International Institute for Applied Systems Analysis
IIASA www.iiasa.ac.at

Health Care System Models: a Review

Fleissner, P. and Klementiev, A.A.

IIASA Research Memorandum
October 1977

RM-77-49

HEALTH CARE SYSTEM MODELS: A REVIEW

Peter Fleissner
Alexandre Klementiev

October 1977

Preface

In December 1975, IIASA's Biomedical group, with the help of WHO, conducted an international conference on public health care modeling in Moscow and Laxenburg. Some participants of this meeting thought it would be helpful to compile a survey of the state-of-the-art in health care models. The Biomedical group started this work in spring 1976 and tried to identify as many modeling teams as possible by means of a snowball system. Questionnaires were sent to several scientists in various countries. Approximately 75 percent sent us responses --quite a satisfactory rate of cooperation. This review is meant to be a first step in further investigations, which should be repeated in due time.

Abstract

In this paper, thirty-eight models of the Health Care System are described in a standardized way. Their main goals, methods, and special features are identified. Three illustrative examples of different methodologies are given in detail. To clarify the use of models for application in the health care planning process, policy problems in health care are summarized. The different stages in creating a model are described.

Acknowledgements

The authors are very grateful to all those scientists who took part in this review by sending us their responses to the questionnaire; to J.-P. Charpentier, whose paper, *A Review of Energy Models* (RR-74-10), provided us with the framework for our questionnaire; and to S. Arthur, R. Gibbs, and M. Segalla for their assistance in the preparation of this paper.

Contents

Health Care System Models: A Review

INTRODUCTION

Health care in industrialized societies is an increasingly complex task, as new types of illnesses and new planning problems come into existence. The complexity of the health care system (HCS) recently created the need for adequately complex planning tools. The most advanced tools--mathematical models --are currently being constructed in many countries.

The Biomedical team at IIASA is working to create a universal model of health care systems. It is anticipated that this model, in its completed form, will be used to increase the effectiveness of health care system management. The model is "universal" in the sense that its structure is relatively independent of the socio-economic conditions in which actual health care systems operate. Scientists from various countries have participated in this work.

In December 1975, the IIASA Biomedical Project conducted an international conference on the subject of public health care modeling where many modeling approaches were presented and discussed (D. Venedictov, 1977). Some participants of this meeting agreed to initiate a survey on the current state-of-the-art in Health Care Models (HCMs). IIASA's Biomedical group started the work on this review in spring 1976.

In order to obtain data on HCS models the authors sent out questionnaires* to various countries in February and May 1976. A copy of this questionnaire is in Appendix 3. The answers received, available literature in this field, as well as the experience of the authors in HCS development served as a basis for the preparation of this review.

By this work it is intended: to demonstrate the different approaches to constructing HCS models; to assist the health care planner in choosing the adequate approach for his problems; and to help the model builder evaluate his own approach by comparison. The authors are well aware of the fact that HCS management problems will not be solved by models but by active people. Nevertheless, models can sharpen and structure the identification and understanding of the problems under investigation. They can clarify the functioning and the dynamics within the HCS and the interrelationships with other sectors such as economy, population, and environment.

---

*The authors of this review based their questionnaire on one used in an earlier IIASA review of energy models (see Charpentier, 1974).

In the present summary there are short descriptions of thirty-eight models developed in eleven countries. The summary consists of two parts and three appendices. The authors found it useful to include in the first (general) part a short description of certain policy problems in health. This description enables the reader to more closely acquaint himself with basic trends in the development of HCS models. The first part also contains a description of the modeling process--how models are developed. To describe the modeling process more clearly, the authors have included in the second (specific) part three suggested examples of actual investigations. In addition, three different classifications of the models already presented are included here. The basis of the first classification is the "readiness and completeness" of the given models. The second classification groups models according to their development goals. Finally, the third classification gives an idea of the methods used by authors in developing their models. By this work, the authors of the review hope to reduce the gap between advanced modeling research and lagging practical experience in the use of these models.

1. GENERAL PART

1.1. General Considerations

The use of computer models is becoming an increasingly important activity, not only in engineering projects but also in socio-economic areas as well. One reason is that users need *quantitative tools* for predicting system behavior, which take into account states of system environments (now and in the future), and control (management) policies. Another reason is the impossibility to experiment with the real system itself because of potentially dangerous after-effects and unadmissible time-lags for getting results of experiments.

1.2. Policy Problems in Health

The health care system of every country is influenced by technological progress, changes in the population's age/sex structure, progress in biomedical science, and by other factors which aggravate the problems of health care system management. Hence, policy makers face many of the same problems and issues. In this section we present a short discussion of some of the major common issues.

Problems of *structure* are concerned with choosing an appropriate health care system, and handling changes in the existing structure.

The major issues in *resource allocation* are what types of resources are available and needed, and where and when resources should be allocated.

Public health planning makes necessary the development of *standards* and guidelines. Such standards must reflect:

- the kind of medical care needed by the population;

- hygienic standards, including maximum permissible concentrations of atmospheric pollutants, etc.; and

- standards which regulate labor productivity of medical personnel (for example, a physician's load).

Standards should be renewed to reflect changes in the sex/age structure of population, advancement of science and technology, and development of the health care system itself. The following question should be answered: how and how often are standards to be renewed?

Problems in the area of *prevention/treatment policy* are connected with deciding what percentage of available resources will be allocated to prevention, and what percentage to treatment.

