 6, N2 = 0) But, this increases the number of late detected cases (M4) which cannot be treated due to lack of resources. As program costs decrease, the number of late detected cases that are not treated diminishes to zero, while the number of deaths falls to 2020. Therefore, according to these results, mass screening should only be implemented if the cost per woman can be reduced to 50% or less of its current value.

TABLE VI-2.3

OPTIMAL SOLUTIONS AT VARIOUS PROGRAM COSTS

BREAST CANCER SCREENING PROGRAM

c1	dollars	16	8	4	2
N1	women in millions	0	15.0	15.0	15.0
N2	women in millions	15.0	0	0	0
M1	women	4050	6930	6930	6930
M2	women	0	0	0	0
E	women	4050	6930	6930	6930
M3	women	4427	131	1631	2070
M4	women	522	1938	438	0
L	women	4950	2070	2070	2070
E/L		.818	3.348	3.348	3.348
T	women	3119	3105	2265	2020
M	T/per million women	208	207	151	135

Total resources (R) = $250,000,000
Target population (P) = 15,000,000

In Table VI-4 the impact of changes in the resources available is studied. There it can be seen that with resources between 250 and 450 million dollars, all early and late detected cases would be treated, i.e., M2= M4 = 0, and there would be some resources not used for treatment that could be devoted to mass screening (N1 becomes different from zero).

The number of persons in mass screening programs(N1) increases with the increments in resources, and should cover the intire population (N1 = 15. * 10 ** 6) when resources reach about $450 million. At the same time, the ratio of early to late detections increases to the point where any additonal funds over approximately $478 million do not add to the number of lives saved.

TABLE VI-2.4

OPTIMAL SOLUTIONS AT VARIOUS RESOURCE LEVELS

BREAST CANCER SCREENING PROGRAM

R	$mil	100	250	300	350	400	450
N1	in millions	0	0	2.471	6.717	10.963	15.000
N2	in millions	15.000	15.000	12.529	8.283	4.037	0
M1	women	4050	4050	4524	5340	6155	6930
M2	women	0	0	0	0	0	0
E	women	4050	4050	4524	5340	6155	6930
M3	women	677	4427	4475	3660	2845	2070
M4	women	4272	522	0	0	0	0
L	women	4950	4950	4475	3660	2845	2070
E/L		.818	.818	1.011	1.459	2.163	3.348
T	women	5219	3119	2693	2465	2237	2020
M	T/per 348 million women	208	180	164	149	135	
slack	$ in millions					2.460	

Target population (P) = 15,000,000

In Table VI-5, the consequences of increasing the costs (c2) of treating early detected cases is studied. A first consequence is equivalent to a reduction of resources, and, as a result, the number of deaths (T) caused by cancer tends to increase. In addition, there are some changes in the allocation of resources from treatment of cases detected late (M3) to the treatment of cases detected early (M1). The reason for this is that despite the increasing cost of treating the cases detected early, this type of treatment should be preferred because its relative cost of saving lives is lower than that of treatment of cases detected late.

TABLE VI-2.5

OPTIMAL SOLUTIONS AT CHANGING EARLY TREATMENT COSTS

BREAST CANCER SCREENING PROGRAM

c2	in dollars	18,000	25,000	30,000	35,000	40,000
c3	in dollars	40,000	40,000	40,000	40,000	40,000
N1	in millions	0	0	0	0	0
N2	in millions	15.0	15.0	15.0	15.0	15.0
M1	women	4050	4050	4050	4050	4050
M2	women	0	0	0	0	0
E	women	4050	4050	4050	4050	4050
M3	women	4427	3719	3212	2706	2200
M4	women	522	1231	1737	2244	2750
L	women	4950	4950	4950	4950	4950
E/L		.818	.818	.818	.818	
T	women	3119	3515	3799	4082	4366
M	T/per million women	208	234	253	272	292

Total resources (R) = $250,000,000

Table VI-6 presents results that can be called the counterpart of those in Table VI-5, namely, the results obtained by decreasing c3, the cost of treating cases detected late. The first effect of this reduction is that resources are available to treat more late detected patients and, as a consequence, their number (M3) increases and the number (M4) of late detected not treated cases decreases, becoming zero for costs between $30,000 and $18,000. For these values, i.e., when all patients are treated, it is also possible to begin a mass screening program. This result shows once more that with the values of the parameters in Table VI-1, treatment of early and late detected cases is more efficient in reducing deaths than mass screening.

TABLE VI-6

OPTIMAL SOLUTIONS AT CHANGING LATE TREATMENT COSTS

BREAST CANCER SCREENING PROGRAM

c2	dollars	18,000	18,000	18,000	18,000
c3	dollars	40,000	30,000	20,000	18,000
N1	in millions	0	2.088	5.001	5.500
N2	in millions	15.0	12.912	9.999	9.500
M1	women	4050	4451	5010	5106
M2	women	0	0	0	0
E	women	4050	4451	5010	5106
M3	women	4427	4549	3990	3894
M4	women	522	0	0	0
L	women	4950	4549	3990	3894
E/L		.818	.978	1.256	1.311
T	women	3119	2714	2557	2530
m	T/per million women	208	181	170	169

Total resources = $250,000,000

Table VI-2-7 shows the results of increasing treatment costs simultaneously. As both treatment costs increase, resources are best diverted from the screening program to treatments in order to minimize deaths.

TABLE VI-2-7

OPTIMAL SOLUTIONS AT CHANGING EARLY AND LATE TREATMENT COSTS

BREAST CANCER SCREENING PROGRAM

c2	dollars	2000	4500	9000	18000	25000	32000	39000
c3	dollars	5000	10000	20000	40000	47000	54000	61000
M1	million	14.079	12.197	8.248	0	0	0	0
M2	millons	0.921	2.802	6.752	15.0	15.0	15.0	15.0
M1	women	6353	6392	5634	4050	4050	4050	4050
M2	women	0	0	0	0	0	0	0
E	women	6753	6391	5634	4050	4050	4050	4050
M3	women	2247	2608	3366	4427	3165	2230	1509
M4	women	0	0	0	522	1785	2720	3441
L	women	2247	2608	3366	4950	4950	4950	4950
E/L		3.005	2.451	1.674	.818	.818	.818	.818
T	women	2069	2170	2383	3119	3826	4349	4753
M	T/per million women	138	145	159	298	255	290	317

Resources (r) = $250,000,000

The continuous higher efficiency of treatment, mainly treatment of early detected cases, over mass screening is somewhat surprising. Essentially, if treatment of early detected cases is substantially more efficient than that of late treated ones, it should be appropriate to increase the number of early ones through screening. Intuitively, it can be said that early detection might be inefficient because the detection rates are low. To study this possibility, the results of increasing early detection rates in Table VI-2.8 can be used. They show that with the resources available, even with a 100% early detection rate of cancer patients, screening programs would not save lives more efficiently than treating patients detected late.

TABLE VI-2.8

OPTIMAL SOLUTIONS AT INCREASING PROGRAM EFFECTIVENESS

BREAST CANCER SCREENING PROGRAM

de1		.77	.82	.87	.97	1.00
N1	in millions	6.72	7.12	7.56	8.66	9.05
N2	in millions	8.28	7.88	7.43	6.34	5.95
M1	women	5340	5630	5956	6751	7037
M2	women	0	0	0	0	0
E	women	5340	5530	5956	6751	7037
M3	women	3600	3370	3044	2294	1963
M4	women					
L	women	3660	3370	3044	2249	1963
E/1		1.459	1.670	1.957	3.002	3.585
T	women	2465	2384	2292	2070	1990
M	T/per	164 million women	159	153	138	133

Resources (R) = $350,000,000

From the above analysis it can be concluded that

at its current costs and detection rates, mass screening is not an advisable alternative. The present costs and successes of treatment programs warrant their continued use.

The conclusion that resources should be channelled to treatment of breast cancer is consistent with previous evaluations of other mass screening programs(horowitz,1976). However, a recent article on screening for cervical cancer staunchly supports the Pap test as a cost-effective means of combating cervical cancer(schweitzer,1974). Through the use of probability analysis and decision trees, Schweitzer develops a decision rule whereby the cost of detection and possible treatment are compared to the value of additional and/ or improved life beyond the screening test. By applying this decision rule to current data, Schweitzer concludes that the Pap test is a cost-effective, one-time screening device from the viewpoint of society.

Although Schweitzer's model was not applied to the breast cancer problem due to lack of appropriate data, the results of such an endeavor might have proved interesting.

However, because of basic differences in the underlying assumptions of the two models, it would not have been surprising if conflicting results had

occurred. Two of these differences involve resources. Schweitzer assumes that resources are available to treat all disease victims if screening is implemented. The above model, however, proposes that screening expenditures limit the resources available for treatment. Secondly, in Schweitzer's model present costs are weighed against future benefits, while the linear programming model compares present costs to current resources. The third major difference lies in the effectiveness indices used. Shweitzer measures effectiveness in terms of the economic value of additional length or quality of life, the above model, in the number of deaths avoided by the health measures implemented. The pros and cons of each of these indices were discussed earlier.

In conclusion, Although both models claim to measure "cost-effectiveness" of early detection and treatment, it appears that they are measuring two different effectiveness dimensions.

VI-3-- Choice Between Prevention and Cure of One Disease

VI-3-1- The Model

In this section, the problem of choosing between preventive and curative measures in order to minimize deaths caused by one disease will be studied. Unlike the above model, where mortality rates and morbidity costs were differentiated according to the time of detection of the disease, this model assumes that the disease considered has only one average treatment cost and one average morbidity rate. Once again, problems associated with the passage of time will not be addressed.

At the risk of some repetition, two forms of the problem to be studied will be considered. Initially, a basic approach will be introduced. Some of the simplifications of this approach will be removed in the second version, but the linear relationships will be maintained.

As mentioned before, the problem to be studied in this section is the influence on the number of deaths caused by a disease of expenditures on preventive and curative measures. The basic model to be introduced allows us to see the relationships among the main variables in a rather simple way. This model does not have any practical application; however, its modification (to be introduced later) can be used in actual planning.

The following notation will be used:

P susceptible population

B total number of people affected by the disease,

(i.e., who become sick)

T total number of deaths

E(1) total expenditure in preventive measures

E(2) total expenditure in treatment of sick people

R total resources available (Datum)

$$R = E(1) + E(2) \quad (1)$$

It will be assumed that the total number of people who become sick is a decreasing function of the total expenditures on prevention. Specifically, it will be assumed that

$$B = P - s(1)*E(1) \quad (2)$$

where s(1) is a parameter that can be called the number of cases that can be avoided with an expenditure of one dollar. In the second model, the method to evaluate s(1) starting with actual data will be presented, and there we will also remove the assumption in equation (2) that every person in the population who has not been protected with a preventive measure will become sick.

Next, we will assume that the number of deaths is the following linear function of the number of people sick and the expenditures on treatment.

$$T = B - s(2)*E(2) \quad (3)$$

where s(2) is a parameter that denotes the number of deaths that can be avoided with the expenditure of one dollar. In the second model, a more detailed analysis of this equation is made along lines similar to those in equation 2.

With equations 1, 2, and 3, the problem of minimizing the number of deaths takes the following form:

Minimize

$$T = P - s(1)*E(1) - s(2)*E(2) \quad (4)$$

subject to

$$R = E(1) + E(2) \quad (5)$$

and

$$T >= 0$$

Since in practice the amount of resources available usually will not be enough to make T = 0, we will ignore the condition T > = 0 in the analysis below.

From 4 and 5 it follows that

$$T = P\ (s(1) - s(2)*E(1) - s(2)*R \quad (6)$$

and

$$0 = E(1) = R$$

Hence T will be a minimum if

$$E(1) = R \text{ when } s(1) >= s(2)$$

$$E(2) = R \text{ when } s(1) = s(2)$$

The results obtained, i.e., spend everything on the

measure with the higher returns per dollar, makes perfect intuitive sense.

The main limitation of the model just presented is that it does not include any indication of the method that should be used to evaluate the parameters s(1) and s(2) using statistical data. This limitation is removed in the model to be presented next. For this, the following notation and equations will be used:

P Susceptible population

N(1) Number of persons who should be protected with preventive measures such as vaccinations in order to minimize deaths

N(2) Number of persons who should not be protected

$$P = N(1) + N(2) \quad (8)$$

b(1) Morbidity rate among the people protected (Datum);

b(2) Morbidity rate among the people not protected (Datum);

B Total number of cases, i.e., people affected by the disease;

$$B = b(1)*N(1) + b(2)*N(2) \quad (9)$$

M(1) Number of sick persons who should be treated with curative measures in order to minimize deaths

M(2) Number of sick persons who should not be treated

$$N = M(1) + M(2) \quad (10)$$

t(1) Mortality rate among people treated

t(2) Mortality rate among people not treated

T Total number of deaths

$$T = t(1)*M(1) + t(2)*M(2) \quad (11)$$

c(1) Cost of protecting one person (Datum)

c(2) Cost of treating one person (Datum)

E(1) Amount that should be spent on prevention in order to minimize deaths

E(2) Amount that should be spent on treatment in order to minimize deaths

R Total resources available (Datum)

$$R = E(1) + E(2) \quad (12)$$

$$E(1) = c(1)*N(1) \quad (13)$$

$$E(2) = c(2)*M(1) \quad (14)$$

The problem is to determine E(1) and E(2) in such a way as to minimize T. A comparison of the two models in equations (4) and (5) with the one in equations (8) to (14) shows that they are essentially identical.

However, the number of parameters and variables needed in the second model makes it difficult to understand the basic principle introduced in the first. In order to reduce the second problem to the first the following transformations are required:

From 10 and 11

$$T = (t(1) - t(2))*M(1) + t(2)*B \quad (15)$$

From 8 and 9

$$B = (b(1) - b(2))*N(1) + b(2)*P \quad (16)$$

From 15 and 16

$$T = t(2)*b(2)*P + t(2)*(b(1) - b(2))*N(1) + (t(1) - t(2))*M(1) \quad (17)$$

And from 13, 14, and 17

$$T = t(2)*b(2)*P + t(2)*(b(1) - b(2))*E(1)/c(1) + (t(1) - t(2)*E(2))/c(2)$$

The problem reduces to minimize T in (18) subject to condition (12). This problem is equivalent to the one in equations (4) and (5) with

$$-s(1) = t(2)*(b(1)-b(2))/c(1) \quad ((19)$$

$$-s(2) = (t(1)-t(2))/c(2)$$

With (19) the solution in (7) can be applied to this case.

From equation (18) it should be clear that s(2), as defined in (19), is the number of deaths that can be avoided with the expenditure of one dollar on treatment, while s(1) is the number of deaths that can be avoided with the expenditure of one dollar on prevention of the disease, but without treating those

who fall sick. It is possible to verify directly the meanings just given to s(1) and s(2) with the following approach.

First, let us observe that from (11) we have

$$dT = t(1)*dM(1) + t(2) * dM(2) \quad (20)$$

where d denotes differentiation,

and from (9), since H is assumed to remain constant, we have

$$0 = dM(1) + d\,m(2) \quad (21)$$

Hence, from (20) and (21)

$$dT = (t(1) - t(2))* dM(1) \quad (22)$$

From (22), with dT = 1, we obtain that

$$-dM = - 1/(t(1)-t(2)) \quad (23)$$

is the number of people to be treated to avoid one death.

Since c(2) is the cost per person treated, the cost to avoid one death with treatment is

$$- c(2)/ (t(1)- t(2)) \quad (24)$$

and its inverse, i.e., s(2) is the number of deaths that can be avoided with the expenditure of one unit. A similar analysis is valid for the case of s(1).

VI-3-2- Choice Between Prevention and Treatment-Whooping Cough

In this section a numerical example of the second model in VI-3-1 will be presented.

The basic statistical data are presented in Table VI-3-1. These data refer to whooping cough in Northern Santiago, Chile, in 1963(alumnada,1965).

TABLE VI-3-1

Basic data needed to apply the model in this section referring to whooping cough in Northern Santiago, Chile, 1963

Symbol	Definition	Value
b(1)	Morbidity rate in protected population	00.45
b(2)	Morbidity rate in non-protected pop	00.60
t(1)	Mortality rate with treatment	00.01
t(2)	Mortality rate without treatment	00.03
c(1)	Cost of protecting one person	00.30
c(2)	Cost of treating one person	28.86
R	Total resources available(Escudos)	31.317

Source: Anumada,J.(et. al.) Health Planning:Problems of Concept and Method, Table 7(p.39),
Pan American Health Organization, Washington, D.C., April, 1965.

Upon application of the linear programming model introduced in the previous section, it is learned that the optimum solution will be obtained when E(1) = R= 31,317 and E(2) =0. In this case the total number of deaths that could be avoided is 470.

It is worthwhile to observe that according to the information in reference (6), the distribution of resources was E(1) = 7,158, E(2) = 24,149, and the number of deaths prevented was 124, i.e., with a planning approach, a total of 346 deaths could have been avoided.

Although the above model was useful with the whooping cough problem, in its present form, its utility is limited to allocation problems dealing with one disease with a single preventive and a single curative device. A model which will take these limitations into consideration will be presented in section 4.

For a more detailed treatment of the above model please see Chapter 11 of Reference(7).

VI-4.- Choice between Prevention and Cure when Several Diseases are Considered

VI-4.1- The Model

In this section the model for choice between prevention and cure of one disease will be expanded to consider the case when several diseases are included. With the inclusion of several diseases, the problem is not only to choose between prevention and treatment, but also the disease to which either or both of the two option should be applied to reduce deaths. In addition, now it is possible to consider methods of prevention that are not disease specific.

Perhaps the most important non-specific prevention method available is good nutrition. Adequate nutrition will be regarded as a general means of disease prevention which can be used alone or as a supplement to disease specific preventive measures such as vaccination, in the improvement of the health of a population. Nutrition also will be introduced as an influential factor towards the final outcome of an illness.

In principle, a person can deviate from "satisfactory" nutritional conditions, in an infinite number of ways. However, below it will be assumed that only one unsatisfactory status is possible. For the satisfactory and unsatisfactory nutritional conditions, precise values of morbidity and mortality rates are assumed to be known. Finally, it will be assumed that by making certain expenditures per person it is possible to supplement the diet of the population all the persons in

it will achieve the "satisfactory" nutritional level. With the explicit consideration of satisfatory and unsatisfactory nutritional conditions of the population, the question of optimum allocation of resources among better nutrition and prevention or cure of disease can be studied in detail.

