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## SYSTEMS ANALYSIS IN HEALTH ADMINISTRATION RESEARCH

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We define systems analysis as a formal approach to decision-making in human organization in which an organization can be as diffuse and complex as a nation or as apparently simple as a physician-patient relationship. In its application to health care of a human population, systems analysis (and the closely related field of operations research) is concerned simultaneously (1) with short-term decisions in the use of existing resources, (2) with consideration of alternative strategies for providing services to an existing population, and (3) with long-range decisions in planning and evaluating programs for a future population.

Examples of short-term decisions treated by systems analysts are found in screening and diagnosis and in the assignment of staff and supply in hospitals and clinics. The study of strategies of patient care recognize such variables as the degree of preventive care rendered, the incentives to providers, the role of health education, and the relation of all of these to the benefits derived by and the costs incurred to the population served. Long-range decisions take into account the changing demographic character of a population, the changes in its morbidity, and mortality, and responsiveness to services offered, as these are affected by social and economic change and new medical technology.

Whatever decisions are studied, systems analysis follows generally a set of steps: (1) the recognition of the system context of the decision - the objectives of the decision-makers and those affected, the constraints on resources, the variables affecting outcomes and whether or not they are controllable; (2) the synthesis of some feasible alternatives - decisions, strategies, programs; (3) the evaluation of the alternatives in terms of

benefit measures and costs with perhaps a declaration of one alternative as optimal, and (4) the implementation and evaluation of the selected alternative.

As it is evolving, health systems analysis is the convergence of several streams of thought. For understanding of organizational behavior, we use statistics and probability and draw upon general systems theory - the science of observation, communication, and control. For decision processes we draw upon economics and philosophy in dealing with problems of value and choice of optimal actions.

A STOCHASTIC MODEL FOR HEALTH SERVICES PLANNING

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The two major components in health services planning are the health status of the people and the medical resources of the nation. The ideal is to so distribute the available resources that an optimum level of health is attained throughout the nation. However, the extent to which medical services contribute to the improvement of health is yet to be assessed. And, in addition to health services, there are many demographic, socioeconomic, and environmental factors that affect human health. Furthermore, in order to determine the level of health in a population, health indices have to be devised. The purpose of this paper is to resolve these problems from a stochastic viewpoint.

The present study begins by defining homogeneous subpopulations according to their demographic, socioeconomic, and environmental characteristics. For each subpopulation, three stochastic models are proposed. The first model describes the dynamics of illness processes taking place in the population. In this model each individual is classified into one of  $s+1$  discrete states:  $S_0, S_1, \dots, S_s$ . He is said to be in  $S_0$  if he is healthy or in  $S_i$  if affected with the specific impairment, for  $i=1, \dots, s$ . At the beginning of a time interval he will be in one of the  $s+1$  states. During the interval he may leave that state and enter another, and at the end of the interval he will be in perhaps another state, or he may have died and thus entered the death state  $R$ . Corresponding transition probabilities have been derived to describe such transitions. These probabilities will thus reflect the influence of health services on an individual's well-being when other factors have been accounted for.

The second and third models describe the end results of such

processes: the frequency of illness occurring in the interval and the duration of disability, respectively. Either model measures an aspect of the state of health; together they represent a comprehensive picture of the entire population's state of health. Based on these models, an index of health is introduced which may be used as a guide for the planning of health services.

AUTOMATED MULTIPHASIC HEALTH SCREENING I

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The analytical techniques of systems analysis can be used both in designing, interrelating, and evaluating the various procedures and their use in individual automated multiphasic health testing (AMHT) programs and in integrating AMHT programs with other complex components of the health care delivery system. The latter application of systems analysis to AMHT has received considerably less emphasis, and explains, in part, the controversy over the usefulness and cost/benefit value of AMHT, particularly in developing countries.

AMHT should be used only when it (1) brings the health care delivery system to a larger segment of the population than otherwise would be the case, (2) increases the productivity, economic efficiency, and overall effectiveness of available health manpower and the total health care delivery system, and (3) permits the provision of more services at reasonable costs and high quality. Systems analysis assists in the design of AMHT to accomplish these objectives and in the evaluation of operating AMHT programs to determine if the objectives have been achieved.