The issue in *health insurance* is the choice of a mechanism for reducing financial burdens on individuals and families. There are various possible approaches, some comprehensive and integrated (such as the National Health Service in the U.K.), some more differentiated, where a mixture of private health insurance companies and different public health institutions is used.

The main functions of a health care system, which may be used as *evaluation criteria*, are (see Venedictov paper in N. Bailey, 1975):

- medical research and accumulation of medical biological knowledge;

- comprehensive measures, undertaken by individuals or community, for prevention of disease, with special emphasis on infant and child care and on environmental and health problems; and

- timely diagnosis of diseases and their adequate treatment and cure.

There are a number of ways to numerically evaluate the activities mentioned above. It should be noted that for certain kinds of activity no direct measures exist, and that there is no single, general quantitative criterion for adequately measuring the effectiveness of health care system activities on the whole. These points underscore the difficulties encountered both by the decision makers obligated to evaluate the quality of various management alternatives and by system analysts attempting to make their health care system models more adequate.

The above problems are not the only ones, but they are typical of public health care. These problems are usually interconnected. Models of health care systems could give a certain assistance in the settlement of such problems (D.F. Bergwall, 1975).

- A quantitative model gives the user the possibility *to evaluate quickly the consequences of different management problems* (e.g. distribution of resources or updating of standards).

- Proceeding from the results of the evaluation, a user *could choose an acceptable decision* among those tested with a model.

- Development of a model, and its running, make it possible *to understand better the nature of the modeled system.*

1.3. The Modeling Process

We will give, in this section, a short review of the modeling process. The process in general is a very complex one. Many steps described here as following each other, in practice will be handled in parallel or will be linked together. Very often a cyclical behavior will evolve (see Figure 1).

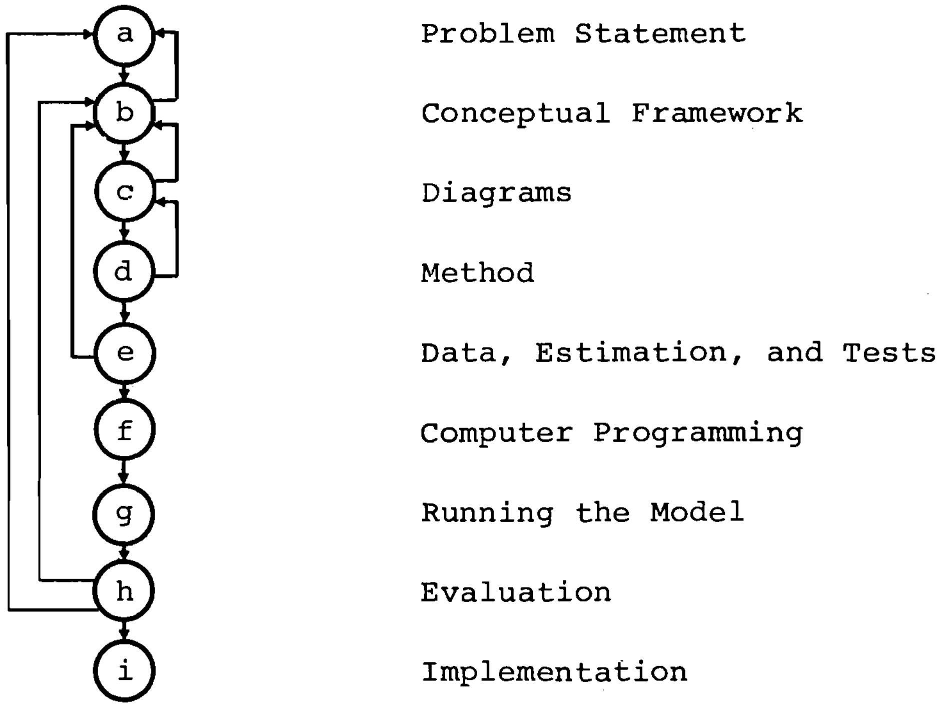


Figure 1

a. *Problem identification and statement*: the most important step in creating a model is to define the problem in question in a clear and precise form. The theoretical background should be clarified. The modeler must be well aware of the way he looks at the problem because by this step he creates the range of possible solutions.

b. *Conceptual framework*: at this step one must define the system, its boundaries, the relevant factors and variables, and their influences and interactions. A definitional framework and a set of hypotheses must be developed. A review of existing models and related literature on health care is very helpful at this stage, to prevent illusions on the practicality of the model, and to help build a model which is neither too simple nor too complex. For qualitative variables, quantitative indicators must be defined. The problem of available data immediately comes into focus. The amount of data necessary for the model is determined largely by the level of disaggregation. One must estimate the amount of resources (manpower, computer time), and their associated costs, to be sure the model can be constructed.

c. *Graphical representation*: for a clear and communicative representation of the model's basic structure, it is very useful to draw a causal loop diagram. This is especially helpful in discussions with experts from other disciplines who are involved in the modeling effort. The most important feedback-loops (if any), the main causal relationships, and the direction of influence can be brought into such a diagram.

More elaborate versions of graphical representation such as DYNAMO-Diagrams may be employed. These are very near to the mathematical description and to the flow-charts corresponding to the computer implementation of the model.

d. *Choosing the modeling method*: usually a mathematical description of the relations between the variables in the model must be given. In general, for dynamic models, this description will be in terms of differential (continuous time) or difference (discrete, often equidistant points of time) equations, giving the behavior of the variables over time.