Again to simplify, the analysis will be restricted to the case in which a health and nutrition plan is designed to combat three diseases. It will be assumed that there is only one specific method of prevention and one method of treatment for each of them. These assumptions greatly simplify the presentation of the model and the data needed. However, they can easily be dispensed with if necessary. As in the previous models, it will be assumed here that the objective is to minimize deaths.

To formalize the model, let

P denote the population considered for the health and nutrition plan

N(i,j) number of persons with nutritional conditions:

i = 1 satisfactory

i = 2 current unsatisfactory

and prevention status

j = 0 none

j = 1 against disease 1 only

j = 2 against disease 2 only

j = 3 against disease 3 only

j = 4	against diseases 1 and 2
j = 5	against diseases 1 and 3
j = 6	against diseases 2 and 3
j = 7	against diseases 1, 2, and 3

A first condition that must be satisfied is

$$P = \sum_{\substack{i = 1,\ldots,2 \\ j = 0,\ldots,7}} N(i,j) \quad (1)$$

The number of cases of disease k among persons with nutritional condition i (to be denoted with b(i,k)) is

$$b(i,k) = \sum_{j = 0,\ldots,7} b(i,j,k) * N(i,j) \quad (2)$$

for

where

b(i,j,k,) is the morbidity rate for nutritional condition, i, preventive care, j, and for disease, k.

As observed, only one treatment is assumed to be possible for each disease. However, this does not mean that every patient has to be treated. Actually, one possibility open to a decision-maker is not to treat some or all patients suffering from a particular disease. Denoting with M (i,k,v) the number of persons with nutritional conditions i = 1,2, disease k = 1,3 who should

be treated (v = 1), or who should not be treated (v = 2), the following constraint is obtained:

$$B(i,k) = \sum_{v=1,\ldots,2} M(i,k,v) \quad (3)$$

the number of deaths of patients suffering from the three diseases becomes

$$T = \sum_{\substack{v=1,\ldots,2 \\ k=1,\ldots,3 \\ i=1,\ldots,2}} t(i,k,m) * M(i,k,v) \quad (4)$$

where $t(i,k,m)$ is the mortality rate for persons with nutritional conditions $i = 1,\ldots,2$, affected by disease $k = 1,\ldots,3$, and with treatment $v = 1,\ldots,2$.

The above four equations 'explain' the number of deaths, but do not deal with resources needed to reduce that number. To consider this element, let $r(i,j,k,w)$ denote resources of type $w = 1,\ldots,W$, needed per person, for prevention $i = 1$, and treatment $i = 2$, for persons with nutritional level i ($i = 1,2$), and for method of prevention j ($j = 0,7$), or treatment of disease k ($k = 1,3$); and with $R(w)$ total resources of type w available. Then the following constraints can be defined:

$$R(w) > = \sum_{j=0,\ldots,7} r(1,j,k,m)*N(j,k) + \sum_{\substack{i=1,\ldots,2 \\ j=0,7}} r(2,j,k,m)* M(j,k,1) \quad (5)$$

$$(5) \quad i = 1,\ldots,2 \quad k = 1,\ldots,3$$

In the example below it will be assumed that $R = 3$,

i.e., that three resources are used to prevent or cure disease. These resources are doctors' services, nurses' services, and financial means. As a consequence, r(i,j,k,1) will be measured in minutes of doctors' time per patient, r(i,j,k,2) in minutes of nurses time per patient, r(i,j,k,3) expenditures per patient.

With the notation above, the problem of integrating health and nutritional planning reduces to that of minimizing (4) subject to the constraints in (1) to (3) and (5).

In the model presented so far, nutrition appears simply as one possible way to use the resources available to improve the health conditions of the population. However, it can also be used to study the impact of deficient nutritional conditions on morbidity and mortality. For this, it is necessary to compare the number of deaths when the population enjoys satisfactory nutritional conditions and when it does not. The first alternative is simulated in the model, assuming that the cost of satisfactory nutritional conditions is zero, and the second assuming that it is so high that none of the resources available should be used for it. Nutritional costs between these two bounds will show the impact on deaths of using some resources to improve nutrition and some to prevent or treat disease.

VI-4.2-HEALTH AND NUTRITION PLANNING-- AN EXAMPLE

The model presented above will be applied below to the planning of health and nutrition for infants and children in the United Arab Republic (Egypt).

As observed, two nutritional levels will be considered. The three diseases to be included are bronchitis, diarrhoea, and measles, which together cause 90 per cent of the deaths of children between 0-4 years of age.

Better housing and clothing are considered to be the preventive measures against bronchitis, a sanitary water supply against diarrhoea, and vaccination against measles.

The data required on morbidity and mortality rates, uses of resources, and costs were estimated, using information from different countries, different governorates of the UAR, and the opinions of health officials in that country. Data were collected in such a way as to reflect the conditions existing in 1970-73. These data are presented in Table VI-4-1.

TABLE VI-4-1

United arab Republic:

Data Used to Specify Optimum Allocation of Resources

for the Integrated Nutrition and Health Plan

No.	Equation Description	Constant	N10	N11	N12		
	objective	0.	0.	0.	0.	0.	
	Constraints						
	Population	5000 =	1.0	1.0	1.0	1.0	1.0
	Disease 1 no nutrition	0 =	.051	0.017	0.045	0.051	0.015
	Disease 1 nutrition	0 =	0.	0.	0.	0.	0.
	Disease 2 no nutrition	0 =	0.35	0.75	0.4	0.850	0.40
	disease 2 nutrition	0 =	0.	0.	0.	0.	0.
	Disease 3 no nutrition	0 =	0.70	0.65	0.68	0.90	0.63
	Disease 3, nutrition	0 =	0.	0.	0.	0.	0.
	Doctors' time	90000>=	0.	0.	2.0	0.	0.
	Nurses' time	180000>=	0.	3.0	3.0	3.0	5.0
	Financial	R > =	0.	7.15	1.0	0.018	8.15

No.	Equation Description	Constant	N15	N16	N17	N20	N21
	Objective		0.	0.	0.	0.	0.
	Constraints						
	Population	5000	1.0	1.0	1.0	1.0	1.0
	Disease 1, no notrition	0.	0.017	0.045	0.015	0.	0.
	Disease 1, nutrition	0 =	0.	0.	0.	0.039	0.013
	Disease 2, no nutrition	0 =	0.750	0.40	0.350	0.	0.
	Disease 2, nutrition	0 =	0.	0.	0.	0.300	0.700
	Disease 3, no nutrition	0 =	0.085	0.090	0.085	0.	0.
	Disease 3, nutrition	0 =	0.	0.	0.	0.650	0.600
	Doctors'time	90000 =	2.0	2.0	2.0	0.	0.
	Nurses' time	180000 >=	5.0	5.0	7.0	5.0	7.0
	Financial	R>=	7.168	1.018	8.168	c	c+7.15

No.	Equation Description	Constant	N22	N23	N24	N25	N26	
	Objective		0.	0.	0.	0.	0.	
	<u>Constraints</u>							
	Population	5000 =	1.0	1.0	1.0	1.0	1.0	
	Disease 1, no nutrition	0 =	0.	0.	0.	0.	0.	
	Disease 1, nutrition	0 =	0.0344	0.039	0.0115	0.013	0.0345	
	Disease 2, no nutrition	0 =	0.	0.	0.	0.	0.	
	Disease2, nutrition	0 =	0.350	0.80	0.87	0.70	0.35	
	Disease 3, no nutrition	0 =	0.	0.	0.	0.	0.	
	Disease 3, nutrition	0 =	0.610	0.070	0.600	0.075	0.075	
	Doctors' Time	90000 =>	0.0	2.0	0.0	2.0	2.0	2.
	Nurses' Time	180000>=	7.0	6.0	10.0	10.0	10.0	
	Financial	R>=	c+1.0	c+0.018	c+8.15	c+7.168	c+1.018	

No.	Equation	Constant	N27	T111	T112	T211	T212	T121
	Objective		0.	0.	0.	0.	0.	0.
	Constraints							
	Population	5000 =	1.0	0.	0.	0.	0.	0.
	Disease 1, no nutrition	0 =	0.	-1.	-1.	0.	0.	0.
	Disease 1, nutrition	0 =	0.0115	0.	0.	-1.	-1.	0.
	Disease 2, no nutrition	0 =	0.	0.	0.	0.	0.	-1.
	Disease 2, nutrition	0 =	0.30	0.	0.	0.	0.	0.
	Disease 3, no nutrition	0 =	0.	0.	0.	0.	0.	0.
	Disease 3, nutrition	0 =	0.075	0.	0.	0.	0.	0.
	Doctors' time	90000 >=	2.0	0.	25.	0.	25.	0.
	Nurses' Time	180000 >=	12.0	0.	32.5	0.	32.5	0.
	Financial	R>=	c+8.168	0.	6.15	0.	6.15	0.

R = 2000,5000,10000,15000,20000,25000
c = 0.,0.10,0.15,0.20,0.50,1.0,2.0,5.0,10.0

Doctors' and nurses' time did not appear to be a scarce factor in any of the analyses made on the basis of these data. This was true without assuming that additonal personnel time could be obtained by using some financial resources for that purpose. Therefore, in the following analysis attention is paid only to restrictions imposed by scarce financial resources.

Tables vi-4-2 through vi-4-4 make it possible to study the influence on morbidity and mortality rates of satisfactory and unsatisfactory nutritional conditions. They are obtained by assuming, firstly, that the cost of satisfactory nutriton is zero, i.e., that the nutritional conditions of the population are satisfactory, and secondly, that the cost of improving nutritional conditions is so high that it prohibits resource utilization for this purpose, because greater reduction of morbidity and mortality can obtained by using the resources in other ways. Table VI-4-2 shows that approximately 40 per cent of the deaths of infants and children could be avoided if their nutritional status were satisfactory. Tables vi-4-2 and vi-4-3 show how financial resources should be used. The fact that the pattern in the two tables is identical is a consequence of the assumption implicit in the data that a satisfactory nutritional status reduces in an approximately proportional way all morbidity and mortality rates. It is

likely that this assumption-- acceptable for the three diseases being considered-- will not hold true in the case of other diseases. For this reason, it should be empirically verified in each specific case.

TABLE VI-4-2

CAR: Minimum number of deaths per year among 5000 infants and children with different nutritional status and health expenditures

Health Expenditure per year	Nutritional status		
	Satisfactory (a)	NonSatisfactory (b)	100(a)/(b)
2000	238	362	65.7
5000	75	134	55.9
10000	37	61	60.7
15000	34	57	59.6
20000	31	52	59.6
25000	28	47	59.6

In the model, nutrition appears as one of the alternative ways to use the human and financial resources available. This makes it possible to study the influence on the number of deaths of different levels of expenditure needed to raise the current nutritional level of the population to a satisfactory level. The results of this analysis appear in Table VI-4-4. An increase in nutritional expenditures when part of the resources are used for better nutrition simply means less resources for other uses in health care. As a consequence, the number of deaths increases. Finally, the position is reached where the cost is too high to justify any expenditure on nutrition. Although this conclusion might seem surprising, it simply means that more lives can be saved with one monetary unit used, say, for vaccination than with one unit used for improving nutrition. The reason for this is not that the life-saving properties of nutrition have been reduced, but that their cost is too high.

rm90

TABLE VI-4-3

UAR: Number of children that should receive preventive measures and the number of patients that should be treated to minimise children's deaths (assuming satisfactory nutritional conditions)

	I	II	III	IV	V	VI
Children in population	5000	5000	5000	5000	5000	5000
Financial Resources available (Egyptian pounds)	2000	5000	10000	15000	20000	25000
Minimum no. of deaths	238	75	37	34	31	28
No. should receive no protection	0 0	0 0		0		0
No. should receive protection from 1	0	0	0	0	0	0
No. should receive protection from 2	0	0	0	0	0	0
No. should receive from 3	5000	5000	0	0	0	0
No. should receive from 1-2	0	0	0	0	0	0
No. should receive from 1-3	0	0	0	0	0	0
No. should receive from 2-3	0	0	4784	4065	3346	2627
No. should receive from 1,2,3	0	0	216	935	1654	2374
Patients of 1 that should not be treated	195	131	0	0	0	0

Patients of 2 that should not be treated	2310	0	0	0	0	0
Patients of 3 that should not be treated	350	350	0	0	0	0
Patients of 1 that should be treated	0	63	168	151	134	118
Patients of 2 that should be treated	1690	4000	1739	1703	1667	1631
Patients of 3 that should be treated	0	0	375	375	375	375

TABLE VI-4-4

Number that should receive preventive measures and number of patients that should be treated to minimize child deaths (assuming current nutritional conditions)

	Case No.					
	I	II	III	IV	V	VI
Children in the population	5000	5000	5000	5000	5000	5000
Financial resources available E lbs.	2000	5000	10000	15000	20000	25000
Minimum no. of deaths	362	134	61	57	52	47
Number should receive no protection	0	0	0	0	0	0
Number should receive protection from 1	0	0	0	0	0	0
Number should receive protection from 2	0	0	0	0	0	0
Number should receive protection from 3	5000	5000	0	0	0	0
Number should receive protection from 1 and 2	0	0	0	0	0	0
Number should receive protection from 1 and 3	0	0	0	0	0	0
Number should receive protection from 2 and 3	0	0	4880	4156	3432	2708
Number should receive protection from 1, 2, 3	0	0	120	844	1568	2292
Patients of 1 that should not be treated	255	237	0	0	0	0
Patients of 2 that should not be treated	2559	0	0	0	0	0

Patients of 3 that should not be treated	450	450	0	0	0	0
Patients of 1 that should be treated	0	18	221	199	178	156
Patients of 2 that should be treated	1691	4250	1994	1958	1922	1885
Patients of 3 that should be treated	0	0	449	446	442	439

TABLE VI-4-5

UAR: Minimum number of deaths among 5000 children when financial resources are used for health and nutrition

Resources Available (E lbs.)	Costs of Nutrition Per Person Per Year (E lbs.) .0	.10	.15	.20	.50	1.	2.	5.	10.
2000	238	267	269	270	362	362	362	362	362
5000	75	91	92	94	134	134	134	134	134
10000	37	37	37	37	42	55	59	61	61
15000	34	34	34	34	35	37	46	56	57
20000	31	31	32	32	33	34	37	51	52
25000	28	29	29	29	30	31	34	46	47

Upon review of the above models, it seems apparent that there are numerous similarities among them. All of the models are linear programming algorithms whose objective is to minimize deaths through individual treatment and public health options. Because of this the objective functions assume the same basic structure: Minimize

$$T = t1M1 + t2M2$$

where the total number of deaths equals the mortality rate for those treated times the number treated plus the mortality rate of those not treated multiplied by the number not treated. Although this specific formula is the objective function of only the second model presented, it can be easily demonstrated that the functions of models 1 and 3 are variations of it.

In the operationalization of all of the models, one should include a condition that the number of deaths to be minimized for any disease be larger than or equal to zero. Since in reality it is not possible to reduce deaths to a negative level, this result in a mathematical operation would simply mean that some resources are being wasted.

Just as the objective functions of the models are similar, the resource constraints of all of the models assume the same basic form, that the cost of all treatment options must be less than or equal to the total amount of resources available.

In addition, all of the models are static ones. However, they could be converted to dynamic ones with minimal difficulty. Unfortunately, lack of the appropriate statistical data prohibits the implementation of such models at the present time.

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alternatives, it follows that an important problem that health planners must face is the specification of the most appropriate kinds of health personnel that a country should have. This is the problem that will be studied in this chapter.

For this analysis, in Section I, a brief description of the main characteristics of the different types of health personnel are presented. In section II an attempt is made to compare their efficiency as factors in the production of health. In Section III, the information presented in Sections I and II will be used in a linear programming model for the optimal selection of health personnel.

Section I

DIFFERENT TYPES OF HEALTH PERSONNEL

VII-1 Introduction

For the purpose of this study, it will be assumed that medical personnel can be classified as follows:

1- Physicians;

2- Auxiliary personnel;

3- "Barefoot doctors";

4- Traditional medical practitioners.

These four classes are described below utilizing

information from the United States, Egypt, China, and India to illustrate the prevailing trends in health planning in developed and developing countries. In this respect, Egypt will be presented as an example of a developing country which adopted the Western health system, while India and China will be presented as examples of countries using unique traditional health systems on a nationwide basis, in addition to using western medical systems.

VII-2 Physicians

Medical education varies significantly from one country to another regarding the criteria of admission to medical school, curricula, duration of medical education, form and nature of postgraduate training. In the United States, following the Flexner report, medical education became rigid because the American Medical Association specified the courses and programs required for medical school accreditation in a detailed manner, since physicians must have graduated from only accredited medical schools to have been licensed. (Rafferty p.126).

In general, in the U.S.A., a college degree (usually B.S or B.A) is required for admission to medical school, and the duration of medical education is four years plus

one year of internship followed usually by a period of residency which may range from one to three years in some specialities.

In other countries, such as Egypt, admission to medical school is directly after the high school (12 years general education), but the medical curriculum is for six years (instead of four), followed by one year compulsory internship, and two years residency in most cases.

Physicians have traditionally occupied the top of the income hierarchy in the health field. For instance, in the United States, the median net income for solo practitioners (defined as those sharing neither income nor practice expenses) in 1966 was $29,740 (Rafferty p.47), compared to $4,272 for a practical nurse, and to $5,736 for a general duty nurse, and to $6,336 for a head nurse in the same year. (Greenfield 1969).

On the other hand, when comparing physicians' income to other nonmedical professions, we find that the median earnings (1969 dollars) were $5,100 for a service worker, $7,265 for clerical workers, and $9,151 for teachers (Statistical Abstract USA 1975).

An idea of the activities performed by physicians can be obtained from the services provided by physicians to ambulatory patients in primary health care . This type of care may be defined as the initial assessment of the patient condition. This include the area of general

practice, emergency medicine, internal medicine, pediatrics, family medicine, and obstetrics. After the initial assessment, the patient may be treated by the primary care physician or referred to the Secondary level or the more specialized types of care, e.g., cardiology, urology, surgery, orthopedics etc.

In Table VII-1 a list of the services provided to ambulatory patients in primary health care is presented. This list represents 82.6% of the activities of this type of practice. (Smith 1972).