Countries and organizations considering the establishment or expansion of AMHT should assure themselves that essential criteria of any AMHT program are met: (1) it must be acceptable to the people served, (2) it must be acceptable to physicians and compatible with the health care system of which it is only one component, (3) it must have a direct relationship with other parts of the health care delivery system to assure use of its findings, (4) its procedures must be sufficiently sensitive and useful to accomplish the purposes for which AMHT was established, and (5) it must have accomplishments in better and more widespread health care that justify its continued financing.

Systems analysis uses these criteria as part of the process of planning, controlling, and measuring the accomplishments of AMHT, particularly by the use of numerical targets to measure AMHT inputs (money, manpower, equipment, and facilities), and AMHT outputs (persons served and accomplishments achieved).



AUTOMATED MULTIPHASIC HEALTH SCREENING II

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Multiphasic health testing is historically defined as mass screening to identify those persons in need of further health services. A fixed test protocol for each program usually evolves, defined primarily by the program sponsors, rather than the consumers of the health testing service. Today's consumers include individual physicians, unions, industries and businesses, insurance plans, schools, hospitals (pre-admission testing), and the like. Consumers have widely varying requirements for test protocol. The challenge to system designers is to effectively and often simultaneously serve this current market for multiphasic health testing. Medical Diagnostic Centers Corporation is operating a facility based on these requirements.

To perform a variety of test protocols intermingled in the same permanent or portable facility on a given day requires a system which has flexibility and adaptability and is responsive to changing test needs. The Medical Diagnostic Centers system lends itself to still another desired goal, that of personalized service since preparatory paperwork for each examinee must be individualized. Yet to be efficient the test sequence must be capable of adjusting to varying patient rates for the varying types of tests. Scheduling becomes critical. The test flow pattern is also critical. Adaptability was achieved by organizing tests into four general groupings, each with its own "staging area," with multiple use rooms and staff trained to perform several tests. The opportunity to add tests easily must also be provided. Multiple screening centers are supported by an automated clinical laboratory with additional capability for non-automated specific procedures. They are also supported by a data processing center, operated in a batch format, using a mark-sense

system with options for test variation and additions. Individual reports are prepared and sent to the referring physician; in most instances this is the examinee's personal physician, although it may be the responsible physician of the referring organization.

In addition to providing screening services, research is conducted on data obtained in multiphasic health screening centers. For example, analyses are being made of data on 25,000 people screened at the Brookdale Hospital Center in Brooklyn, New York. Normal and abnormal values derived from such studies are used to define the out-of-range values used in individual report analysis.

SYSTEMS ANALYSIS APPLIED TO THE OPERATION  
OF TECHNICAL SERVICES IN HOSPITALS

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Systems analysis consists of the investigation of the interaction of people and things that are used in conjunction to attain a specified goal. The examination of technical services in hospitals is aided by building a model of that system, and most important, but usually most challenging, quantifying the model at key points. Once the present system has been factually described it is usually easy to make improvements, as this procedure provides insight into what can be accomplished within the constraints of desired quality, time, and minimum cost.

The radiology service in a hospital can be used to illustrate how systems analysis has been employed. At a recent world conference of heads of radiology held in Geneva, Switzerland, it was learned that very little quantifiable information has been gathered concerning the activities of radiologists and their work environment. This service may be viewed as a subsystem of the total health care system, or a system in its own right. There is a growing shortage of radiologists in the United States, and accordingly an analysis of the radiology diagnostic system, within a radiology department, was carried out in three West Coast radiology departments with a goal toward establishing operational baselines and developing labor saving devices. Studies were made to quantify the acquisition of radiological information, information flow, the loan function, and operational procedures. It appeared that much of the radiologists' work could be delegated to subordinates or equipment.

Several established work measurement techniques were adopted for use in the radiological environment, such as random work sampling, continuous stop watch time study, time lapse motion picture photography, and the use of

existing records. The ever common problem that was solved was the acquisition of facts without changing the setting.

Five mobile multi-paneled film viewers have been developed and installed in a revised radiology department, which permits the most efficient use of space and radiologists' time. The study established a saving in time and money which justifies investment in display devices in many hospitals. A quantitative evaluation of the overall system of film flow has been made to substantiate the predicted increase in output.

Other areas of health service have been studied and may be used to illustrate the various phases of application of the system's approach, as follows:

1. Anesthesiology - initial phase of investigation and identification of strategic factors.
2. General Practice - considerable data has been gathered to document the effect of introducing a doctor's assistant (Medex) into the practice.
3. Mobile Intensive Coronary Care Unit - analysis almost complete of an urban rescue system.