To select some "optimal" solution at one point of time, or during a time interval, mathematical programming techniques, often linear programming, are used. Optimization requires one or more objective functions and a set of constraints (described by inequalities).

Among other standard procedures and structures which are available to represent the real processes, some of the most widely used are:

- *input-output techniques*: under some restrictive assumptions for the production (generation) of certain amounts of things (outputs, commodities, illness-types, etc.) the amounts of necessary inputs at a certain level of technology are given. These techniques are often used in combination with constraints and an objective function for optimization.

- *stochastic processes*: a matrix shows the probability of transition from state i to state j over time (Markovian Model).

- *queuing*: one can express how many units of things or persons arrive within an interval of time, and how long they have to wait to be served (or treated).

- *gravity model*: this model is used mostly by urban or regional planners. It implies that people living at a greater distance from an institution are less likely to use it, and that people use a larger institution more often than a smaller one.

- *DYNAMO-model*: to create a dynamic model, main variables are split into levels (stocks) and rates (flows, changes per time unit). A computer language enables the user to circumvent the explicit mathematical formulation by means of direct programming statements. Only recursive structures can be generated. (No influence from A to B and from B to A in the same moment is allowed.) DYNAMO's numerical abilities approximate a set of canonical differential equations by means of (nonlinear) difference equations.

- *econometric models*: originally these methods were developed for application in the economic sector. Later on these techniques of model formulation, parameter estimation, and forecasting were used in other sectors as well. An econometric model consists of behavioral and definitional equations. Behavioral equations represent "quasi laws" of the sector under investigation, definitional equations represent identities assured by theoretical considerations.

- *logical model*: for describing decisions the logical structure can be reflected by 0/1 variables (yes/no, true/false) and their relationships.

Each structure may be used for simulation purposes. Many others, more refined, are possible.

e. *Data, estimation, and tests*: in working out a quantitative model it is necessary for the designer to determine the validity of mathematical relations, and to define the parameters and/or constants included in the mathematical relations. In order to carry out this work, the designer must have the appropriate quantitative data. Experience in health care system modeling has shown that usual sources of initial numerical data are:

- the official published state medical and demographic statistics of the given country;
- the official statistics of WHO;
- clinical and current health statistics published in medical and health care periodicals; and
- expert evaluations.

The parameters and/or constants of the model can be estimated in different ways. The method of estimation is determined largely by the kind and amount of data available. If there is a sufficient data base (time series or cross-section data) statistical methods (regression analysis, correlation analysis, path analysis, econometric methods, spectrum analysis, etc.) may be applied. Hypotheses may be tested and the value of parameters derived (e.g. normal regression, T-test, F-test). As a rule equations which are not rejected are assumed to be true in the future, and used for forecasting.

If there are no quantitative data available, the value of the parameters should be estimated approximately. The methods vary from intuitive and individual determination, delphi-techniques to group consensus. Often the results of the model will lead to changes of such "soft" parameters.

f. *Computer programming*: after a reasonable set of equations or inequalities has been determined, these must be translated into a computer language. Many languages for digital computers are available, more or less problem oriented (e.g. ALGOL, BASIC, CML, COBOL, DYNAMO, FORTRAN, GPSS, PL/1, SIMULA, SIMSCRIPT).

If there is no need for high accuracy of the solution and there are highly nonlinear differential equations, the analogue computer is very useful.

Every type of error check, even though time consuming, should be included in this step.

g. *Running the model*: to get solutions from the model, three stages must be mentioned: feeding in initial data, numerical solutions, and representation of results.

- *Initial data*: in addition to parameters reflecting the quantitative behavior and/or relationships between variables, initial data must be given for dynamic models.

They define the starting point of the model for further development of the variables. For optimization models parameters of the objective function must be specified.

- *Numerical solution*: problems arise in the numerical solution of large systems. At the moment nonlinear simultaneous systems are usually solved by iteration on a digital computer. There are many other methods available (gradient methods, Fletcher-Powell-algorithms, etc.) where derivatives must be given explicitly. The solution of optimization models needs complex algorithms and large storage space and/or computer time. Easiest to solve are recursive systems, where the solution is directly reached step-by-step.

  On analogue computers, solutions are available in very little time. The influence of parameter changes can be studied almost immediately.

- *Representation of results*: the resulting figures can be printed as numbers or plot-diagrams. Sometimes digital computers use a plotter (as analogue computers very often do). With its help, continuous graphs are produced. For analogue computers the usual form of output is given on a screen (like on television). Photographs or other reproduction techniques are possible. Here it should be mentioned not to forget to document the results and initial assumptions. A model builder can very easily become confused by an overflow of computer output. It is not enough to publish the results without comment. Interpretations must be given, in terms of the applied theory and hypotheses.

h. *Evaluation*: the outcome of the model should be evaluated by those who have a good understanding of the real world system itself. They should look for impossible behavior of the model compared with reality. Of course, forecasts of such things as negative numbers of medical doctors demand changes in the model hypotheses.