TABLE VII-1

SERVICES PER 1000 VISITS TO AMBULATORY PATIENTS

OF VARIOUS PRIMARY CARE CENTERS, USA

SERVICES	NUMBER	SERVICES	NUMBER
PHYSICAL EXAMINATION		URINARY INFECTION	4
WELL CHILD (AGE 0-1)	40	HEART DISEASE	
WELL CHILD (AGE 1-16)	141	WITH ECG	1
ABBREVIATED	30	WITHOUT ECG	1
COMPLETE FEMALE	24	EXOGENOUS OBESITY	21
COMPLETE	55	HYPERTENTION	
COMPLETE WITH ECG	14	WITHOUT OBESITY	4
PRENATAL EXAMINATION		WITH OBESITY	2
ROUTINE	42	ELDERLY	6
WITH GENETIC COUNSELING	14	WITH ABBREVIATED PHYSICAL	2
FIRST VISIT-PREGNANCY	10	FRACTURES	18
BIRTH CONTROL RELATED PROBLEMS	10	LACERATIONS	
DESENSITISATION SHOTS	56	FIRST VISIT	4
SKIN ALLERGY	30	CHECK AND REDRESS	26
IMMUNIZATION	47	REMOVE SUTURES	20
SORE THROAT	54	MUSCLE CONTUSION	

HEMATOMA	1	BURNS	8
REMOVE EAR WAX	15	ABSCESS	8
WARTS		WOUND INFECTIONS	12
EXCISE	7	ARTHRITIS	6
FOLLOW-UP	7	ALL OTHER SERVICES	176

SOURCE: Kenneth R. Smith; Marianne Miller; Fredrick L. Holladay, "An Analysis of The Optimal Use of Inputs in The Production of Medical Services", The Jornal of Human Resources 7:209-25 (Spring 72)

It is worth mentioning that the percentage of physicians' time devoted to ambulatory care is more than 70% of their total practice time (rough estimate).

VII-3 Auxiliary personnel

"Auxiliary personnel" can be further subdivided into the following types of assistants: (ref. 1)

A- Allied health workers or traditional medical aides;

B- Intermediate-level health workers or "Physician extenders";

C- Medical technicians;

D- Nonmedical assistants.

These four types will be described below.

A- Allied health workers also known as traditional medical aides include Registered Nurses (R N), Licensed Practical Nurses (LPN), and Medical Assistants (MA). The role of these personnel is mostly limited to indirect patient care since, in real practice, they spend a relatively lesser amount of their total working time in direct contact with patients, and during the time which they spend with patients they are mostly engaged in mechanical and social tasks, and the amount of

substitution of their time for physicians' time in the area of direct patient care has typically been minimal in actual practice. Table VII-2 presents the educational background, activities, and income of these personnel.

B- Intermediate-level health workers or "Physician Extenders" include the Medices, Pediatric Nurse Practitioners (PNP), Nurse Midwives, and the Physician Assistants (PA).

During the past decade, over one hundred programs have been developed in the U.S.A. for training of the various types of Physician Extenders (Reference 1). The initial experience, duration, and level of training as well as the tasks that could be delegated differ widely among these groups. The Medix is trained to deal with medical emergencies at the site of the scene, while a Pediatric Nurse Practitioner (PNP) is trained to work side by side with the pediatrician and to perform some delegated tasks such as weighing, body measurement, vision and hearing screening, immunization. On the other hand, a nurse midwife is trained to substitute for the physician in normal deliveries and some other obstetrical and gynecological tasks while a physician assistant (PA) usually performs the following tasks: (Smith 1972).

Removing warts and follow up

Treating sore throats

Treating sinusitis

Performing well-child examinations

Treating minor burns

Treating muscle contusion (without x-ray)

Birth control counseling (in conjunction with the physician)

Table VII-2 summarizes the educational background, activities, and income of this group of health personnel.

C- Medical technicians: X-ray and laboratory technicians. The role of the former group is to utilize X-ray and electron beam equipment in order to diagnose and treat patients. They also assist in preparing and handling radioactive materials for therapy purposes. The role of the latter group is to administer the various diagnostic laboratory techniques. For educational background and income, refer to Table VII-2.

D- Nonmedical assistants such as clerical and administrative personnel. Their role may be book-keeping, processing insurance claims, filing data, secretarial work, and other similar administrative tasks.

It should be noted that the classification of auxiliary health personnel described above is used in the U.S.A. Other countries may establish different programs to train and graduate different categories of auxiliary health personnel according to the needs and resources available in each country. To illustrate this point, a brief description of the auxiliary health personnel in Egypt is presented below as an example from a developing country.

E-Auxiliary Health Personnel in Egypt:

1- Nurses

Basically the following types of nurses' training exist in Egypt:

a- The High Institute of Nursing Curriculum

This is a five year curriculum leading to a B.S. degree. Admission to this program is after completion of the high school (12 years of general education).

b- The technical secondary nurse program

Candidates are admitted after completion of the middle school (9 years of general education) and the curriculum is for three years leading to a diploma.

c- Midwives

Graduate nurses may specialize in midwifery by attending a special program for another two years. In

fact, these nurses are highly trained midwives and are usually utilized in obstetrical hospitals.

d- Assistant nurses

This program is for one and a half years after the middle school, and training is usually for one specialty (this program was abandoned recently).

e- Assistant nurse midwives

Admission to this program is after the middle school, and training is for one and a half years.

2- Allied health workers

a- Laboratory technicians, x-ray technicians, and dental technicians

The curriculum for these programs is for two years after high school leading to a diploma in these specialities.

b- Sanitarians

The curriculum for this program is also for two years after the high school.

c- Others

Such as health visitors, laboratory assistants, dental assistants, administrative assistants. The programs for those specialities are usually two years after the middle school.

Table VII-3 presents a comparison among the salaries

of the various Egyptian health personnel.

There is an important point which must be made regarding the above presentation. In the description of the possibilities of substitution among the physician, the allied health worker, and the physician extender, it should be noticed that physicians have to fully utilize their personnel. Consequently, in actual practice, physician extenders and allied health workers may be used by physicians in essentially the same way. For instance, a Physician Assistant (PA), with much less formal training than a Registered Nurse, may be delegated the same tasks as are normally delegated to the RN.

Because of this, some idea will be given here about the educational background of these groups. Table VII-2 presents a comparison between physician extenders, allied health workers, and medical technicians regarding their formal education, main activities and income.

TABLE VII-2

COMPARISON BETWEEN ALLIED HEALTH WORKERS,

PHYSICIAN EXTENDERS

AND MEDICAL TECHNICIANS

TYPE OF WORKERS	EDUCATION*	ACTIVATIES*	INCOME
ALLIED HEALTH WORKERS:			
RN'S	TYPICALLY ATTAINED A BACCALAUREATE AND OFTEN A MASTER'S DEGREE	ASSIST THE PHYSICIAN IN BED SIDE PATIENT CARE, PROVIDE SPECIALTY SERVICES WHEN REQUIRED BY INISTITUTIONAL AND COMMUNITY NEEDS. MOSTLY INDIRECT PATIENT CARE	$6,000
LPN	VOCATIONAL SCHOOL LEVEL		$3,888
MA	HIGH SCHOOL EDUCATION + ON JOB TRAINING FOR AT LEAST 6 MONTHS		$2784
PHYSICIAN EXTENDERS:			

PA	NO STANDARDIZED TRAINING ENTIRE SPECTRUM OF DIFFERENT TRAINING	RENDER DIRECT AND SPECIFIC ASSISTANCE TO PHYSICIANS IN CLINICAL AND RESEARCH WORK, TAKING MEDICAL HISTORIES, PERFORMING DETAILED PHYSICAL EXAMINATIONS, AUDITORY AND VISUAL SCREENING, AND LABORATORY TESTS.	$9216
MEDEX	ROUGHLY THE SAME AMOUNT OF FORMAL TRAINING AS THE REGISTERED NURSE		NA
PNP			NA
NURSE MIDWIFE			NA

MEDICAL TECHNICIANS:

X-RAY TECHNICIAN	VOCATIONAL SCHOOL LEVEL (12-36 MONTHS)	MAINTAINS AND SAFELY USES EQUIPMENTS AND SUPPLIES NECESSARY TO DEMONSTRATE PARTS OF HUMAN BODY ON X-RAY FILMS OR SCREENS TO DIAGNOSE DISEASES.	$3696
LABORATORY TECHNICIAN	VOCATIONAL SCHOOL LEVEL (12-24 MONTHS)	WORKS UNDER THE SUPERVISION OF PHYSICIAN, MEDICAL TECHNOLOGIST, OR PATHOLOGIST, IN PERFORMING THE MORE SPECIALIZED OR COMPLEX BIOLOGICAL, BACTERIOLOGICAL, AND CHEMICAL TESTS TO HELP	

DIAGNOSE DISEASES AND EVALUATE
EFFECTIVE TREATMENTS.

$6912

Source*: Elaborated from Allied Health Education Programs in Junior and Senior Colleges 1973 Health Planner Edition Vol. 1,2 U.S., DHEW

From the economic point of view, it was estimated by Scheffler and Stinson (Scheffler 1972) that the mean starting salary of a PA in 1972 was $10,501 while the possible gain to the physician is two or three times as much. Moreover, it has been shown by Reinhardt and Smith (1974) that "...the physician time can be reduced by 50 percent by the use of 1.5 pediatric nurse practitioner" (Rafferty 1974).

It was also estimated by Reinhardt (Reinhardt, 1972) that the marginal productivity of an auxiliary tended to increase up to the level of about one aide per physician, then diminishing, until becoming negative at a level between 5 and 5.5 aides per physician. According to this, at prevailing wages, "the average solo practitioner could profitably employ almost twice as many ancillary personnel as are currently being used, i.e., from 1.9 to 4 aides per physician" (Rafferty, p. 157).

On the other hand, Kehrer and Zaretsky (1972) found that doubling of the allied health personnel input increased the total patient visits per physician by 20 to 25% (Kehrer, 1972).

In other studies, it was shown that roughly 40% of the patients are well and about 50% of the pediatrician's patient contact time is devoted to well-child care. In addition, about 30% of the pediatrician's time is devoted to minor illnesses (Rafferty p.25).

Table VII-3

Starting Salaries Per Year

For Health Personnel In Egypt

Category of personnel	Egyptian Pound	U.S. Dollars
High Institute Nurse	300	429
Tech. Secondary Nurse	180	257.4
Midwives	198	283.14
Assist. Nurse	144	205.92
Assistant N. Midwives	144	205.92
Technicians	204	291.72
Sanitarians	204	291.72
Health Visitors	180	257.4
	Median Salary Per Year	
Physicians	3000	4290

As a consequence, one obvious direction of change is to substitute the less expensive units of health manpower (PA, PNP, etc) for the more expensive ones, especially physicians. In this respect, the tasks which are repetitive and require less training are delegated to the allied health workers or the physician extenders. Data on the characteristics that delegation takes in different specializations is available from the American Medical Association's seventh periodic survey of physicians, conducted in 1971. This survey included questions about delegation of tasks by physicians in office based practices. Ten tasks were identified in the questionnaire.

Table VII-4 presents the percentages of times these ten tasks are delegated in various specialities (Kehrer, 1974).

TABLE VII-1

MEDIAN PERCENTAGES OF TIME TASKS

ARE DELEGATED BY SPECIALITY

Speciality group	History	Instructions	Blood pressure	Immunizations	Chest x-rays	Skin grafts	EKGs	Cast	Minor sutures	Well child exam
	TASK									
General/ family practice	0.0	0.0	10.0	90.0	92.5	30.0	99.0	0.0	0.0	0.0
Internal medicine	0.0	5.0	0.0	75.0	99.0	...	99.0	...	...	...
Pediatrics	1.0	0.0	2.0	90.0	0.0	3.5	0.0	0.0	0.0	0.0
General Surgery	0.0	2.0	5.0	50.0	7.0	10.0	3.0	0.0	0.0	...

Obstetrics-gynecology	0.0	10.0	50.0	2.0	...	...	...	...	...	...
Orthopedic Surgery	0.0	5.0	0.0	0.0	0.0	3.0	...	10.0	0.0	...
Ophthal-mology	20.0	5.0	...	...	...	...	...	...	...	...
Radiology	...	...	...	...	99.0	...	...	...	...	...

Source: Kehrer,H., Intriligator,M. "Task Delegation in Physician Office Practice", Inquiry II: 292-99 (Dec. 1971).

From Table VII-4 it is obvious that the procedures which can be easily routinized are delegated more frequently than those requiring clinical judgement. Table VII-5 shows the types of personnel to whom those tasks are delegated

TABLE VII-5

PERCENT OF RESPONDENTS REPORTING THAT SPECIFIC TYPES OF AIDES MOST OFTEN PERFORM DELEGATED TASKS*

Type of Allied Health Personnel	Task: History	Instructions	Blood pressure	Immunizations	Chest x-rays	Skin prep.	EKG's	Cast	Minor sutures	Well-child exam
Registered Nurse	45.2	48.3	51.5	53.9	8.2	52.0	22.0	40.6	52.5	57.0
Licensed Practical Nurse	13.0	11.0	16.0	14.9	4.0	15.0	7.8	12.0	11.4	15.8
Nurse's aide	9.0	7.6	9.6	7.7	3.8	10.8	6.0	9.0	5.9	5.5
X-ray technician	1.2	1.4	0.5	0.2	46.2	0.3	6.5	9.0	0.5	0.1
Laboratory technician	0.3	0.6	0.7	1.8	6.4	0.3	17.9	1.6	0.0	0.6
Medical technician	4.2	4.3	4.6	4.9	3.6	5.1	8.5	4.7	5.9	6.7
Secretary	12.2	7.9	1.6	1.3	0.8	1.3	3.3	0.9	1.5	1.2
Others	14.9	18.8	15.5	15.2	26.9	15.1	28.0	22.1	13.3	13.3
Number of	1106	1481	1553	1641	1292	1149	1423	443	232	165

observations										
Response rate to question	21.8	29.4	30.6	32.3	25.4	22.6	28.0	8.7	1.0	3.3

*Respondents in all specialities are included.

Source: Kehrer,B; Intriligator,M., "Task Delegation in Physician Office Practice", Inquiry 11: 292-99 (Dec.1974)

VII-1.4 "Barefoot doctors"

"Barefoot doctors" is the name given to medical practitioners in rural mainland China. As background to the way they contribute to the health system in that country, it should be observed that the administration of Chinese rural areas falls under a hierarchy of local governments, starting with the perfecture, which is divided into several counties. A county, in turn, is divided into several communes, each covering from 15,000 - 30,000 people. A commune is further subdivided into several brigades of sizes ranging from 2,000 - 5,000 people, which is further subdivided into smaller work teams of 2000 - 8000 people (New, 1975).

The barefoot doctors (BMD's) are usally young production brigade members of the "poor and lower-middle" peasants, usually selected by their fellows or recommended by the political cadres on the basis of their willingness and their ability to serve the people. The prior education of the BMD's is minimal, and differs widely from one BMD to another. They are given a short period of training which ranges from few months to more than a year, with three to six months being the average. Table VII-6 presents the educational background, training, and medical specialities of BMD's in some selected locations. As is shown in this Table, the educational background ranges from primary education to a college level. However, as observed from this Table, the middle school level

is the most frequent one. Consequently, this level of education will be used as a term of reference throughout this chapter. In other words, the average education of BMD's will be considered here as middle school level, which is equivalent to nine years schooling, besides a period of training of about six months.

							Coordinator of Obstetric training
Number 6	30	F	Middle Sch. Grad.	1965	4 mos.	Immunization, Sanitation, Propaganda	
Number 7	34	F	1 yr. Middle Sch.	1968	6 mos.	Western Pharmacy	
Number 8	35	F	Primary	1967	1 yr.	Obstetrics	
Number 9	35	M	4th grade	1969	2 mos.	Accounting	
Number 10	39	M	1 yr. College	1970	None	Chinese Medicine	Learned from father's friend
Man-Fan (Peking)							
Number 1	22	F	Middle School	1968	6 mos.	-	Worked at home for the area in the commune
Number 2	26	F	Middle School	1967	13 mos.	-	Worked at Religious clinic
Number 3	29	F	Middle School	1967	6 mos.	Midwife	
Hsi-Ch'ang-An street (Peking)							
Number 1	38	F	3rd Grade	1970	4 mos.	-	Semiliterate
Number 2	44	F	Middle Sch. Grad.	1970	1 mos.	-	Apprentice to physician

TABLE VII-6

FORMAL EDUCATION, TRAINING, AND MEDICAL SPECIALITIES,

OF 25 BMD'S IN SELECTED LOCALITIES, CHINA, 1973

COMMUNE	AGE	SEX	EDUCATION	BECAME BMD	LENGTH OF INITIAL TRAINING	SPECIALTY	OTHER DATA
July 1 (Shanghai)							
Number 1	24	M	1 yr. Middle Sch.	1968	3 mos.	-	
Number 2	26	F	Primary	1964	2 mos.	-	From Bourgeois Background
Number 3	26	M	Middle Sch. Grad.	1966	1 mo.	-	
Number 4	28	F	Middle Sch. Grad.	1963	3 mos.		
Evergreen (Hangchou)							
Number 1	24	M	Middle Sch. Grad.	1968	3 mos.	Laboratory	
Number 2	26	F	Primary	1965	3 mos.	Cashier	
Number 3	26	M	Primary	1968	3 mos.	Chinese Herbs	
Number 4	27	M	Middle Sch.Grad.	1963	3 yrs.	Western Med.- Surgery	Is surgeon in the Commune Hospital
Number 5	29	F	Middle Sch. Grad.	1971	none	Administration	Not trained as BMD;

Number 3	49	F	none	1970	4 mos.	-	Illiterate
Number 4	50	F	Primary	1970	4 mos.	-	
August 1 (Shen Yang)							
Number 1	25	F	Middle School	1968	2 yrs.	-	Grad. of School of Public Health
Number 2	27	M	Middle School	1968	2 yrs.	-	Grad. of School of Public Health
Number 5	32	F	Middle School	1965	9 mos.	Midwife	Does IUD insertions
Number 6	49	F	Primary	1963	3 mos.	Midwife	Does not insert IUD

SOURCE: Elaborated from Peter Kong-Ming New and Mary Louie New ; "THE LINKS BETWEEN HEALTH AND THE POLITICAL STRUCTURE IN NEW CHINA", HUMAN ORGANISATION, Volume 34, Number 3, Fall 1975.