Up to now there are no reliable validity tests for models in the social sciences. In fact the modeler is satisfied if the model explains past behavior more or less accurately. Sensitivity analysis is a useful method for studying the influence of changes of a parameter on the solution. More sensitive parameters should be measured more accurately. Nevertheless there exists a practical limit in sensitivity analysis in checking every possible combination of parameters. This is particularly true for large nonlinear systems.

i. *Implementation*: many of the models are used only within the academic community and are only for academic discussion. Few models reach their goal: to be implemented at some institutions for decision making purposes. There are many reasons for this fact:

- unrealistic assumptions in the model,
- investigation of irrelevant problems,
- inadequate level of aggregation,
- high cost,
- erroneous forecasts,
- apprehension at seeing the computer as the new decision maker (perhaps justified),
- lack of documentation,
- lack of comprehensiveness, etc.

The model should be adapted whenever new data are available. It should be brought to the most recent level of scientific knowledge so as to function as a useful tool for decision making.

2. SPECIFIC PART

2.1. Status of Reviewed Models

The 38 questionnaires received can be clustered into groups according to: the amount of information available about the model; its state of readiness; and the subsectors it includes. We found it useful to introduce five categories:

- A: model finished, well-documented, additional papers available.
- B: model finished, questionnaire only.
- C: model partly finished and/or applied.
- D: model in planning stage.
- E: subsector(s) only.

Table 1 indicates, for each model, its status according to the above categories.

Table 1

A	11	A1*, C1, J1, S1, S3, S5, U1, U2, U7, U8, W1
B	8	C4, C7, C10, F2, S4, S8, U3, W2
C	8	C5, C11, F1, P1, S2, S6, S7, S9
D	3	B1, J2, U6
E	8	C2, C3, C6, C8, C9, I1, U4, U5
$\sum$	38	

*) For abbreviations (models' codes), see Appendix 1.

2.2. Goals of Modeling

In addition to the basic identification of a model--its author, name, and main references--we asked the model builders for the goals and motivations they used in formulating their models. Although the goals were not always transformed into adequate model structures, the perception of the use of the models in health care can be summarized from the answers.

In all, sixty answers were identified, with goals expressed on very different levels of generality. Of these, nineteen look on HCMs as tools to support national (or regional) health planning in general. The other answers are more specific.

a. Fifteen answers specify more explicitly the *usage* of the model in the planning process:

- for testing policy options or assessing resource allocation;

- as a learning tool;

- as a forecasting tool.

b. Four answers stress the goal of *illustration*, e.g. of:

- main trends in HCS;

- contradictions between planning and effectiveness;

- influences of environment and medical care on health status;

- the application of a computer language.

c. Nine answers see the model as a way to help *discuss*, *study*, *explore*, or *analyze*:

- hospital systems;

- the dynamics of HCSs;

- the related costs, resources, and needs;

- problems of investment and personnel;

- the effects of different sectors on each other;

- factors contributing to the rapid increase in demands on medical care.

d. Three answers mention the usefulness of the model in the *evaluation* of:

- effectiveness of HCSs;

- comparisons between HC programs;

- reliability of the data collected.

e. Six answers perceive the model as a precise instrument to *determine*, *compute*, *observe*, or *specify*:

- optimal allocation of resources;

- optimal investment policy under environmental constraints;

- characteristics of regional HCSs;

- effects of population dynamics on allocation of resources.

f. Other specific goals mentioned include:

- creating a HCM as part of an overall socio-economic model;

- creating a HCM as a more generally accepted basis for cost/benefit analysis;

- helping to form a consensus, among pressure groups in a region, on the development of a medical information system;

- using a HCM for comparative analysis of the activities of different HCSs.

2.3. Methods Used

The answers received reflect nearly all possible methods of mathematical and verbal modeling. In this case the clustering of the models was easy. Most of them are either simulation models or structural models. Many of them used Forrester's systems dynamics as a tool. A second group estimated the parameters of the model by econometric methods, mostly regression analysis. Linear or nonlinear optimization models form the third group. Nonlinear programming seems not to be commonly used. The rest of the models consist either of Markovian or patient flow techniques, or of iconic, logic, semantic, etc., descriptions. Table 2 shows the different groups.

Table 2

	Simulation Models	Econometric Models	Optimization Models		Markovian Flow Models	Others
			Linear	Nonlinear		
A1	X	X				
B1						X
C1			X			
C2		X		X		
C3		X				
C4		X			X	
C5			X			X
C6						X
C7		X				X
C8						X
C9		X				
C10					X	
C11						X
F1	X					
F2	X					
I1	X					
J1	X					
J2	X					
P1		X				
S1	X					
S2	X					
S3	X					
S4		X	X	X		X
S5			X			
S6			X	X	X	
S7						X
S8			X			X
S9		X	X	X	X	
U1				X		
U2			X			
U3					X	
U4	X				X	
U5	X					
U6						X
U7		X				
U8		X				
W1	X					
W2			X			

2.4. Three Examples

Because we could not get complete descriptions of each of the models in time, and also because the answers to the questionnaires were on too general a level to enable us to make comparisons, we decided not to describe each model in detail but instead to present an example of each of the most widely used methods: an econometric model, a simulation model (systems dynamics), and an optimization model. We excluded our own models to reduce bias in reporting, and we included a model only if:

- it was already completed and well-documented descriptions were presented to us;
- its main task was to model the HCS in a comprehensive way; or
- concrete results and conclusions from the model had been published.

2.4.1. A Macroeconometric Model (U8)*

The authors used the macroeconometric approach as the proper framework for the following reasons:

- it is relatively uncomplicated and hence accessible to planners not trained in econometrics;
- it is sufficiently detailed to be useful to health-policy makers, without inundating them in more output than could be digested in a reasonable time period for decision making;
- it can be implemented at both the state and local levels using available data.

The authors claim that the first two advantages are also the model's weaknesses. If aggregate magnitudes are directly forecast, distributional effects of policy actions on subpopulations are sacrificed. Similarly, the model is too crude to use in forecasting the details of complex programmatic changes. The authors feel, nevertheless, that this model represents a reasonable compromise between intricate detail and relatively uncomplicated analysis.

---

*Survey of a paper by Yett, D.E., et al.: A Macroeconometric Model of the Production and Distribution of Physician, Hospital, and Other Health Care Services (in D. Venedictov, 1977).

The System Analyzed and its Boundaries: the scope of the model is the entire personal HCS, excluding mental health, drugs, and dental care. It treats the following three sectors of health care institutions.

Sector A. *Inpatient services* from:

(1) voluntary and proprietary short-term hospitals;

(2) state and local government short-term hospitals; and

(3) skilled nursing homes.

The endogenous variables for these institutions are the number of patient days utilized, the number of beds available, the occupancy rates, and the daily service charge for (1) and (3).

Sector B. *Outpatient institutions*:

(4) outpatient clinics of short-term voluntary and proprietary hospitals;

(5) outpatient clinics of short-term state and local governmental hospitals;

(6) offices of medical specialists (including general practitioners) in private practice; and

(7) offices of surgical specialists in private practice;

described by number of patient visits and price per visit for (4), (6), and (7).

Sector C. *Health manpower*:

(8) M.D. general practitioners in private practice;

(9) M.D. medical specialists in private practice;

(10) M.D. surgical specialists in private practice;

(11) other specialists in private practice;

(12) physicians employed by hospitals;

(13) hospital interns and residents;

(14) registered nurses;

(15) practical nurses;

(16) allied health professionals and technicians; and

(17) non-medical labor (e.g. housekeeping, maintenance, and clerical).

In addition to the number of such "active" or employed personnel, the model includes the annual wages for (14), (15), and (16).

There are demand and supply equations for the number of patient days and daily service charges for inpatient care, and for the number of patient visits and prices per visit for outpatient institutions. Health services and health manpower categories are linked through the fact that quantities of health services produced are used to determine the demands for each type of health manpower.

The model consists of 47 endogenous variables--13 in Sector A, 9 in Sector B, 25 in Sector C--and 47 exogenous variables, 17 of them representing geographic differences specific to a particular state or area.

Parameter Estimation: most macroeconometric models are estimated using time-series. In this case, sufficient data were not available. Therefore, the authors used the following strategy:

1. Cross-sectional state data were used to estimate a "generalized" model (1970 data).

2. Initial values were set equal to their 1967 levels for one state (California), and forecast development was compared to actual development for 1968-1972.

3. For variables whose historical values could not be forecast within acceptable limits, alternative specifications of the equations were tried.

4. To improve the model's historical behavior, the authors experimented with adjustments ("add-factors").

5. Similar simulation experiments were conducted on other states and regions, without respecification or "add-factors", to see the performance of the model.

Examples of Equations: Two typical equations, chosen to illustrate the method of constructing this model, are:

$$PD\text{-}P = \underset{(-2.38)}{-36.2394}\,\frac{P\text{-}HP}{P\text{-}OP} + 61.1378\%OLD \qquad (1)$$

$$+ \underset{(4.91)}{656.3433}\,\frac{HBEN}{P\text{-}HP} - \underset{(-9.32)}{0.9308}PDGA + 317.88 \quad ,$$

where

$$S.E. = 119.4853 \quad \text{and} \quad \bar{R}^2 = 0.81 \quad ;$$

$$OCCP = \frac{PD\text{-}P}{0.00365BEDP} \quad . \qquad (2)$$

Equation (1) expresses the relationship between the annual number of inpatient days (PD-P, for short-term voluntary and proprietary (STVP) hospitals, in millions), and the average daily service charge (in STVP hospitals, (P-HP)/(P-OP)); the proportion of the population aged 65 and over (%OLD); the benefits per capita for hospital care paid by private and public insurance programs (HBEN, per unit of average daily service charge in STVP hospitals (P-HP)); and the weighted average of inpatient days provided by short-term state and local government hospitals (PDGA).

Equation (1) is called a behavioral equation. It describes the behavior of demand in relation to the other variables. We conclude, by looking at the coefficients, that there is a negative relationship between the demand in patient days and the ratio of the price of hospital care to outpatient care. We also conclude that the higher the percentage of population aged 65 and over, the higher the demand for hospital days, etc.

Equation (2) is called a definitional equation. Parameters are not estimated empirically but are determined by definition. The average occupancy rate in STVP hospitals, OCCP, is defined by the ratio of demand for hospital-days to the annual (365 days) available bed-days in STVP hospitals.

For behavioral equations the authors added t-values (written in parentheses under the estimated parameters), standard errors of regression (S.E.), and multiple correlation coefficients ($\bar{R}^2$) to show the goodness of fit in historical performance.