In-service training is usually given when needed or feasible. It can be conducted by physicians at city or commune hospitals, or sometimes by medical teams consisting of MD's and BMD's from the Red Army or even by some experienced barefoot doctors from other communes, in some circumstances. In general, there is no national or regional professional standard for selection and training of BMD's (Hsu, 1974),

BMD's spend approximately half of their time doing medical work in various health clinics placed throughout the commune, and the other half working in the fields as farmers or in the factories as workers.

The barefoot doctors' medical duties vary from one commune to another and even from one brigade to another within the same commune. In general, they are able to treat about 70% of the patients they see, and refer the others to medical doctors (Quinn). They usually use a combination of Chinese herbs, acupuncture, and Western medications. Some of them can perform vasectomies, insert intrauterine devices (I.U.D's), and remove some types of tumors (Kong-Ming, 1975).

Because the Chinese program emphasises disease prevention and health education as the primary function of BMD's (Hsu, 1974), the responsibilities of the BMD's can be classified into the following categories:

a- Disease prevention

includes:

1- Environmental sanitation.

2- Health education.

3- Immunization.

b- Aspects of patient primary health care (defined before)

Includes:

1- First aid.

2- Initial assessment of the patient condition.

3- Administering treatments.

4- Referral of cases to MD's when needed.

c- Post-illness follow-up by means of home visits in order to monitor the effect of treatment given to the patient and to detect any late complications or recurrence of disease as early as possible

d- Other patient-related services

Includes:

1- Providing continued contact with the patient and often his family.

2- Acting as the patient advisor in the area of health care.(Health Services Research, 1975).

As stated in the 1968 China Medicine (Sidel, 1972) "All of them can prescribe around a hundred medical preparations and diagnose and cure around a hundred common ailments of frequent occurrence in the country side...some of them have shown greater ability in practical work than some of the doctors in the commune clinic, who are graduates of medical school but lack practical experience".

It is worth mentioning that each BMD, after completion of

his primary training, is given a "Barefoot Doctor's Manual" which may differ from one region to another, depending on the relative importance of diseases in each region (Hossain, 1974). The manual serves as a reference to the BMD's for diagnosing and treating their patients. A list of diseases discussed in one of these BMD's manuals is presented in appendix "A". (Running Press, 1977).

As already mentioned, the BMD's are usually able to treat about 70% of the patients they see. The spectrum of diseases which they can treat varies according to prevalent diseases in the region in which they receive their training. For the purpose of this study, a trial is made to specify among the tasks performed by physicians and presented in Table VII-1, those that BMD's can also perform. This is presented in Table VII-7. This Table is only an educated guess at the services which may be performed by BMD's in a primary care facility.

TABLE VII-7

AN EDUCATED GUESS ON THE SERVICES WHICH MAY BE PERFORMED BY BMD'S IN A PRIMARY HEALTH CARE FACILITY

Services usually performed by MD's	Performed by BMD's	Services usually performed by MD's	Performed by BMD's
Physical examination		Urinary infection	+?
Well child (age 0-1)	+	Heart disease	
Well child (age 1-16)	+	With ECG	-
Abbreviated	+	Without ECG	-
Complete female	-	Exogenous obesity	+
Complete	+?	Hypertention	
Complete with ECG	-	Without obesity	+?
Prenatal examination		With obesity	+?
Routine	+?	Elderly	+?
With genetic counseling	-	With abbreviated physical	+?
First visit-pregnancy	+?	Fractures	+?
Birth control related problems	+	Lacerations	
Desensitisation shots	+	First visit	+
Skin allergy	+	Check and redress	+
Immunization	+	Remove sutures	+
Sore throat	+	Muscle contusion	

Otitis externa and media	+	With x-ray	-
Sinusitis	+?	Without x-ray	+
Thrombophlebitis	+?	Muscle pain	+
Bunions	+	Burns	+
Remove ear wax	+	Abcess	+
Warts		Wound infections	+
Excise	+	Arthritis	+
Follow-up	+		

+ sign = the service can be done by DMD's

+? sign = the service may be done by DMD's, but the quality of performance is questionee.

- sign = cannot be done by DMD's

Source: List of services is taken from Colladay, Frederic L.; Hunter, Marilyne L.; and Smith, Kenneth R. "Dental Economics in the Delivery of Medical Care: A Mixed Integer Programming Analysis of Efficient Manpower Utilization", Journal of Human Resources 9:50-62 (winter 1974). Whether they can be performed by DMD's was specified by authors after consulting one of the DMD's manuals and from the information presented in references (11-15)

Regarding the income of BMD's, communes pay for their services through funds that they collect from their residents. The BMD's monthly salary differs from one commune to another with an average equivalent to $20 to $60 per month. This is slightly higher than the average farm worker's salary. In some communes, the BMD's salary is equivalent to other farm workers' salaries (New, 1975).

In comparison, the monthly salary of personnel with similar training in the U.S.A., may be as low as $230 in the case of medical assistants, or as high as $768 in the case of physician assistants (1971 estimates).

VII-1.5 Traditional medical practitioners (TMP's)

In virtually every developing country, and even in some of the most advanced ones, providing adequate medical care is considered a major problem. Due to the scarcity of qualified health personnel (WHO, 1968), the vacuum is usually filled by traditional or indigenous medical practitioners (TMP) that at worst are practicing without any medical training, and at best have some information of traditional medical practices, many of them without scientific basis. However, due to their immediate availability and ability to sell themselves, they have managed to gain the confidence of the populace they serve. Many countries, such as Turkey (Taylor), have formally outlawed

TMP's. Moreover, others are considering the possibility of using traditional or indigenous medicine practitioners for medical care mainly in rural communities. Examples of these countries are: India, Iran, Tanzania, Guatemala, and Cuba. (Newell, 1975).

The extent of using TMP's is likely to differ widely from one country to another depending on the cultural and supporting institutional and social structures of each. India has tried to strengthen and standardize the teaching of indigenous medicine througnout the country. A brief historical note will help explain the strength of this system of medical care in India today. The Ayurvedic system of medicine ("Science of Knowlege of Life") originated in India more than 3000 years ago as a part of the Hindu religion. It is concerned with the whole of life, with emphasis on the spiritual aspects of healthful living. This system was emphasized by the Indian Universities as early as the second century B.C. During the Moghul period, the Unani medicine was introduced. The Hakimes (who practice the Unani System) are still numerous in India and practice a combination of Ayuvedic and Arab Systems of Medicine. Moreover, modern medicine was introduced to India during the period of British colonization. Starting around the 1920's, efforts have been made to revive and modernize the complex system of Ayurvedic medicine by establishing programs leading to diplomas. The length of the programs range from two to five years with an average of three years. Moreover, a

period of formal training and apprenticeship ranging from a few months to five years was not uncommon.

Regarding their basic education, it was shown in one study at two regions in India that half had completed middle school, and about forty percent had completed high school. Regarding their income, it was shown in the same study that the average fee paid to TMP's for their services was about two Rupees per visit. However, the number of visits varies widely from one TMP to another, and there is no available estimate given. (Neuman, 1971).

On the other hand, in other countries TMP's may not have any basic education or formal training. Examples are the needleman in Turkey, the Curandero in Latin America, and the Witch doctor in Africa. However, all of them should have a period of apprenticeship to other TMP's in order to be trained. Many of these TMP's may be trained by means of formal programs and function as medical workers who give emergency care and treat minor illnesses.

The differences between TMP's and BMD's are mainly that the latter group shows total devotion to the health of their people, without thought of any personal material gain. This should be one of the main points emphasized during the training of the TMP's. Moreover, BMD's are not totally committed to medical services only; they also perform other duties as farmers or factory workers.

SECTION II

VII-2 A COMPARISON OF THE EFFICIENCY OF DIFFERENT TYPES OF HEALTH PERSONNEL

In order to specify the type or types of health personnel that should be formed in a country, it is necessary to have some idea about the health problems of that country.

In general, it can be said that acute, infectious, and parasitic diseases are still the main threat to health in developing countries. (Furnia).

One of the criteria that should be used to decide the type of health personnel that should be used is their capacity to combat disease. To do so, some idea of the diseases they are likely to treat has to be presented first. This will be done in Section II-1. A comparison of the impact that the different types of health personnel are likely to have is presented in Section II-2.

VII-2.1 Some observation on the health problems of a typical developing country

To demonstrate the health problems of developing countries, some of the health problems of Egypt are presented here. In this regard, an attempt is made to delineate diseases

of critical importance to the health of the Egyptian populace.

1- Schistosomiasis: this is regarded by almost all public health officials in Egypt as the most serious health problem. The prevalence of this disease is on the increase despite all the efforts and the costs envolved in its control. The cause of the increasing prevalance of this disease is attributed to the change in the irrigation system after the High Dam. It was estimated in the 1960's that 60% of the population was infected with Schistosomiasis. It was also estimated that one in every 22 Egyptians in the Northern part of the Delta died of this disease, in which the patient is condemned to live in growing pain and exhaustion, and in most cases this exhaustion limits the productivity of the individual to the extent that the work day is reduced to only three hours.

2- Gastrointestinal diseases: This group of diseases includes intestinal parasites, diarrheal diseases and dysenteries. Among these diseases, acute gastroentritis is the second major public health proolem in Egypt. Generally speaking, this group of diseases are due to inadequate sanitary conditions and lack of health education.

3- Diseases of infancy and childhood: the most important disease in this group is infantile diarrhea, which accounted for more than half the deaths of infants in rural areas during the sixties. Other diseases are measles, mumps, whooping cough, chickenpox, and German measles. These diseases usualy occur in periodic epidemics.

4- Typhoid and Paratyphoid Infections: these diseases are still frequent in Egypt, with an estimated annual rate of 1500 cases per 100,000 population.

5- Malaria: by 1973-74, the incidence of malaria was approximately 10,000 cases. Plasmodium vivax is the cause of the majority of the cases.

6- Trachoma: although this disease does not cause death, it is responsible for total blindness or impairment of eyesight in a large portion of the population.

7- Tuberculosis: although the incidence of this disease has declined substantially since 1960's, it is still considered one of the endemic diseases in Egypt.

VII-2.2 The impact of the various types of health personnel

on the health of the population:

Because the diseases which constitute the major health problems are not necessarily the leading causes of death, an attempt is made here to separate these two issues. Table VII-8 presents the significant Egyptian health problems and compares the impact of utilising the services of physicians only, BMD's or TMP's only (when they are used), or a combination of them on the estimated case fatality rates of these diseases. From this Table it is obvious that the most important health problems in Egypt are the parasitic and the

Diphtheria (032)	235	90-100	10-30	10-30	25-50	
Typhoid paratyphoid (001)	523	20-100	3-20	3-20	10-50	
Malaria (084.9)	16	1-5	.3-1	.3-1	.5-1.5	
Trachoma (076)	0	0	0	0	0	
Tuberculosis (011.9)	2452	90-100	15-35	15-40	50-80	
Meningococcal meningitis (320.8)	251	80-100	7-30	7-35	40-70	
Acute respiratory diseases:						
pneumonias (480-85)	14391	80-95	5-30	5-35	10-50	
Bronchitis (490)	9438*	5-20	.5-5	.5-5	1-7	
Hepatitis (573.0)	420*	5-25	2-4	2-4	5-10	
Rheumatic heart disease (394-397)	8162	20-50	1-10	1.5-15	5-20	within 10 years
Hypertention (400-404)	12137	100	50-55	50-60	60-80	within 20 years
Ischemic heart disease (410)	6699	80-90	1-15	1-25	5-50	within 5 years
Malignancy of all types	7114	100	10-60	10-70	99-100	within 5 years

** International classification of disease 1965 version.

* Estimated numbers - Other numbers are reported deaths, EGYPT, 1973.

Number)**	number of deaths	ESTIMATED DEATHS PER 100 CASES OF DISEASE with no medical attention	with only MD's	with MD's+ BMD's or or TMP's	with BMD's or TMP's	Notes
asis (120)	1400*	80-90%	1-5%	1-5%	1-8%	within 20 y
estinal diseases:						
rms (362)	600*	1-5	0.1-1	0.1-1	0.1-1.5	
entritis (009.2)	1096*	30-60	1-10	1-10	1.5-15	
ry (009.0)	6	30-50	1-10	1-10	1.5-15	
infancy childhood:						
ile diarrhea)	1100*	50-70	5-15	5-15	10-25	
s (055)	825	5-50	1-15	1-15	5-25	
(072)	5*	1	.002-.1	.002-.1	.002-.2	
ng cough (033.9)	21	30-60	.5-20	.5-20	5-30	
npox (052)	2*	2	.01-.5	.01-.5	.5-1	
measles (056)	15*	5-30	1-10	1-10	5-15	

acute infectious diseases, most of which are preventable through environmental sanitation, health education, and immunization; tasks which could be achieved with very satisfactory results using well trained TMP's or BMD's. On the other hand, the increase in the case fatality rate as a result of substituting physicians by TMP's in treating the diseases presented above seems reasonable in most cases.

Table VII-9 compares the impact of substituting physicians by TMP's (or BMD's) on the case fatality rate of the ten leading causes of death in Egypt (classified according to the abbreviated international list, 1965 revision).

ESTIMATED DEATHS PER 100 CASES OF DISEASE

	number of deaths	with no medical attention	with only MD's	with MD+ others	with BMD's or TMP's	Notes
...other diseases						
...of 240-738)	167,549**					
...testinal disorders:						
...enteritis and colitis						
...ulcerative of non infectious						
...(561)	15448	30-60%	1-10%	1-10	1.5-15%	
...itis (567)	5149	50-90	1-10	1-12	5-50	
...subacute necrosis						
...liver (570)	5149	100	80-90	80-90	80-95	
...ative hepatitis and						
...abcess (572)	5149	95-100	20-50	20-60	90-95	
...tory diseases:						
...bronchitis	10298	15-60	.5-5	.5-6	1-8	

Encephalitis and encephalomyelitis (323)	5406	100	40-100	40-100	80-100	
Multiple sclerosis (340)	2318	100	80-100	80-100	[illegible]	[illegible]
B 45- SYMPTOMS AND ILL-DEFINED CONDITIONS (780-796)	104,428**					
INCLUDES:						
COMA (780)	23206	85-100	5-60	5-65	40-80	
CONVULSIONS (780.2)	23206	80-100	5-60	5-65	40-90	
ENCEPHALOPATHY (781.7)	34809	90-100	50-60	60-65	60-85	
ACUTE HEART FAILURE, UNDEFINED (782.4)	23206	50-80	25-30	30-40	50-60	
B 33-BRONCHITIS, EMPHYSEMA, AND ASTHMA	28,316**	20-50	1-5	1-6	2-10	[illegible]
B 44-OTHER CAUSES OF PERINATAL MORTALITY	22,062**					
Includes:						
Chronic circulatory and genitourinary disease in mothers (760)	3860	60-80	1-10	5-15	20-40	
Maternal ante- and intra-partum infections (763)	7721	70-90	1-10	1-12	5-20	
Other complications of pregnancy and childbirth (769)	1655	20-60	1-5	1-6	40-50	
Conditions of umbilical cord (771)	1655	60-90	5-10	5-10	5-10	
Termination of pregnancy	3860	5-10	.1	.1	.2	

And bronchiolitis (466)					
Empyema (510)	4577	10-30	.5-2	.5-2.5	1-1.5
Lung abcess (513)	4577	15-50	.5-5	.5-6	1-8
Pulmonary collapse (519.0)	4577	100	1-2	1-2.5	80-100
Other diseases of the lungs (519.2)	6865	10-90	1-5	1-6	2-10
- Urinary diseases:					
Hydronephrosis (591)	7724	80-100	20-60	20-65	80-100
Calculus of kidney And ureter (592)	3862	20-80	1-5	1-7	50-60
Acute tubular nephrosis (593.1)	3862	20-80	5-30	5-35	20-50
Urinary tract infections (599.0)	15448	10-20	0-2	0-2.5	1-5
Diseases of arteries and veins:					
Arteriosclerosis (440)	2574	80-90	20-40	20-50	50-70
Arterial embolism and Thrombosis (444)	5149	90-100	20-100	20-100	80-100
Pulmonary embolism and Infarction (450)	5149	100	80-100	90-100	100
Portal vein thrombosis (452)	2574	100	60-90	60-90	100
Diseases of the nervous system:					

(773)						
Immatutity, unqualified (777)	1655	90-100	10-30	10-45	90-100	
Fetal death of unknown cause (779)	1655	100	70-80	70-85	90-100	
BE 49- SUICIDE AND SELF INFLECTED INJURIES	16,167**	95-100	10-50	15-60	30-80	
B 29- OTHER FORMS OF HEART DISEASE (420-429)	15,005**					
Includes:						
Acute and subacute endocarditis (421)	2500	100	40-100	50-100	100	
Acute myocarditis (422)	2500	100	25-100	30-100	100	
Pulmonary heart dis.(426)	3751	60-80	30-35	35-40	60-70	within 5 years
Congestive heart failure(427)	3751	50-60	20-25	25-30	40-50	within 5 years
Ill-defined heart dis.(429)	2500	20-30	5-10	5-15	15-20	within 10 years
B 32- PNEUMONIA (480-486)	14391**					
Includes:						
Viral pneumonia (480)	2878	40-60	25-30	25-40	25-50	
Pneumococcal pneumonia (481)	5756	20-40	5-17	5-25	5-35	
Bronchopneumonia (458)	5756	30-50	25	37	40	
B 27- HYPERTENSIVE DISEASE (400-404)	12,137**					
INCLUDE:						
MALIGNANT HYPERTENTION (400)	2427	100	55	60-65	60-80	within 20 years
ESSENTIAL HYPERTENTIUN (401)	2427	90	50	55-60	55-75	within 20 years
HYPERTENSIVE HEART DIS.	2427	95	55	60-65	65-85	

(402)/						
HYPERTENSIVE RENAL DIS.	2427	95	55	60-65	65-85	within 20 years
(403)						within 20 years
HYPERTENSIVE HEART AND RENAL DISEASE (404)	2427	100	55	60-65	65-85	within 20 years
B26- CHRONIC RHEUMATIC HEART DIS. (393-398)	8,162**					
INCLUDES:						
DIS. OF MITRAL VALVE (394.0)	3060	20-50	1-5	1.5-7.5	10-30	within 10 years
DIS. OF AORTIC VALVE (395)	1530	30-60	5-10	7.5-15	20-40	within 10 years
DIS. OF TRICUSPID VALVE (397.0)	1530	25-55	5-10	7.5-15	20-40	within 10 years
B19- MALIGNANT NEOPLASMS INCLUDING THOSE OF LYMPHATIC AND HAEMOPOIETIC TISSUE (140-209)	7114**	100	10-60	15-90	30-100	within 5 years

** REPORTED DEATHS, CLASSIFIED ACCORDING TO THE ABBREVIATED INTERNATIONAL LIST, 1965 REVISION

SOURCE: UNITED NATIONS DEMOGRAPHIC YEAR BOOK 1975 - OTHER NUMBERS ARE ESTIMATED DEATHS.