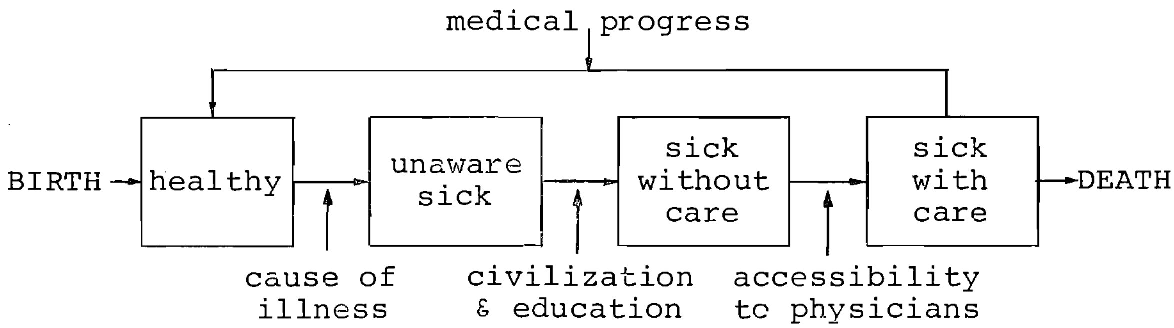
All the equations of the model consist alternatively of two types: behavioral or definitional. Any collection of these equations is called an econometric model.

Results: a baseline simulation was performed on the assumption that recent trends for each of the exogenous variables would continue from 1973 to 1980. Experiments performed with the model involved assuming (through, say, certificate-of-need regulations) that the number of total hospital beds per capita in California would be held constant at the 1972 level (i.e. would grow in direct proportion to population). The average occupancy rate rises in comparison with the baseline projection, since hospital beds increase less rapidly than utilization. This, in turn, leads to some differences in the forecasted prices of health services and wage rates for the various categories of health manpower. There is also a modest increase in outpatient visits, since the model permits some substitutability of outpatient for inpatient care.

Other experiments showed that, if small changes of limited duration were allowed, the resulting changes in the values of the endogenous variables would be correspondingly small. Longer and more long-lasting changes would have shown more sizeable consequences. Also, the direct effects of both experiments were, to some extent, partially offset by secondary effects elsewhere in the model. The existence of such offsetting secondary effects reinforces the importance of forecasting the secondary as well as the primary effects of policy changes.

2.4.2. A Systems Dynamics Model (J1)

One of the most impressive trends in the past years in Japan has been the rapid increase of medical demands, represented by prevalence rate and consultation rate. As very little is known about the mechanisms of these changes, the purpose of this model was to analyze the evolution of medical demand, to clarify the factors influencing the changes, and to estimate future medical demands in Japan. To begin this task, population was divided into four groups: *healthy*, *unaware sick*, *sick without medical care*, and *patients*. The *unaware sick* might be considered as latent needs for medical care and the *aware sick* as real medical demands. Flows of people were assumed to exist between these groups (see flow diagram below).

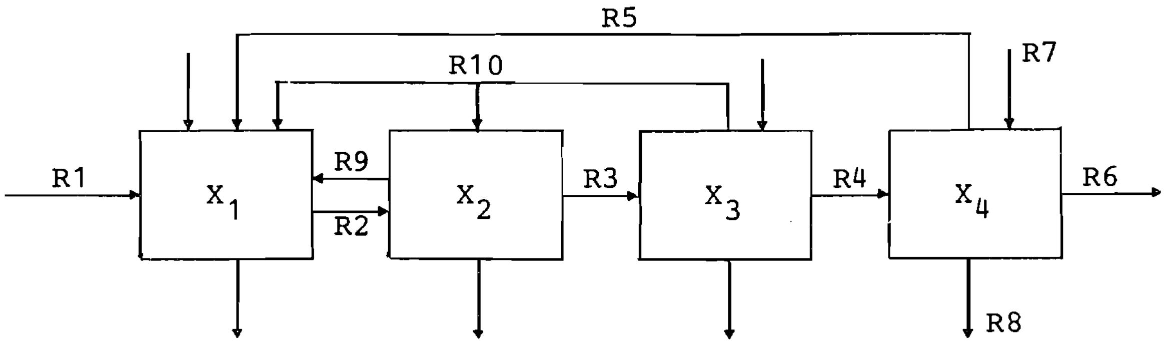


Basic Flow Diagram of HC-Model (J1)*

*Kaihara, S., A Simulation Model of Health Care in Japan, paper presented at the 3rd European Conference on Cybernetics and Systems Research, Vienna, 1976.

A part of the healthy population is assumed to become ill at some constant rate; then the *unaware sick* shift into the group of *sick without medical care*, and the *sick* into *patients*. A subgroup of the patients dies, another subgroup recovers and flows back to the healthy group again. The factors which are supposed to influence the flows are also shown in the flow diagram.

For computational reasons, a more refined structure was assumed:



R7, R8, R9, and R10 represent additional flows, e.g. R9 is the flow from X_2 to X_1, the sick who get well without consulting physicians.

Each group is divided into four levels by age: less than 14; 15-44; 45-64; and over 65. Each age group has the same structure as in the above diagram. R7 and R8 represent the flows between these age groups. This means that the model is made up of 16 different groups (population by health status and age) and 29 flows between them.

The above model is then expressed in a set of differential equations. If the rates are assumed constant in a year and if the system is in equilibrium insofar as no large changes from external cause take place, the equations can be solved.

Known and Unknown Variables: for the calculation of the model, the statistical values used as indicators for the variables described in the previous section were:

- birth rate for R1;
- number of first visits to physicians for R4;
- duration of illnesses for the calculation of R5;
- death rate for R6;
- population survey for R7 and R8;
- rate of selecting medical care for the calculation of R10;

- patient survey for X_4; and
- prevalence rate of "National Health Survey" for X_3.

No such statistical values were available for:

- R2 (ideal incidence rate of illness);
- R3 (the rate at which *unaware sick* become *aware*);
- R9 (number of *healthy*); and
- X_2 (number of *unaware sick*).

However (and this shows the main advantage of this method), if one of these values is given, the other parameters can be derived from the equations. In this study, R2 was assumed to be constant for the past 15 years, and the other parameters were calculated. The calculation was performed for each year, assuming the system to be in equilibrium within a year. After all parameters were obtained for each year, the entire model was run for the past 15 years, using the program DYNAMO.

Main Results: with the help of the model, one can break down the mechanism of change of medical demand into four factors:

- demographic change;
- rate at which the *unaware sick* become aware of their illnesses (R3);
- rate of recovery (R5); and
- accessibility to physicians (R4).

It is interesting to note that the change in population structure did not contribute much to the increase of medical demands in the past years. The change in R3 was most remarkable, and was considered to be the main factor in increased demand. In the future there will be a different cause for the change of medical demand. Here the main factors will be:

- aging of the population;
- decrease of R5 for 45-64 age groups; and
- increase of R3.

2.4.3. An Optimization Model (U1)*

The form of the organization of HC in the United Kingdom requires first a corresponding form of strategic models of the HCS. Second, in contrast to descriptive models which tend to perpetuate the status quo, such models should take a very long-sighted view of the options open to National Health and incorporate an understanding of what the ideal types of service would be. Third, strategic models should represent the behavioral conflicts that result from having less resources available than the number needed to attain ideal levels of HCS. The answer of the authors to these three necessities is the "Inferred Worth Model", an optimization model. It is specifically concerned with the way in which the development of services for one client group may interact and compete with the development of services for another client group because of constraints on the overall availability of resources. It represents the pattern of care given to different types of patients in terms of:

- *cover*, the number of patients receiving care,
- *modes*, the types of care available, and
- *standards*, the levels at which care is given to individual patients in quantitative terms,

and explores alternative patterns.

Within the model there is a representation of alternative modes of care for a number of patient categories within each main client group. However, the special value of the model is in showing the conflicts and interactions between the proposed developments for the different client groups. This required that results from the model be reported at a level above the subdivisions of the Department of Health and Social Security, with which the project group had to work closely to achieve a correct representation.

The model is capable of exploring patterns of service that are radically different from those that are obtained today. Only by taking into account the ideal, extreme possibilities can one select the best direction in which to move. Decision makers will not thank their predecessors for having looked no further than the prevailing limits for change.

It is important to realize that the model is not an optimizing model in the classical sense. It is an exploratory model. Its principle function is to predict the consequences for patients of different mixes of resources being provided

---

*Based on a paper by McDonald, A.G., and R.J. Gibbs: Some Requirements for Strategic Models of Health Services Illustrated by Examples from the United Kingdom (in D. Venedictov, 1977).

by the service. Thus planners use the model in a "what-if" manner, iteratively, to explore options. They suggest one set of resources, observe the likely consequences as estimated by the model, suggest a modified set of resources, and so on until they find a set of resources which they judge to be best. The key technical feature of the model is that it attempts, via the inferred worth functions, to represent how, in practice, the HCS rations out scarce resources between patients, modes and standards; i.e. it represents the value system that operates in the care delivery process, which is not necessarily the same as the value system of the central decision maker. This is important, since in the U.K. health service the decision maker does not in general control the precise way in which resources are used when care is delivered. However, he does have considerable control over the aggregate supply of each of the main resources. Thus his problem is to discover that mix of resources which, within the prevailing financial constraints and given the value system operating in the field, will produce the outcome for patients that is best in his valuation.

It is, however, possible to use the model in a way that is more akin to classical optimization. In this type of run the model is given some limited freedom to search for a set of aggregate resource levels which, within the prevailing financial constraints, maximizes total net inferred worth. The solution to such a run represents an optimization with respect to the value system in the care delivery process, not the value system of the central decision maker. Thus, if the model builders offer such a solution to the decision maker, they must urge him to closely examine the solution for possible conflicts with his values. Reassuringly, however, experience with this type of limited optimization suggests that the solutions obtained are often dominant in most respects over solutions obtained by other means.

In most of the planning applications of the model so far, a series of runs has been performed including runs of both the "what-if" type and the limited optimization type.

An Example of Application: consider, for example, the hernia category, one of approximately 200 patient categories currently represented in the world. There are two different *modes* of treatment:

- surgery, with a stay in the acute ward of a hospital; and
- day surgery followed by a number of nurse visits to the patient's home.

Although the second mode of treatment is cheaper for the health service, it is employed only for a small proportion of hernia patients, although the trend is for this proportion to increase. Some of the reasons for this behavior are:

- the scarcity of home nurses;
- disapproval of the treatment by some clinicians; and
- unsuitability of some patients for the treatment.

Each of these reasons can be represented in the model by constraints.