As can be observed from Tables VII-8 and VII-9, the impact of substituting physicians by TMP's on the case fatality rate is greater in case of the leading causes of death (Table VII-9) than in the case of the important health problems (Table VII-8). This may be attributed to the fact that the former group of diseases requires more sophisticated techniques for diagnosis and treatment than the TMP's or the BMD's are trained to handle. However, it is clear from Table VII-8 that the TMP's (or the BMD's) can handle most of the diseases which constitute the major health problems, and which contribute to the marked decline of the population productivity.

Regarding the preparation of Tables VII-8 and VII-9, it is to be noted that since the case fatality rate of any disease differs widely according to many factors such as the type and nature of the disease, the age of the patient, the virulance of the organism, the physical condition of the patient and his body resistance, occurrance of complications, presence of other diseases, effectiveness of a given treatment, availability of medical and hospital facilities, social and economic factors related to the patient, environmental factors, etc., an accurate estimate of this rate requires a good system of reporting of all cases of disease, all deaths, and standardized reporting of the cause of death.

However, for the purpose of this study, and because of the

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However, for the purpose of this study, and because of the

lack of statistical informations, an attempt is made to estimate the case fatality rates of the diseases presented in Tables VII-8 and VII-9 based on clinical experience in Egypt and on the discussions presented about those diseases in references (21-26).

At the same time, it is emphasized here that the figures presented are still rough estimates that are useful as illustration of the data needed.

SECTION III

VII-3 A MODEL FOR THE OPTIMAL CHOICE OF HEALTH PERSONNEL

VII-3.1-Presentation of the Model

In the previous section, it has been observed that the different types of health personnel have different impacts on the health prospect of patients of different diseases. It will be assumed in this section that health decision makers can select the type of health personnel that is most efficient to a country or a region. The most efficient health personnel will be considered here to be the one that minimizes the number of deaths.

the model above are the following:

(1) The death rate per 1000 population per year without using any medical service.

(2) The death rate per 1000 population per year when using the ith type of medical personnel, where i = 1,...,N.

(3) The cost per person of using the ith type of medical personnel per year where i = 1,...,N.

(4) The total resources available for one year.

Table VII-10 summarizes the data needed to solve the model in equations (5) through (7).

For the purpose of illustrating the data needed, the death rate per 1000 population of the United States (9.4) is used, and an assumption is made that this death rate will double when using BMD's only (18.8); it will be one and half times its original value (14.1) when using a combination of BMD's and MD's; and it will reach three times its original value (28.2) with no medical attention.

In this section, only an aggregate model will be presented, that is, a model in which only the average mortality rates of the population are considered. A more realistic model would consider seperately each of the different diseases that affect the population of a country, their incidence and the deaths that they cause. Such a model is perfectly feasible with the mathematical methods presently available, and it would be advisable in actual practice. However, for instructional purposes, it is more convenient to use the aggregate model that includes the essential points and is much easier to understand. In the consideration of the model, it will be assumed that there are N (where N is a positive integer) different categories of health personnel that can be used to deliver the health services. Each category will be designated with a number that ranges from 1 to N. Only the effect of each method on the mortality rate of the population is considered; that is, the differences in effectiveness of the methods of delivering the medical care, for example, when patients having different socio-economic status use them, are not considered. Finally, only the personnel costs of using those methods of delivering the medical care are considered. The costs of medicines, equipment, and facilities are excluded.

To present the model, the following notations will be used:

Beta(i): yearly death rate per 1000 persons

i = 0 without medical care

TABLE VII-10

DATA NEEDED TO SOLVE THE MODEL

(I)	Type of medical personnel	death rate per 1000 Beta(I)	cost per person
0	No medical service	28.2	0
1	MD's	9.4	20.752*
2	MD + assistant	9.4	14.649*
3	BMD's	18.8	3.19**
4	BMD + MD	14.1	7.58**

*Elaborated from Kenneth R. Smith; Marianne Miller; Fredrick L. Golladay "An Analysis of the Optimal Use of Inputs in the Production of Medical Services," The Journal of Human Resources, Vol. VII No.2 (Sprin, 1972).

**Estimation based on the salary of workers in the U.S.A. with an average number of years of education and training similar to BMD's.

Resources are assumed to be $700 million, that is

R = 700 * 10 ** 6 (100 million)

In this section, only an aggregate model will be presented, that is, a model in which only the average mortality rates of the population are considered. A more realistic model would consider seperately each of the different diseases that affect the population of a country, their incidence and the deaths that they cause. Such a model is perfectly feasible with the mathematical methods presently available, and it would be advisable in actual practice. However, for instructional purposes, it is more convenient to use the aggregate model that includes the essential points and is much easier to understand. In the consideration of the model, it will be assumed that there are N (where N is a positive integer) different categories of health personnel that can be used to deliver the health services. Each category will be designated with a number that ranges from 1 to N. Only the effect of each method on the mortality rate of the population is considered; that is, the differences in effectiveness of the methods of delivering the medical care, for example, when patients having different socio-economic status use them, are not considered. Finally, only the personnel costs of using those methods of delivering the medical care are considered. The costs of medicines, equipment, and facilities are excluded.

To present the model, the following notations will be used:

Beta(i): yearly death rate per 1000 persons

i = 0 without medical care

i = 1,...,N with medical attention from personnel (i).

Alpha(i): deaths avoided per 1000 persons when attended by personnel (i). As a consequence,

Alpha(i) = Beta(0) - Beta(i), i = 1,...,N

X(i): number in thousands of persons who should be treated by personnel type (i) to maximize deaths avoided.

C(i): cost of treating one patient by personnel type (i).

R: total financial resources available (in 1000 dollars).

P: total number of persons in the population.

With the notation above it can be said that

Alpha(i) * X(i) i = 1,...,N

is the number of deaths avoided with treatment by type (i), and

Z = Sum Alpha(i) * X(i)

i = 1,...,N

is the total number of deaths avoided.

Similarly,

C(i) * X(i)

i = 1,...,N

is the total cost of treating patients by utilizing type (i) of medical personnel and

Sum C(i) * X(i)

i = 1,...,N

is the total cost of treating patients with the different types of medical personnel.

Similarly,

$$\text{Sum } X(i)$$
$$i = 1,\ldots,N$$

is the total number of persons treated.

With the notation above the problem of selecting the most appropriate type of health personnel becomes that of maximizing the total number of deaths avoided, i.e.; maximizing

$$Z = \text{sum Alpha}(i) * X(i) \qquad (1)$$
$$i = 1,\ldots,N$$

subject to the resource constraint

$$\text{Sum } C(i) * X(i) <= R \qquad (2)$$
$$i = 1,\ldots,N$$

to the population constraint

$$\text{Sum } X(i) <= P \qquad (3)$$
$$i = 1,\ldots,N$$

and to the non negati ity constraint

$$X(i) >= 0 \qquad (4)$$
$$i = 1,\ldots,N$$

It is interesting to obtain the algebraic solution of the problem above, assuming that only the resources $to-2 constraint 's binding, and that there are only two types of medical personnel. With this, the problem becomes :

Mazimize:

$$\text{Alpha}(1) * X(1) + \text{Alpha}(2) * X(2) \qquad (5)$$

subject to:

$$C(1) * X(1) + C(2) * X(2) = R \qquad (6)$$

from the constraint (6) one obtains :

$i = 1,\ldots,N$ with medical attention from personnel (i).

Alpha(i): deaths avoided per 1000 persons when attended by personnel (i). As a consequence,

$$\text{Alpha}(i) = \text{Beta}(0) - \text{Beta}(i), \quad i = 1,\ldots,N$$

X(i): number in thousands of persons who should be treated by personnel type (i) to maximize deaths avoided.

C(i): cost of treating one patient by personnel type (i).

R: total financial resources available (in 1000 dollars).

P: total number of persons in the population.

With the notation above it can be said that

$$\text{Alpha}(i) * X(i) \qquad i = 1,\ldots,N$$

is the number of deaths avoided with treatment by type (i), and

$$Z = \text{Sum}_{i=1,\ldots,N} \text{Alpha}(i) * X(i)$$

is the total number of deaths avoided.

Similarly,

$$\text{C}(i) * X(i)$$

$$i = 1,\ldots,N$$

is the total cost of treating patients by utilizing type (i) of medical personnel and

$$\text{Sum}_{i=1,\ldots,N} \text{C}(i) * X(i)$$

is the total cost of treating patients with the different types of medical personnel.

Similarly,

$$X(1) = (R-C(2)*X(2))/C(1) \qquad (7)$$

Replacing (7) in (5) and simplifying, one obtains the following expression for deaths avoided :

$$Z = Alpha(1) * R/C(1)$$
$$+ (Alpha(2) - Alpha(1) * C(2)/C(1)) * X(2) \quad (8)$$

From equation (8) it follows that the total number of deaths avoided will be maximized if:

$$(Alpha(2) - Alpha(1) *C(2)/C(1)) > 0 \qquad (9)$$

and X(2) is made as large as possible; or if the coefficient of X(2) is negative, making X(2) = 0

From the observation above, the interpretation of the coefficient of X(2) in (8) becomes crucial. From (9), it follows that X(2) should be maximized if:

$$C(1)/Alpha(1) > C(2)/Alpha(2) \qquad (10)$$

Since C(2) is the cost per person treated by personnel type 2; 1000 * C(2) is the cost to treat 1000 persons. With the attention to 1000 persons, Alpha(2) deaths are avoided. This means that

$$1000 * C(2)/Alpha(2)$$

is the cost to avoid one death, with type 2 medical attention. In a similar way

$$1000 * C(1)/Alpha(1)$$

is the cost to avoid one death with treatment 1.

From (10) and the observations above, it follows that to maximize deaths avoided, the numbers of persons treated with type 2 of medical services should be maximized, if

$$\text{Sum } X(i)$$
$$i = 1,\ldots,N$$

is the total number of persons treated.

With the notation above the problem of selecting the most appropriate type of health personnel becomes that of maximizing the total number of deaths avoided, i.e.; maximizing

$$Z = \text{Sum Alpha}(i) * X(i) \qquad (1)$$
$$i = 1,\ldots,N$$

subject to the resource constraint

$$\text{Sum } C(i) * X(i) <= R \qquad (2)$$
$$i = 1,\ldots,N$$

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It is interesting to obtain the algebraic solution of the problem above, assuming that only the resources $to-2 constraint is binding, and that there are only two types of medical personnel. With this, the problem becomes :

Mazimize:

$$\text{Alpha}(1) * X(1) + \text{Alpha}(2) * X(2) \qquad (5)$$

subject to:

$$C(1) * X(1) + C(2) * X(2) = R \qquad (6)$$

from the constraint (6) one obtains :

$$X(1) = (R-C(2)*X(2))/C(1) \quad (7)$$

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$$1000 * C(1)/Alpha(1) > 1000 * C(2)/Alpha(2)$$

that is to say, if the cost per death avoided with treatment type 2 is lower than the cost per death avoided with treatment type 1. From equation (7), it follows that the largest number that X(2) can attain is:

$$X(2) = R/C(2) \qquad (11)$$

and that this occurs when X(1) = 0.

If the number of patients treated is R/C(2), the maximum number of deaths avoided is

$$Alpha(2) * R/C(2) \qquad (12)$$

Similar results can be obtained with respect to X(1) if the inequality (9) is inverted.

VII-3.2 Explanation of the data needed:

It is to be noted that the case fatality rates from different diseases presented in section II are the number of deaths per 100 cases of disease, and they are used in that section to illustrate the impact of different types of health personnel on the health prospect of patients with different diseases. However, for the purpose of this aggregate model, an average mortality rate from all these diseases is needed. In this respect, and with the assumption that each member of the population may have one or another of these diseases during a period of one year, the death rate per 1000 population per year can be used here. Consequently, the basic data needed to use

$$1000 * C(1)/Alpha(1) > 1000 * C(2)/Alpha(2)$$

that is to say, if the cost per death avoided with treatment type 2 is lower than the cost per death avoided with treatment type 1. From equation (7), it follows that the largest number that X(2) can attain is:

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the model above are the following:

(1) The death rate per 1000 population per year without using any medical service.

(2) The death rate per 1000 population per year when using the ith type of medical personnel, where $i = 1,\ldots,N$.

(3) The cost per person of using the ith type of medical personnel per year where $i = 1,\ldots,N$.

(4) The total resources available for one year.

Table VII-10 summarizes the data needed to solve the model in equations (5) through (7).

For the purpose of illustrating the data needed, the death rate per 1000 population of the United States (9.4) is used, and an assumption is made that this death rate will double when using BMD's only (18.8); it will be one and half times its original value (14.1) when using a combination of BMD's and MD's; and it will reach three times its original value (28.2) with no medical attention.

Now the problem can be restated as follows:

Maximize:

$$Z = 18.8\ X(1) + 18.8\ X(2) + 9.4\ X(3) + 14.1\ X(4)$$

subject to:

$$20.752\ X(1) + 14.649\ X(2) + 3.19\ X(3) + 7.58\ X(4) <= 700{,}000$$

and:

$$X(1) + X(2) + X(3) + X(4) <= 200{,}000$$

Table (12) gives the number of deaths avoided with expenditure of 1000 dollars using the ith method where i = 0,...,4.

TABLE VII-11

ESTIMATING THE DEATHS AVOIDED

(i)	Beta(0) - Beta(i)	Alpha(i)
0	28.2 - 28.2	0
1	28.2 - 9.4	18.8
2	28.2 - 9.4	18.8
3	28.2 - 18.8	9.4
4	28.2 - 14.1	14.1

TABLE VII-12

THE NUMBER OF DEATHS AVOIDED PER 1000 DOLLARS

(I)	Alpha(i)/C(i)
0	0/0 = 0
1	18.8/20.752 = .9059
2	18.8/14.649 = 1.2834
3	9.4/3.19 = 2.947
4	14.1/7.58 = 1.8602

From this Table it is obvious that the highest number of deaths avoided per 1000 dollars used is Alpha(3)/C(3) =2.947, and the total deaths avoided is Alpha(3)/C(3)*R = 2.947*700,000 = 2062696 which is equivalent to:

Alpha(3)*R/C(3)=9.4*100,000/3.19=2062696 deaths avoided.

These equations can be solved by using linear programming (for the technical details of linear programming, refer to Correa, 1977).

Results

VII-3.3 Table VII-13 presents the effect of changing the amount of resources (R) on the choice of the type of personnel that should be used in order to maximize the number of deaths avoided.

The estimated values of Alpha(i) (the number of deaths avoided per 1000 persons in the population) are presented in Table VII-11.

Table VII-13

The Effect Of Changing The Amount Of Resources*

On The Choice Of Personnel

R Resources	Y Deaths avoided	X(1) Treated by MD's	X(2) Treated by MD's+Asst.	X(3) Treated by BMD's	X(4) Treated by MD's+BMD's	X(5)	X(6) No. of people not treated	X(7) Excess money
300	884000	0.0	0.0	94014	0.0	0.0	105956	0.0
350	1031000	0.0	0.0	109720	0.0	0.0	90282	0.0
400	1179000	0.0	0.0	125390	0.0	0.0	74609	0.0
450	1326000	0.0	0.0	141070	0.0	0.0	58934	0.0
500	1473000	0.0	0.0	156740	0.0	0.0	43265	0.0
550	1621000	0.0	0.0	172410	0.0	0.0	27586	0.0
600	1768000	0.0	0.0	188090	0.0	0.0	11912	0.0
605	1783000	0.0	0.0	189660	0.0	0.0	10345	0.0
610	1797000	0.0	0.0	191220	0.0	0.0	8777.4	0.0
615	1812000	0.0	0.0	192790	0.0	0.0	7210	0.0
620	1827000	0.0	0.0	194360	0.0	0.0	5642.6	0.0
625	1842000	0.0	0.0	195920	0.0	0.0	4075.2	0.0
630	1856000	0.0	0.0	197490	0.0	0.0	2507.8	0.0
635	1871000	0.0	0.0	199000	0.0	0.0	940.44	0.0
640	1882000	0.0	0.0	199540	455.58	0.0	0.0	0.0
645	1887000	0.0	0.0	199110	1594.5	0.0	0.0	0.0

650	1893000	0.0	0.0	197270	2733.5	0.0	0.0	0.0
700	1946000	0.0	0.0	185980	14123	0.0	0.0	0.0
750	2000000	0.0	0.0	174190	25513	0.0	0.0	0.0
800	2053000	0.0	0.0	163100	36902	0.0	0.0	0.0
850	2107000	0.0	0.0	151710	48292	0.0	0.0	0.0
900	2161000	0.0	0.0	140320	59681	0.0	0.0	0.0
950	2214000	0.0	0.0	128930	71071	0.0	0.0	0.0
1000	2268000	0.0	0.0	117540	82460	0.0	0.0	0.0
1500	2803000	0.0	0.0	3644.6	196360	0.0	0.0	0.0
2000	3142000	0.0	68168	0.0	131530	0.0	0.0	0.0
2500	3474000	0.0	139200	0.0	60801	0.0	0.0	0.0
3000	3760000	11503	188500	0.0	0.0	0.0	0.0	0.0
4000	3760000	175360	24644	0.0	0.0	0.0	0.0	0.0
4500	3760000	200000	0.0	0.0	0.0	0.0	0.0	349600
5000	3760000	200000	0.0	0.0	0.0	0.0	0.0	849600
10,000	3760000	200000	0.0	0.0	0.0	0.0	0.0	5849600
15,000	3760000	200000	0.0	0.0	0.0	0.0	0.0	10849600
20,000	3760000	200000	0.0	0.0	0.0	0.0	0.0	15849600
25,000	3760000	200000	0.0	0.0	0.0	0.0	0.0	20849600
30,000	3760000	200000	0.0	0.0	0.0	0.0	0.0	25849600
50,000	3760000	200000	0.0	0.0	0.0	0.0	0.0	45849600
100,000	3760000	200000	0.0	0.0	0.0	0.0	0.0	95849600

*R's: In Millions of Dollars

X(1) through X(6): are numbers of people in thousands.

X(7): is in thousands of dollars.

In Table VII-13 it can be observed that the types of personnel delivering the medical care depend on the amount of resources available. When the resources available equal $300 millions, the BMD's should be used in order to maximize the number of deaths avoided. With this value of resources, the number of people treated by BMD's -X(3)- is 94044 and the number of people left without any medical attention -X(6)- is 105960 (note that the values of X's are in thousands). It can also be seen that the number of people treated by BMD's -X(3)- increases with the increase in the value of resources available while the number of persons without treatment -X(6)- decreases with the increase in the value of R until this value reaches a certain point (640 millions in the case presented here) where the value of X(3) reachs its maximum and the value of X(6) reachs zero. At this point (R = 640 millions), the amount of resources available is enough to deliver medical care to the total population using BMD's -as in X(3)- and MD's + BMD's -as in X(4)-. From this point on, the value of X(3) decreases proportionally with the increase of R, while the value of X(4) increases proportionally with the increase of R til the value of R reaches a certain point (2000 millions in this case) where the number of people treated by BMD's -X(3)- becomes zero, the number of people teated by BMD's + MD's -X(4)- starts to decrease proportionally with the increase of R, and the number of people treated by MD's + Assistants -X(2)- changes from zero to 68468. At this value of resources (R = 2000 millions), the

types of personnel that should be used in order to maximize the number of deaths avoided are MD's + Assistants and MD's + BMD's. From this point on, X(2) starts to increase proportionally with the increase of R while X(4) starts to decrease proportionally with the increase of R until R reaches a certain value (3000 millions in this case), where X(4) becomes zero, X(2) reachs its maximum value, and the number of people treated by MD's -X(1)- changes from zero to 11503.

At this value of resources (R = 3000 millions), the types of personnel that should be used to maximize the number of deaths avoided are the MD's and the MD's + Assistants. From this point on, X(1) starts to increase with the increase of R, while X(2) starts to decrease with the increase of R until a point is reached where X(2) becomes zero and X(1) attains its maximal value (R = 4500 millions in this case). At this point, the type of personnel that should be used in order to maximize the number of deaths avoided is the MD's.

From Table VII-13 it is also observed that the value of the number of deaths avoided -Y- increases proportionally with the increase in the value of R until Y reaches its maximum value, where no further increase in its value can be attained. In the case presented here, this maximum value of Y is attained when R equals 3000 millions. When the value of R increases to 4500 millions, it is observed that the value of the excess money after treating all the population -X(7)- increases from zero to 349600. With the increase of R to 5000 millions, i.e.,

500 millions increase, the value of X(7) becomes 849600 (500 millions increase), i.e., the increase in resources is not used in delivering the medical care utilizing the previously specified personnel, and this trend continues with the increase in the value of R.

It is important to note that the results presented above depend on the amount of resources, the value of the mortality rates used, and the cost of utilizing each type of medical personnel. In other words, when the mortality rates or the cost of utilizing the different types of personnel change, the types of personnel who should be used in order to maximize the number of deaths avoided will also change. Table VII-15 shows the results of changing the mortality rate of the population attended by BMD's when the value of resources is $700 millions, and all other variables kept constant. The numbers of deaths avoided - Alpha - that correspond to each mortality rate are calculated in Table VII-14.

Table VII-14

Changing The Deaths Avoided Per 1000 Population

Attended By BMD's And By MD's + BMD's

Case No.	Beta(0) - Beta(3)	Alpha(3)	Beta(0) - Beta(4)	Alpha(4)
1	28.2 - 18.8	9.4	28.2 - 14.1	14.1
2	28.2 - 19.3	8.9	28.2 - 14.6	13.6
3	28.2 - 19.8	8.4	28.2 - 15.1	13.1
4	28.2 - 20.3	7.9	28.2 - 15.6	12.6
5	28.2 - 20.8	7.4	28.2 - 16.1	12.1
6	28.2 - 21.3	6.9	28.2 - 16.6	11.6
7	28.2 - 21.8	6.4	28.2 - 17.1	11.1
8	28.2 - 22.3	5.9	28.2 - 17.6	10.6
9	28.2 - 22.8	5.4	28.2 - 18.1	10.1
10	28.2 - 23.3	4.9	28.2 - 18.6	9.6
11	28.2 - 23.8	4.4	28.2 - 19.1	9.1
12	28.2 - 24.3	3.9	28.2 - 19.6	8.6
13	28.2 - 24.8	3.4	28.2 - 20.1	8.1
14	28.2 - 25.3	2.9	28.2 - 20.6	7.6
15	28.2 - 25.8	2.4	28.2 - 21.1	7.1
16	28.2 - 27.3	0.9	28.2 - 21.1	6.6
17	28.2 - 27.8	0.4	28.2 - 22.1	6.1

Table VII-15

The Effect Of Changing The Value Of The Mortality

Rate On The Choice Of Personnel

Case No.	Y Deaths avoided	X(1) Treated by MD's	X(2) Treated by MD's+Asst.	X(3) Treated by BMD's	X(4) Treated by MD's+BMD's	X(5)	X(6) No. of people not treated	X(7) Excess money
1	1946000	0.0	0.0	185880	14123	0.0	0.0	0.0
2	1846000	0.0	0.0	185880	14123	0.0	0.0	0.0
3	1746000	0.0	0.0	185880	14123	0.0	0.0	0.0
4	1646000	0.0	0.0	185880	14123	0.0	0.0	0.0
5	1546000	0.0	0.0	185880	14123	0.0	0.0	0.0
6	1446000	0.0	0.0	185880	14123	0.0	0.0	0.0
7	1347000	0.0	5410.6	194590	0.0	0.0	0.0	0.0
8	1250000	0.0	5410.6	194590	0.0	0.0	0.0	0.0
9	1153000	0.0	5410.6	194590	0.0	0.0	0.0	0.0
10	1055000	0.0	5410.6	194590	0.0	0.0	0.0	0.0
11	957900	0.0	5410.6	194590	0.0	0.0	0.0	0.0
12	898400	0.0	47785	0.0	0.0	0.0	152220	0.0
13	898400	0.0	47785	0.0	0.0	0.0	152220	0.0
14	898400	0.0	47785	0.0	0.0	0.0	152220	0.0
15	898400	0.0	47785	0.0	0.0	0.0	152220	0.0
16	898400	0.0	47785	0.0	0.0	0.0	152220	0.0

As can be observed from Tables VII-14 and VII-15, with the decrease of the value of deaths avoided by using BMD's - Alpha - (i.e., increasing the mortality rate of the population attended by BMD's), the total number of deaths avoided - Y - decreases until it reaches a certain point (Alpha = 3.9 in this case) where it remains constant with any further decrease in the value of Alpha (i.e., increase in the value of mortality rate). At the same time, when Alpha equals 9.4 (case number 1), the number of people treated by BMD's - X(3) - is 185880, the number of people treated by MD's + BMD's - X(4) - is 14123, and the types of personnel that should be used in order to maximize the number of deaths avoided are BMD's - as in X(3) - and MD's + BMD's - as in X(4) - and these results remain constant with the decrease of the value of Alpha untill a point is reached (Alpha = 6.4 in this case) where the number of people treated by BMD's -X(3) - becomes 194590, the number of people treated by MD's + BMD's - X(4) - becomes zero, and the number of people treated by MD's + Assistants changes from zero to 4510. At this point (Alpha = 6.4), the type of personnel that should be used to maximize the number of deaths avoided is the BMD's - as in X(3) - and MD's + Assistants as in X(2). These results remain constant until a point is reached (Alpha = 3.9 in this case) where the total number of deaths avoided -Y- stabilizes at 898400, X(2) stabilizes at 47785, X(3) becomes zero, and the resources available are not enough to give medical attention to the total population, so the number of people not treated - X(6) - changes from zero to 152220. At this point, the type of personnel

that should be used to maximize the number of deaths avoided is the MD's + Assistants, and these results remain constant with further decrease in the value of Alpha.

On the other hand, when the cost of utilizing the different types of personnel changes (keeping all other variables constant), the types of personnel that should be used in order to maximize the number of deaths avoided will also change. Tables VII-16 and VII-17 present the effect of changing the cost of utilizing BMD's when the value of resources available is also $700 millions and all other variables kept constant.

Table VII-16

Changing The Cost Of Utilising BMD's

Case No.	Cost of utilizing BMD's	Cost of utilizing MD's + BMD's
1	3.19	7.58
2	4.19	8.58
3	5.19	9.58
4	6.19	10.58
5	7.19	11.58
6	8.19	12.58
7	9.19	13.58
8	10.19	14.58

Table VII-17

The Effect Of Changing The Cost Of Utilizing BMD's

On The Choice Of Different Types Of Health Personnel

Case No.	Y Deaths avoided	X(1) Treated by MD's	X(2) Treated by MD's+Asst.	X(3) Treated by BMD's	X(4) Treated by MD's+BMD's	X(5)	Z(6) No. of people not treated	X(7) Excess money
1	1946000	0.0	0.0	185480	14123	0.0	0.0	0.0
2	1570000	0.0	0.0	167060	0.0	0.0	32936	0.0
3	1268000	0.0	0.0	134870	0.0	0.0	65125	0.0
4	1063000	0.0	0.0	113090	0.0	0.0	86914	0.0
5	915200	0.0	0.0	97357	0.0	0.0	102640	0.0
6	898400	0.0	47785	0.0	0.0	0.0	152220	0.0
7	898400	0.0	47785	0.0	0.0	0.0	152220	0.0
8	898400	0.0	47785	0.0	0.0	0.0	152220	0.0

From Tables VII-16 and VII-17 it can be observed that when the cost of utilizing BMD's is $3.19 (case number 1), the total number of deaths avoided is 1946000, the number of people treated by BMD's - X(3) - is 185880, and the number of people treated by MD's + BMD's - X(4) - is 14123. In this case , the types of personnel that should be used in order to maximize the number of deaths avoided are the BMD's -as in X(3) - and the MD's + BMD's - as in X(4).

With the increase of the cost to $4.19 (case number 2), the number of deaths avoided - Y - decreases to 1570000, the number of people treated by BMD's - X(3) - decreases to 167060, the number of people treated by MD's + BMD's - X(4) - becomes zero, and the number of people not treated - X(6) - changes from zero to 32936. With further increase in the cost of utilizing BMD's to $5.19 (case number 3), the total number of deaths avoided - Y - becomes 1268000, X(3) becomes 134870, X(6) becomes 65125. With further increase in the cost, the total number of deaths avoided - Y - decreases, X(3) decreases, and X(6) increases untill a point is reached (case number 6) where Y stabilizes at 898400, the number of people treated by MD's + Assistants - X(2) - changes from zero to 47785, X(3) becomes zero and X(6) becomes 152220 and these results remain constant with further increase in the cost. At this point (case number 6), the type of personnel that should be used in order to maximize the number of deaths avoided is the MD's + Assistants.

Appendix "A"

Diseases treated by BMD's

Epidemic influenza, measles, chickenpox, pertussis, diphtheria, infantile paralysis, pulmonary tuberculosis, epidemic parotitis, epidemic encephalitis, bacterial dysentry, amebic dysentry, typhoid, infectious hepatitis, epidemic encephalitis b, malaria, leptospirosis, tetanus, rabies, schistosomiasis, filaariasis, ankylostomiasis, ascariasis, fasciolopsiasis, enterobiasis, taeniasis, upper respiratory t. infections, acute bronchitis, chronic bronchitis, asthma, lobar pneumonia, lung abcess, acute gastro entritis, gastric and duodenal ulcers, liver cirrhosis, prolapse of rectum, glomerulonephritis, chronic nephritis, pyelonephritis , calculi in the urinary system, retention of urine, rheumatic arthritis, rheumatoid arthritis, heart failure, hypertention, stroke, epilepsy, neurosthenia, trigeminal neuralgia, migraine headache, sciatica, anemia, thrombopenic purpura, anaphylactic purpura, leukaemia ,endemic goiter, beriberi, neurodermatitis, contact dermatitis, drug dermatitis, menstrual irregularities, dysmenorrhea, amenorrhea, pelvic inflamations, leakorrnea, uterine bleeding,prolapse of uterus vomiting of pregnancy, mastitis, purperal sepsis, post partum bleeding, infantile convulsions, marasmus, rickets, infantile diarrhea, enuresis, colic, favism, summer fever, rhinitis, sinusitis, nasal polyp, acute tonsillitis, laryngitis, toothache, otitis externa,

otitis media, deaf-mutism, styes, acute conjunctivitis, trachoma, keratitis, trichiasis, eye injuries.

Surgical Conditions

Fractures, dislocations, sprains, carbuncle, cellulitis, erysipelas, tuberculosis of the cervical nodes, acute appendicitis, acute cholicystitis, acute peritonitis, intestinal obstruction, hernia, internal hemorrhoids, external hemorrhoids, leg ulcers.

Other diseases

Frostbite, chapping, imptigo, urticaria, eczema, tinea capitis, tinea corporis and pedis. first aid, other medical emergencies.

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VIII PLANNING NUMBER,SIZE AND LOCATION OF HEALTH FACILITIES

VIII-1 INTRODUCTION

The problem to be considered here is that of selecting the optimum number, size, and location of hospitals, clinics, dispensaries, etc.

The basic reason why such selection is necessary is that not enough resources are available to provide all facilities to all the population. As a consequence it is necessary to select the facilities so that the need for them can be satisfied using the resources availalble,

The different contributions that different types of facilities can make to the health of the population must also be understood. Comparison of small and large facilities suggests that the large ones usually have more or better means for restoring the health of the patients, and usually they can use more spacialized personnel with the same purpose.

However, the contributions of small facilities might be greater because a larger number of them can be made available. When many units are available it is usually possible to have some facility close to the persons who demand medical services. This implies that they will be used more frequently.

In summary, it can be said that the problem to be considered here is that of selecting the appropriate distribution of resources between large and small facilities, considering that the large ones can make a greater contribution to the health of the patients once they have checked into them, while the smaller ones are more likely to be in frequent contact with the patients.

However, the size of the hospitals is not the only criterion that should be used in planning for the number, size and location of health facilities. In hospital planning, hospitals should be evaluated realistically in terms of the personnel available to work in them. It is a waste of resources to build hospitals on the assumption that certain types of personnel will become available. After they are opened, many wards and clinics remain under-used or unused because of shortage of necessary personnel to operate them, or shortage of money to pay those personnel. Moreover, the hospital system in a country depends to a large extent on the social institutions, level of development, needs and resources of that country. The hospital administration in each country is also the result of historical developments over long periods of time. As a result, it is impossible to recommend a uniform scheme of hospital organization to all countries of the world. However, within the framework of regional planning , definite functions can be assigned to

each type of hospital. Therefore, hospital organization should be a compromise between centralization and decentralization. In general this compromise should be related to the economic, social, and cultural development of each country.

A description of the different types of health facilities and a method to select the most appropriate type(s) to improve health conditions of the population are presented, taking into consideration the availability of health personnel and other resources, is presented in this chapter. In section 2, definitions of the indices of hospital utilization are presented. Section 3 describes and compares the different types of health facilities. Their organization, structure, and quantitative guidelines necessary for their departmentalization and staffing are presented. In section 4 , the factors which influence hospital utilization and the impact of hospital location are briefly discussed. In section 5, an integer programming model for the optimum selection of number, size, and locations of the various types of health facilities is presented.

VIII-2 DEFINITIONS OF TERMS AND INDICES DEALING WITH HOSPITALS AND HOSPITAL UTILIZATION

Before proceeding to discuss the various types of hospitals, it is advisable to define the terms used. Definitions used by the World Health Organization are summarized below (Davis, 1966).

- Hospital beds:

Those beds that are regularly maintained and staffed for the accomodation and full time care of a succession of in-patients and are situated in wards or areas of the hospital in which continuous medical care for in-patients is provided. This definition excludes the cots for normal, healthy, newborn babies in maternity wards but includes incubators and bassinets for premature babies.

- Hospital admissions:

The number per year of acceptances by a hospital of patients receiving medical care while in residence therein and who are expected to remain for one or more nights. Normal, healthy, newborn babies should not be counted as in-patient admissions, while babies requiring special care should be included.

Admission rate:

Also known as the hospital frequentation rate or the hospital attendance rate and usually expressed as the

number of hospital admissions per 1000 of the population per year. In calculating this rate, all admissions, including readmissions for the same pathological condition, are counted.

Bed-days or patient-days:

The total number of days spent by inpatients in a hospital. In some hospitals, the day of admission and the day of discharge are counted as one day. In others, a full day is counted only when admission is before mid-day or discharges is after mid-day. Patient-days should not include the data for healthy, newborn infants. one "bed-day" or "patient-day" is the unit denoting the services rendered to one inpatient between two successive days.

Discharges and deaths:

The annual number of discharges includes the number of patients who have left the hospital (cured, improved, or died), and the number transferred to another health or social inistitution.

Average length of stay:

The average period in hospital (in days) per patient admitted.

Bed-occupancy rate:

This rate reflects the ratio between the average number of beds used and the total number of beds provided. It is calculated by dividing the average number of beds occupied

per day, by the bed complement (the nominal number of beds in the facility) and multiplying by 100.

Bed-occupancy ratio:

The average daily number of persons hospitalized per unit population (usually per 1000 population).

Turnover interval:

Expresses the average period, in days, that a bed remains empty, i.e., the average time elapsing between the discharge of

Hospitalization rate per person:

Expresses the volume of hospitalization in terms of number of hospitalization days per person per year. It is calculated by dividing the total number of hospitalization days in one year by the mean population in the same year.

Bed/population index:

Expresses the availability of hospital beds in terms of the number of beds per 1000 of the population.

VIII-3 DIFFERENT TYPES OF HEALTH FACILITIES

VIII-3.1- Introduction

Hospitals are alike in certain respects, but different in others.

Some are large scale organizations with hundreds of beds and thousands of

employees, while many of them are smaller institutions with only a few dozen beds. Some are located in large urban communities, while others are scattered in small cities or villages. Many are only concerned with providing patient care and treatment, while some are also envolved in teaching medicine, training medical personnel and conducting research. Some offer the most up-to-date specialized medical, surgical, and nursing services, while others deal with only the more common acute diseases and the relatively routine cases. Because of this, a need arises to categorize and define the various types of hospitals. Below, health facilities will be classified as follows:

a) Relatively large health facilities, i.e., regional

Hospitals, District Hospitals, Local Hospitals.

b) Relatively small health facilities, e.g., Rural Health Centers, Rural Health Clinics, Rural Health Offices.

VIII-3.2- Large health facilities

VIII-3.2.1 Definitions

The following categories of hospitals were established and defined by the WHO Expert Committee on the Organization of Medical Care (WHO,1972).

(1) The regional hospital, designed to provide a complete range of treatment, including such specialities as radiotherapy, neurosurgery, thoracic surgery, and plastic surgery. Where possible, such a hospital would comprise, or be closely associated with, an undergraduate medical teaching center. This hospital would be strategically placed in the region so that patients in need of its highly specialized services could be readily referred to it.
(2) Intermediate (or district) hospital of several hundred beds providing a high standard of medical, surgical, obstetrical, and specialized treatment.
(3) The small, local (rural) hospital of 20 to 100 beds, probably undifferenciated, providing where necessary, general medical, surgical, and maternity care.

The various kinds of hospitals defined above may be

divided into two categories: special hospitals and general hospitals (Davis, 1966). The first category deals only with certain specific organs or systems of the body. Examples are: eye, ear, nose, and throat; tuberculosis hospitals; infectious diseases hospitals. On the other hand, the second category deals with a wide range of specialist services, provides medical care to all age groups suffering from any form of illness (except the highly infectious and dangerous conditions, e.g., smallpox, cholera, and similar diseases). In addition, rural hospitals may vary among themselves regarding their size, number of personnel needed to operate them , and number of people they serve. A comparison of the different types of large hospitals is presented in Table VIII-1. A detailed description of them is presented below.

VIII-3.2.2- Regional hospital center or medical center

This consists of a group of hospitals integrating their services to fulfill a complete range of functions. It should be located in the largest city in a region, where the most complex elements of modern life are co-ordinated (Bridgman). It is usually a hospital group, consisting of institutions and integrated services and comprising or closely associated with a medical teaching

center. This center should offer a complete range of specialized departments where patients suffering from the rarest diseases can be treated. Other common specialties should be also included. Table VIII-1 presents a comparison between this type of hospital and the district and local ones.

Table VIII-1

COMPARISON OF THE DIFFERENT TYPES OF HEALTH FACILITIES

1- RELATIVELY LARGE FACILITIES

Variable	Medical center	District hospital	Local hospital
Goals	Service, training and research	Service, training and research	Mainly service
Services Offered	Inpatient, outpatient and emergency services	In patient, outpatient and emergency services	Inpatient, outpatient and emergency services
Specialties	Complete range of specialized departments where patients suffering from the rarest disease can be treated. These include cancer department which includes: radiology lab. nuclear-physics lab. neurosurgery department advanced chest surgery special operations	Common specialties such as: paediatrics gastro-entrology obstetrics dermatology cardiology otorhinolaryngology urology besides: general medicine general surgery	General medicine General surgery Maternity services Communicable diseases Endemic diseases Some of the common specialtiss such as: paediatrics gynaecology obstetrics

	besides other common specialties such as: paediatrics gastro-entiology gynaecology dermatology cardiology otorhinolaryngology ophthalmology urology Besides: general medicine general surgery maternity setvices communicable diseases endemic diseases	maternity services communicable diseases endemic diseases	
Number of beds	600+	300 - 400	70 - 150
Number of population served	1.5 - 2 millions	300,000 - 500,000	100,000 - 150,000
Personnel needed to operate the facility:			
Administrative and supportive setvices:			
administration	30	7	2

business office	70	40	10
dietary	90	54	15
engineering and maintenance	75	25	7
housekeeping and laundary	80	44	11
medical records	35	12	3
nursing services	600	232	60
outpatient	60	31	10
personnel	15	5	2
pharmacy	45	15	4
anesthesia	40	10	3
clinical lab.	65	22	6
physical therapy	16	4	-
radiology	80	16	4
purchasing	24	6	2

Medical staff:

general practitioner	200	24	10
surgical staff	90	17	3
obstetrical staff	30	8	1
pediatrics staff	28	7	1
radiologists	4	1	1*
pathologists	4	1	-
anesthesiologists	4	1	1*
otorhinolaryngologists	4	1	-

ophthalmologists	4	1	1*
dermatologists	4	1	-

*Part-time

VIII-3.2.3- General district hospitals

General district hospitals are usually considered the basic units in the hospital system, and for this reason the main departments of a hypothetical short-term general care facility are described and discussed in some detail in this section. These hospitals are assumed to provide general acute care in the following four areas: medical, surgical, obstetrical, and pediatrics. However, it is important for the reader to be aware that there are no known ratios and standards which are universally accepted as definitive measures of "what should be" (Champion, 1976). Hospital structure varies from hospital to hospital, from one point in time to another, and from one geographic region to another.

Outpatient department

The outpatient department is assumed to consist of the following clinics:

(1) General medicine	(2) General surgry
(3) Pediatrics	(4) Obstetrics
(5) Gynecology	(6) Cardiology
(7) Orthopedic	(8) Physical therapy
(9) Well baby	(10) Ear, nose , and throat
(11) Family planning	(12) Ophthalmic

It is advised that the outpatient department should

be located on the ground floor, because many patients may have difficulty in climbing stairs, otherwise adequate lift communication should be available. In addition, the clinics should be located so that it is impossible to look into the examination rooms from the outside. In general, the location of the department should be such that traffic of outpatients through the in-patients wards is reduced to a minimum. In many cases, it is recommended that various clinics be combined in such a way that a number of specialists make use of the same rooms.

A laboratory for routine tests incorporated in the outpatient department is only economically justified from the point of view of staff, if the available work load constitutes a full time task for the personnel in charge (Bouwcentrum, 1961).

Following is a summary of rooms required to operate an average outpatient clinic:

Entrance, office (for keeping the economic and medical records), space for parking perambulators, waiting rooms (their sizes and numbers depend on whether adopting an appointment system or not), canteen, patients' bathrooms, policlinic for nose , ear, and throat (consulting room, treatment room, dark room, and rest room), ophthalmic policlinic (combined consulting and treatment room, dark room), five dual-purpose policlinical suites (five consulting rooms and ten examination rooms, operating

theatre, and plaster room), laboratory for routine tests, rest rooms, space for storage of wheeled stretcher, closets for cleaning materials, and staff toilets.

In-patient units

There are certain services which require in-patient facilities of a special type. Examples are pediatrics, maternity and infectious diseases. However, in-patient care for most patients can be discussed in general terms (Davis, 1966).

In planning a hospital , the in-patient areas should have easy communication with certain parts of the hospital such as the kitchens, the supply and sterilizing departments, and the pharmacy. On the other hand, particular attention should be devoted to the routes by which infected or used materials of all kinds are disposed of.

The traditional nursing unit from which most contemporary arrangements have arisen was the ward containing 25 to 35 patients. Because of increasing complexity, technical difficulty, and responsibility of the nurses today, it has been found that planning large wards leads to less personal contact between patients and nurses. Consequently, smaller nursing units are recommended. These are especially desirable from the

point of view of privacy and comfort of the patients. Generally speaking, modern hospitals are composed principally of rooms for four or six patients, together with a number of single -bed rooms. It is recommended that about 20% of the beds be provided in single rooms in order to be able to isolate certain categories of patients, especially those whose condition is distressing to the others. It is also necessary to isolate patients having infectious conditions. Since single-bed rooms are frequently occupied by seriously ill patients who need special care, the area of these rooms should be large enough to allow for the use of bulky medical apparatus such as respirators, x-ray machines, oxygen tents, etc. Consequently, a nursing unit of 20 beds might have two six-bed rooms, one four-bed room, and four single rooms.

Apart from rooms and toilets for patients, other important facilities are needed, such as a nurses' station for each nursing unit, provided with chairs and a desk, a telephone, and other facilities. A treatment room should be provided for every 30 to 40 beds in order to carry out dressings and other surgical treatments under aseptic conditions. Other facilities are needed by the ward staff, such as toilets and changing rooms, private office for the head nurse, and offices for medical staff. An interview room and a seminar room are also useful.

The discussion so far has been concerned with outpatient and in-patient departments as examples of major departments of a general district hospital. A comparison between this type of hospital, on the one hand, and the medical center and local hospital, on the other, is presented in Table VIII-1

VIII-3.2.4 Local hospitals

These institutions are mainly concerned with general medicine, general surgery, maternity services and communicable diseases. All or some of the common specialties may also be offered. Table VIII-1 presents a comparison between this type of hospital and the medical center and district hospital.

VIII-3.3 Relatively small facilities

VIII-3.3.1 Definitions

A brief description of the Egyptian rural health system is presented as an example of small or rural health facilities.

Egypt is divided into twenty five governorates (regions or provinces), each of which is subdivided into a number of districts termed "Markaz", the total number of "Markaz" being 123. Each district or "Markaz" consists of

a number of villages. the total number of these is 4200.

The ministry of health establishes the technical policies and plans the programs, which then implemented by the governorate health administration and by the district and rural health levels. In other words, the central administration is responsible for supervising the technical policias and programs throughout Egypt, and is also responsible for the recruitment and staffing of the health services throughout the country. The governorate health administrations are responsible for the administration of the personnel of the health services in their area (Furnia, 1975).

On the rural health level or the village level, the Egyptian government has created a system of rural health centers and rural health units to provide health care to the entire rural population. Each rural health unit serves about 5,000 people, with the unit being no more than three kilometers from the most distant member of this population. It was estimated that there should be a rural health center (which frequently combined community development activities) for every three rural health units (serving up to 20,000 persons). The staffing pattern and services offered by these units are described in Table VIII-2.

TABLE VIII-2

COMPARISON OF THE DIFFERENT TYPES OF HEALTH FACILITIES

2- RELATIVELY SMALL FACILITIES

Variable	Rural health center	Rural health unit	Small office
Goal	Service and training	Service	service
Services Offered	Inpatient, outpatient and first aid	outpatient and first aid	outpatient and first aid
Specialties:	General medicine General surgery Public health services such as: maternal and child welfare communicable disease control environmental sanitation housing control food control health education school health services laboratory examination	General medicine and public health services, as in rural health center	General practice some public health services, such as: vaccination and health education

	for endemic diseases keeping statistical records in-service training of medical personnel		
Number of beds	15 - 20	no beds	no beds
Number of population served:	about 20,000	about 5000	about 1500
Personnel needed to operate the facility	physicians 2 dentist 1* sanitarian 1 assistant midwives 3 assistant nurses 3 assistant sanitarian 1 laboratory technician 1 male and female orderlies 8 - 10 ambulance driver 1 cook 1	physician 1 sanitarian 1 assistant midwives 2 assistant nurse 2 laboratory assistant 1 male orderlies 2 female orderlies 2	BMD 1

* Part-time

VIII-3.3.2 Rural health centers:

A rural health center consists essentially of an out-patient department, in-patient department, small operating room, small laboratory, dispensary, kitchen and annexes, and a place for accomodating the medical staff.

Out-patient department

This consists of waiting rooms with wooden benches (separate rooms for men and women), separate sanitary facilities for men and women, medical examination room, dressing and first aid room, a room for nurses (containing scales, sink, necessary shelves for medicines and dressings to be used for preparing injections and instruments at the physician's request), and a room for dental examinations (served regularly by a dentist once or twice a week).

In-patient department

Accomodates 15 to 20 patients in two separate wards for men and women. Each ward may be divided into smaller rooms containing six beds, three beds, and one bed. Hospital furniture is simple and to easy to maintain and repair locally. Beds, tables, chairs, benches, and cupboards are usually metal, in order that they may be easily cleaned and disinfected. The in-patient department also contains the following facilities:

Nurses' workroom with a table for preparing injections, a counter and sink for cleaning used

instruments.

Built-in cupboards for clean linen, cleaning utensils, spittoons, bedpans, urinal etc.

Fire extinguishers.

Sanitary installations for patients: one sanitary installation for every four patients.

Operating room

used for aseptic minor surgeries such as removal of foreign bodies, simple hernias and varicoceles. This room is joined by a sterilizing room.

Delivery room

used for normal deliveries and some complicated deliveries which do not require major obstetrical intervension.

Laboratory

a spacious room with central table to receive samples from the out-patient and the in-patient departments. It also contains a centrifuge (electric and/or manual), a refrigerator, and laboratory equipment for examining parasitic and endemic diseases.

Dispensary

Used to prepare certain types of drugs and distribute drugs for both in-patients and out-patients. It is also used to store drugs and vaccines. It contains a sink, balances, a number of cupboards, and a special place for keeping poisons and narcotics.

Accomodations for staff

These present a reasonable standard of comfort in order to make the stay in rural areas as pleasant as possible. Accomodation is free of charge (including lighting, laundry and house keeping).

VIII-3.3.3 Rural health units:

These units are located in small villages with populations of about 5,000. They provide out-patient services only. A rural health unit consists of the following facilities:

An out-patient department similar to that of the rural health centers, except for the abscence of the dental services.

Small laboratory, dispensary, and a place for accommodating the medical staff, similar to that described under the rural health centers. For the staffing pattern and services offered by these types, of health facilities refer to Table VIII-2.

VIII-3.3.4 Dispensaries:

Another type of smaller rural health facility is the small dispensary type of facility. This type is suitable for use by a "Barefoot doctor" such as those in China, or

by other health personnel of similar training in other countries. A comparison between this type of health facility and the Egyptian rural health units and centers is presented in Table VIII-2.

VIII-4 DETERMINANTS OF HOSPITAL UTILIZATION

VIII-4.1 Introduction

The extent and form of utilizing hospital beds are influenced by many factors that depend on the socio-economic, educational, and cultural characteristics of each population, and on the attitudes and special habits of the medical profession. For instance, in developing countries, people may exert pressure on the attending physician in order not to be hospitalized, because of their fear of the hospital or their unwillingness to be separated from their families. On the other hand, the reverse may occur in developed countries. Some of the factors that influence hospital utilization (1, 7-12) are presented in section 4.2, and a method to

evaluate the impact of hospitals' location on their utilization is presented in section 4.3.

VIII.2 Factors affecting hospital utilization

VIII.2.1 Factors refering to facilities

1- Availability of hospital beds: @

Although it has been observed in many countries that the larger the number of available hospital beds, the higher the volume of their utilization, it is unlikely that one of these factors caused the other. Both are the result of other factors which are linked to the socio-economic development of a country, such as better health education, better health consciousness, and higher standard of living. A saturation level will eventually be reached, especially for specialized services. $to585 Sometimes a direct relationship may be found between the bed/population ratio and utilization indices such as bed-occupancy rate, admission rates, and per person hospitalization rate (Davis, 1966, p. 320).

2- Distribution of hospital beds:

An even geographic distribution of hospitals increases their utilization by making them more easily avaible to all the people. A high bed /population index in itself does not guarantee a full population coverage if most hospitals are concentrated in urban areas (Davis, 1966 p.

32).

3- The efficiency of the supporting sevices:

Supporting sevices in a hospital are very important to the efficiency of the overall hospital services. Examples of such services are X-ray departments, operating rooms, and laboratories. Lack of equipment or personnel in these departments prolongs the average length of stay, decreases the admission rate and increases the cost per patient (Davis, 1966, page 33).

4- Other hospital functions:

Teaching hospitals are usually more selective in their admission policies. They tend to accept cases which are of value for training medical personnel or for research purposes. The average length of stay also tends to be longer.

VIII-4.2.2 Factors referring to physicians

5- Availability of physicians:

In areas with shortage of physicians, the admission rate tends to be low. As the number of physicians increases, this rate also increases as the result of detecting more cases of illness, until a maximum point is reached where physician/population ratio becomes such that there is practically complete coverage of the population, but the number of patients per doctor is very high. At this

point, physicians become overburdened and they tend to refer to hospitals patients who could normally be dealt with efficiently on an out-patient basis. A further increase in the number of physicians reduces the load on them, and allows for more medical attention for patients outside the hospital. Consequently, the admission rate tends to level off.

6- Attitudes of the medical profession:

Medical customs differ from one country to another. For instance, in some countries, hospital deliveries for almost all births are the rule. In other countries, hospital deliveries are only confined to abnormal cases and primiparas. Moreover, the length of stay in hospitals in normal obstetric cases varies considerably from one country to another.

VIII-4.2.3 Factors refering to the patient populations

7- Age of the population:

The higher the proportion of aged persons in a population, the greater is the volume of hospitalization. This is reflected as a high per person hospitalization rate and a high average length of stay per patient.

8- Morbidity pattern:

The morbidity pattern in a community greatly affects the pattern and volume of hospital utilization. Acute

infectious diseases increase the demand for beds in "short-stay" institutions, while chronic and degenerative ones tend to increase the average stay in hospitals.

9- Housing conditions:

Many hospital admissions are due not to the real need for hospital care, but to the inconveniences encountered when caring for patients in small houses or apartments.

10- Capacity to pay and method of payment:

Payment for hospital services may be either directly by the patients, or indirectly through a third party such as an insurance company . The method of payment usually influences the decision of weather to be hospitalized or not. Also, the demand for a hospital should decline as the costs of reaching it increase (Morrill, 1968).

11- Religion:

Religious preferences may play a decisive role in hospital attractiveness. In the work done by Morrill and Earickson (1969), it was found that the average Jew evaluates the distance to non-Jewish hospitals to be about three times as great as it actually is. Meanwhile, Catholics evaluate distance to non-Catholic hospitals as about twice as far, and Protestants evalute Catholic and Jewisn hospitals as about twice as far, but evaluate the nonreligiously-oriented hospitals about the same as Protestant ones.

12- Social class:

In their comparisons between the middle and working

classes, Weiss and Greenlich (1970) conclude that distance affects the medical care process differentially by social class.

VIII-4.3 Quantitative evaluation of the impact of hospitals' location on their utilization

In agreement with the observations in section 4.2, distances traveled to hospitals are a complex function of the location of patients with respect to physicians and hospitals, together with various characteristics of the hospital itself such as size, quality of care offered, possible discrimination according to race or method and/or ability of payment, religious affiliation and so forth.

In order to examine the impact of locating hospital facilities within certain distances from population centers, Morrill and Kelley (1970) have developed the concept of "distance decay". These are convenient mathematical formalizations designed to reflect real behavior or perception and response to distance. Considering a simple gravity type model as expressing the relative attractiveness of equivalent facilities with increasing distance, Morrell and Kelley hypothesized that attractiveness "R" can be related to distance "D" with the formula

R = 1 / (D ** b)... (1)

where "**" denotes exponential, and "b" is a parameter to be estimated from actual data. Assuming that b = 1 for medical facilities located at distances = [1, 2, 3, 4, 5, 6], one obtains "attractiveness" = [1, 1/2, 1/3, 1/4, 1/5, 1/6]. As a perceptual model, this may express logically and reasonably the patients' view of distance, since it takes three times as much effort to get to a place three times as far away. On the other hand, if b = 2, one will obtain "attractiveness" = [1, 1/4, 1/9, 1/16, 1/25, 1/36]. In this way, a place three times as far away as another is 1/9 as attractive.

The equation in (1) can be modified to consider that the different types of health facilities described above may have different degrees. In this case it can be written as:

R(i) = K(i) / (D ** b)

where the subscript "i" denotes that the variable refers to the type of health facility "i". The more attractiveness a facility has, the higher will be the value of K(i). If a simple exponential model is used, for instance, R = 2 / (2 ** D), in this case, for the given distances, "attractiveness" = [1, 1/2, 1/4, 1/8, 1/16, 1/32]. Here an additional unit of distance involves a constant degree of decrease in attractiveness, i.e., each additional mile reduces attractiveness to the same facility by half. It is still quite logical that some

persons may perceive and respond to distance in this way.

Since a person's perception of distance could be a mixure of both the gravity and exponential cases described above, other forms of distance decay were also suggested. For instance, R = 2 / (D ** 0.5) (2 **D) or R = 1 / D ** - 0.5 + 0.5 D

If the closes,t hospital is more distant, at eight miles for example, with others at ten, eleven, and thirteen miles, Morrill and Kelley (1970) noticed that patients tend to discount the distance to the closest facility, since they must have medical care. They view the distance to the closest facility as a unit effort (as one mile) and then view the other as three, four, and six miles.

VIII-5 AN INTEGER PROGRAMMING MODEL FOR THE OPTIMUM SELECTION OF NUMBER, SIZE, AND LOCATION OF HEALTH FACILITIES.

VIII-5.1 Presentation of the model

In the presentation below it is assumed that in a country or geographical area, N locations where health facilities could be located have been identified. These locations can be cities, villages, or other collectivities. They will be designated below with a subscript that takes values from 1 to N.

The number of inhabitants in the locations will be designated by P(I), with I = 1,...,N to indicate the location.

The total number of persons in the region being considered will be denoted with P, i.e.,

$$P = \underset{I=1,\ldots,N}{\text{SUM}} P(I)$$

In the simplified problem to be considerd here, only two types of medical facilities will be considered: small and large. The small ones will be called dispensaries, and the large ones hospitals. Subindices with values from 1 to N will be used to designate a dispensary in location I = 1,...,N, and a subcript I= N+1,...,2N, will indicate a hospital in location I to N. In what follows, the

dispensary in location I will be called dispensary I, and the hospital in location I to N, will be hospital I.

For the analysis below it is useful to introduce the variable B(J), where J =1,...,N for dispensaries and J = N+1,...,2N for hospitals. B(J) can be defined as the index of location as well as of type facility. That is , the value of J indicates both the location of a facility and the average of number indicates , as mentioned above, the type of facility. To illustrate this, let us take B(18). Because J is between 11 and 20, the facility would be a hospital. To identify its location, one would have to subtract ten from 18 (i.e, from the number between 11 and 20). Thus the hospital would be at location 8. When a facility is available B(J)assumes the value of 1, and when one is not available,it assumes the value of 0

As observed, the number of persons demanding services in a specified facility plays a basic role in the model. To introduce this concept, the following notation will be used:

A(I,J) = proportion of persons from location I that would use facility J, for J = 1,...,2N.

It should be observed that the proportions A(I,J) reflect the preferences of the persons of the different localities with respect to the medical facility that they

would use if it were available, and not their actual behavior. For this reason, it is not only possible, but likely that

$$\sum_{J=1,\ldots,2N} A(I,J) > 1.$$

This point can be illustrated by the following example. It is reasonable to assume that if a facility is available in a community, 90 per cent of the population would utilize its services. If one is not available, then 60 per cent would probably go to a facility in another community. In this case, the sum of the A(I,J) would be 1.5. However, this does not mean that 150 per cent of the persons from that community receive medical attention.

With the notation above, it follows who the number of persons from locality I who demand medical attention in facility J, if available, is

$$A(I,J)*P(I)*B(J), \quad I=1,\ldots,N \quad J=1,\ldots,2N \qquad (1)$$

From formula (1) it follows that the number of persons who demand services in facility J is

$$\sum_{I=1,\ldots,N} A(I,J)*P(I)*B(J), \quad J=1,\ldots 2N \qquad (2)$$

Form fromula (1) it also follows that the number of persons from locality I who are treated in all the medical

facilities available is

$$\sum_{J=1,\ldots,2N} A(I,J)*P(I)*B(J) \quad I=1,\ldots,N \qquad (3)$$

and the number of persons from locality I not treated in any medical facility is

$$P(I) - \sum_{J=1,\ldots,2N} A(I,J)*P(I)*B(J) \qquad (4)$$

i.e., it is equal to the number of persons in locality I minus the total treated in all dispensaries and hospitals.

The total number of persons from all localities treated in all the medical facilities available is

$$\sum_{\substack{I=1,\ldots,N \\ J=1,\ldots,2N}} A(I,J)*P(I)*B(J). \qquad (5)$$

and the total number of patients not treated in any medical facility is

$$\sum_{I=1,\ldots,N} P(I)*[\ 1 - \sum_{J=1,\ldots,2N} A(I,J)*B(J)\ ] \qquad (6)$$

Denoting with V(J) the survival rate for persons with no medical attention (J=0), and for persons with attention in a dispensary or hospital J, (J = 1,...,2N), one obtains, using formula (1), that the number of persons from locality I treated in

dispensary or hospital J, and who survive is

$$V(J)*A(I,J)*P(I)*B(J) \quad J=0,\ldots,2N \qquad (7)$$

From formulas (2) and (6) it follows that the total number of persons surviving from among those demanding medical services at facility J is

$$\underset{I=1,\ldots,N}{\text{SUM}} V(J)*A(I,J)*P(I)*B(J) \qquad (8)$$

From formulas (2) and (6) one also obtains that the total number of persons in I who demand medical attention and survive is

$$\underset{J=1,\ldots,2N}{\text{SUM}} V(J)*A(I,J)*P(I)*B(J). \qquad (9)$$

Formulas (8) and (9) imply that the total number of persons in all hospitals and dispenaries who survive is

$$\underset{\substack{I=1,\ldots,N \\ J=1,\ldots,2N}}{\text{SUM}} V(J)*A(I,J)*P(I)*B(J) \qquad (10)$$

To compute the total number of persons surviving, those surviving among those not treated in any medical facility must be specified. This result is obtained by multiplying the number of people in region I who are not treated in any facility - that is, formula (3) - by the survival rate, V(0). As a result, one obtains the following expression

$$V(0)[\ P(I) - \underset{J=1,\ldots,2N}{SUM}\ A(I,J)*P(I)*B(J)\ ] \qquad (11)$$

and the total survival for the non-assisted population will be

$$V(0)[\ \underset{I=1,\ldots,N}{SUM}\ P(I) - \underset{\substack{I=1,\ldots,N \\ J=1,\ldots,2N}}{SUM}\ A(I,J)*P(I)*B(J)\ ] \qquad (12)$$

With the meaning given previosly to P , i.e., the total population in the region being considered, formula (10) becomes

$$V(0)*[\ P - \underset{\substack{I=1,\ldots,N \\ J=1,\ldots,2N}}{SUM}\ A(I,J)*P(I)*B(J)\ ]$$

In the model being presented it will be assumed that the objective is to maximize total survival. With the formulas above, total survival is equal to

$$V(0)*P + \underset{\substack{I=1,\ldots,N \\ J=1,\ldots,2N}}{SUM}\ [\ V(J) - V(0)\ ]*A(I,J)*P(I)*B(J). \qquad (13)$$

The maximization of total survival must be done subject to the constraints imposed by the resources available, and the demand for medical services, which is dependent on the location and size of the facility. These two types of constraints will be discussed below.

In principle, many types of resources can be considered in the type of model being presented. For the sake of simplicity, only two of them will be considered here: Human and financial resources. To formalize them,

the following notation wil be used:

C(R,J) = Units of resource R, R = 1, for human, and R = 2, for financial resources, needed for facility J, for J = 1,...,2N.

K(R) = Total amount of resource R available.

With the notation above, the total amount of resource R used by all the facilities available will be

$$\sum_{J=1,\ldots,2N} C(R,J)*B(J) \qquad (14)$$

and these total amounts must be, at most, equal to the total amount of resource R available, i.e.,

$$\sum_{J=1,\ldots,2N} C(R,J)*B(J) <= K(R). \qquad (15)$$

To introduce the constraints imposed by the population's demand for medical services, it should be remembered that when presenting the definition of the coefficients A(I,J), it was observed that they are likely to count each member of the population more than once, since one person could look for medical facilities in several localities until he finds one that is available. In the model being counstructed, this characteristic of the A(I,J) should be eliminated, since in actual practice,

a person cannot attend several medical facilities at the same time. For this reason, the following constraint must be introduced

$$\sum_{J=1,\ldots,2N} A(I,J)*B(J)*P(I) <= P(I). \qquad (16)$$

This constraint simply says that the total number of persons from locality I attending all the different medical facilities must be less than or equal to the total population of that locality.

It should be observed that the constraint (16) can be written as follows:

$$\sum_{J=1,\ldots,2N} A(I,J)*B(J) <= 1. \qquad (17)$$

In summary, the model can be reduced to the following:-

Maximize:

$$V(0)*P+\sum_{\substack{I=1,\ldots,N\\ J=1,\ldots,2N}}[V(J)-V(0)]*A(I,J)*P(I)*B(J)$$

Subject to:

$$\sum_{J=1,\ldots,2N} C(R,J)*B(J)<=K(R),\ R=1,2$$

$$\sum_{J=1,\ldots,2N} A(I,J)*B(J)<=1,\ I=1,\ldots N$$

with variables B(J),J=1,...2N, being the decision variables which take on the values 0 and 1.

VIII-5.2 Numerical example

The data needed for the application of the model as well as for its solution are illustrated in this section with a judicious numerical example.

In the numerical example it will be assumed that the number, size and location of the health facilities for the ten villages represented in Figure 1 has to be specified. The number of persons living in each of these villages is presented in Table VIII-3.

TABLE VIII-3

Annual Population in Villages in Project

Village	Total Population
1	1,529
2	1,1013
3	2,014
4	2,211
5	1,621
6	1,041
7	891
8	8,721
9	4,901

10 5,213

The simplest way to estimate the proportions A(I,J) of persons in location I who would attend facility J is to assume that they are determined by the distances D(I,S) for I and S =1,...N, from one village to another. The distances assumed for the present example are presented in Table VIII-4.

TABLE VIII-4

Assumed Distances from One Village to Another

S	1	2	3	4	5	6	7	8	9	10
I										
1	-	17	19	13	18	21	26	21	16	17
2		-	6	18	23	26	31	39	11	17
3			-	20	25	28	33	41	13	24
4				-	5	8	13	33	8	1
5					-	13	18	38	13	7
6						-	5	41	16	9
7							-	46	21	14
8								-	36	36
9									-	7

10

Table VIII-4 indicates the distance between one village and another by reading the figure at the intersection of row and column. For example, the distance between village 3 and village 5 is 25 kilometers as can be seen from row 3 and column 5.

Since the preference for attending a particular medical facility decreases with distance and increases with the quality of medical care, the A(I,J) are computed here with the following formulas:

$$A(I,J)=3*(1/D(I,S)),\quad I=1,\ldots N \quad I=S=1,\ldots,N$$

and

$$A(I,J)=6*(1/D(I,S)),\quad I=1,\ldots N \quad J=N+S=N+1,\ldots,2N$$

The first formula above states that the projection of patients attending a dispensary is equal to 3 times the inverse of the distance between the village where the patients live and the village where another health facility is located. In the second formula, it is assumed that a hospital is twice as attractive as a dispensary. It should be emphasized again that although the parameters for the formulae above can be estimated from actual data, this is not the case for the figures used

in our example. The results obtained are presented in Table VIII-5.

TABLE VIII-5

Proportions, A(I,J), of Persons in Locality I That Would Attend Facility J

(a) DISPENSARIES

J	1	2	3	4	5	6	7	8	9	10
I	.70	.18	.16	.23	.17	.14	.11	.14	.19	.18
2		.70	.51	.17	.13	.11	.09	.84	.27	.16
3			.70	.15	.12	.11	.09	.84	.27	.16
4				.70	.60	.37	.22	.09	.38	1.0
5					.70	.22	.17	.84	.23	.42
6						.70	.60	.07	.19	.33
7							.70	.07	.14	.21
8								.70	.08	.08
9									.70	.43
10										.70

(b) HOSPITALS

j	11	12	13	14	15	16	17	18	19	20
1	1.0	.35	.31	.46	.34	.29	.23	.29	.39	.35
2		1.0	1.0	.34	.26	.23	.19	.16	.55	.27
3			1.0	.30	.24	.22	.18	.14	.46	.25
4				1.0	1.0	.75	.46	.18	.75	1.0
5					1.0	.46	.37	.16	.46	.84
6						1.0	1.0	.14	.38	.67
7							1.0	.13	.29	.43
8								1.0	.17	.17
9									1.0	.86
10										1.0

The next parameter to be considered here is the survival rates of those without medical attention, and of those using either dispensaries or hospitals. For simplicity it will be assumed that the survival rate of persons who receive medical attention is the same for all dispensaries and all hospitals. The values to be used in the example are given in Table VIII-6.

Table VIII-6

Survival Rates for Patients of Dispensaries and Hospitals

No medical attention V(0)=.97

For dispensaries J=1,...,10 V(J)=.98

For hospitals J=11,...,20 V(J)=.99

Next, the human and financial resources needed for health facilities will be considered. The requirements of dispensaries and hospitals are presented in Table 7.

Table VIII-7

Assumed requirements of human and financial resources

Facility	Number of personnel needed	Financial resources for unit operation*
Dispensaries	30	75
Hospitals	120	225
Maximum available	800	600

*1000's of Dollars

ANALYSIS: Using the data given in our numerical example in the previous section, that is, in Tables 1 to 5, several runs were made using a Mixed Integer Programming solution. In each run the value of K(2) (which indicates the quality of hospital) was changed. The results are presented in Table VIII-8.

In Table VIII-8, the following data is presented:- (a) K(1) and K(2): the co-efficients of dispensaries and hospitals respectively--when compared (i.e. K(2)/K(1)), they indicate the preference for hospitals over dispensaries based on quality; (b) B(J): the location selected for a medical facility--for J=1 to 10 (dispensaries) and J=11 to 20 (hospitals); (c) Percentage of population: the percentage of the population covered by medical services; (d) Value of the objective function: the number of people who survive as a result of medical services; and (e) R(1) and R(2): the amount of financial and human resources that are used.

TABLE VIII-8

SENSITIVITY ANALYSIS FOR DIFFERENT PREFERENCES FOR HOSPITALS

(Coefficients for Dispensaries K(1)=3)

Coefficients for Hospitals K(2)	Ratio K(1)/K(2)	Location B(J)	Percent Pop.	Value of Objective Function	Human Resources B(1)	Financial Resources B(2)
3.0	1.0	8,9,10	25.7	28502.55	90	225
3.5	1.2	8,9,10	25.7	28502.55	90	225
4.0	1.3	8,9,10	25.7	28502.55	90	225
4.5	1.5	18	39.1	28507.35	120	225
5.0	1.7	18	39.9	28512.35	120	225
6.0	2.0	20	41.3	28527.35	120	225
7.0	2.3	20	46.6	28551.35	120	225
8.0	2.7	20	50.7	28575.00	120	225
9.0	3.0	20	54.8	28599.35	120	225
10.0	3.3	19	59.0	28623.55	120	225

According to our results, when the quality of the dispensary and the hospital are the same (ie. K(1)=K(2)=3), dispensaries are selected for B(8), B(9) and B(10). The results remained the same when the quality of the hospital was 1.16 and 1.33 times better than the dispensary. In all three cases the value of the objective function was 28502.55 and the percentage of people covered by medical services was 25.7 per cent.

When the quality of the hospital was 150 percent and 167 percent better than the dispensary, a hospital was selected for location 8. Here the number of people who survived was 28507 and 28512 respectively, and 39 and 40 percent of the population had access to medical services.

Increasing the differences even more--200,233,267 and 300 percent--a hospital for location 10 was chosen. As shown in Table 6, the number of people who survive ranged from 28527 to 28599. Similarly, the percentage of the population covered ranged from 41.3 to 54.8 percent.

Finally, when the difference in quality was 333 percent, a hospital was chosen for location 9. The number of persons who survive was 28623, and the percentage of the population covered, 59 percent.

A close examination of the results for the first three runs indicated that in all instances the three most populous locations in the region were selected. With respect to the choice of hospital, the first location chosen had the largest population. However, as differences between hospitals and dispensaries increase, the next most populous rather than the most was chosen. It would seem, then, that a factor other than population size is determining the choice of location.

A possible explanation is the interaction between distance and quality of facility. This can be illustrated by the following two factors: (a) 1/D(I,S) and (b) K(I)--FOR I=1 and 2. When the value of K(I) is high, that is, when one type of facility is far superior to the other, the proportion of people attending that facility would also increase. Thus, as the quality of a facility increases, there is a shift away from the location

with the higher population to the one that offers greater coverage of the region's population. This is borne out in Table VIII-7.

With respect to the constraints, it can be observed that the most important of them is not the resource constraints, but the proportion of people attending a facility--that is, the sum of the A(I,J)'S. Because we established earlier that no more than 100 percent of the people from a region can attend a facility in the same location and that the sum of the A(I,J)'S can not exceed 1, only one hospital can be chosen. It is this constraint, and the above influences that determine the selection of a location for a medical facility.

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