Another aspect of the model is important. It concerns the *standards* of care. Thus, for the day surgery mode of care for hernia patients, U.K. literature suggests that on average an ideal or desired standard might be about six post-operative home nurse visits. Similar ideal standards of care are defined for other modes in the model. In practice, the service employs modes of care at considerably less than these ideal standards because of resource scarcities. This behavior is represented in the model by a function, "Inferred Worth". It is hypothesized that the service attempts to maximize inferred worth net of cost. At ideal standards the contribution to the total inferred worth is zero. For less than ideal standards there is a negative contribution, depending on the direct resource unit cost. The Inferred Worth function allows one to predict the services' behavior in the case of a mixture of different patient categories (e.g. hernia patients, elderly clients, etc.). The model will select that combination of modes, standards, and cover which maximizes Inferred Worth overall.

To show the mathematical framework of the model, we include below the original summary of the Inferred Worth Model.

*The Inferred Worth Model - Summary**:

Definitions: i - category of patient;

ℓ - mode of care;

k - resources;

$x_{i\ell}$ - number of patients in category i allocated to mode ℓ;

d_i - number of patients in category i to receive treatment;

D_i - total population of potential patients in category i;

---

*Summary submitted to us by R.J. Gibbs, et al. Full account of the Inferred Worth Model is given in McDonald, A.G., G.C. Cuddeford, and E.M.L. Beale, Balance of Care: Some Mathematical Models of the National Health Service, *British Medical Bulletin*, 30, 3, 1974.

E_i - elasticity of demand of patients in category i with respect to opportunity cost;

π_i - a constant (to be determined);

C_k - unit cost of resource k;

$u_{i\ell k}$ - standard (amount of resource allocated) for resource k used in mode ℓ for category i;

$U_{i\ell k}$ - corresponding ideal standard;

F_{ik} - elasticity of the actual allocation of resource k to each patient in category i with respect to the opportunity cost of the resource;

B_k - availability of resource k.

Hypothesis: The service will choose the d_i, $x_{i\ell}$ and $u_{i\ell k}$ so as to maximize the following function W (total net inferred worth):

$$W = \sum_i g_i(d_i) + \sum_i \sum_\ell \sum_k h_{i\ell k}(u_{i\ell k})x_{i\ell} - \sum_i \sum_\ell \sum_k C_k u_{i\ell k} x_{i\ell} \quad ,$$

where

$$g_i(d) = \begin{cases} \dfrac{\pi_i D_i^{1/E_i}}{1 - 1/E_i} \cdot d_i^{(1-1/E_i)} & \text{for } E_i \neq 1 \\ \pi_i D_i^{1/E_i} \ln d_i & \text{for } E_i = 1 \end{cases}$$

and

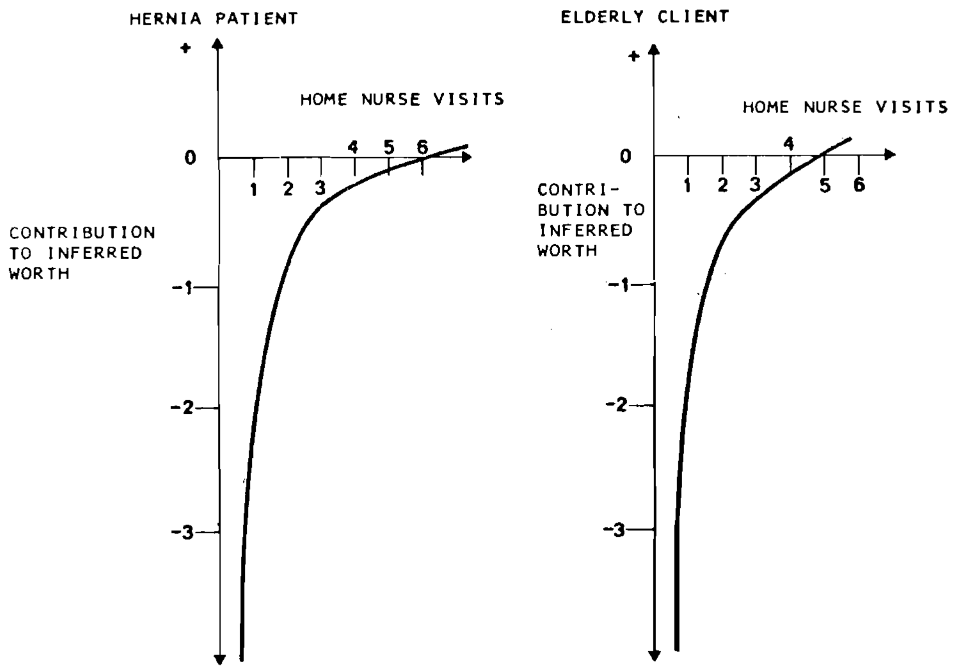
$$h_{i\ell k}(u_{i\ell k}) = \begin{cases} \dfrac{C_k U_{i\ell k}}{1 - 1/F_{ik}} \left\{ \left(\dfrac{u_{i\ell k}}{U_{i\ell k}} \right)^{1-(1/F_{ik})} - 1 \right\} & \text{for } F_{ik} \neq 1 \\ C_k U_{i\ell k} \ln\left(\dfrac{u_{i\ell k}}{U_{i\ell k}} \right) & \text{for } F_{ik} = 1 \end{cases}$$

subject to the constraints:

$$\sum_{\ell} x_{i\ell} - d_i = 0 \qquad \text{for all } i \quad ,$$

$$\sum_{i} \sum_{\ell} u_{i\ell k} x_{i\ell} \leq B_k \qquad \text{for all } k \quad ,$$

and to any bounds that are specified on the values of d_i, $x_{i\ell}$ and $u_{i\ell k}$.



HERNIA PATIENT		ELDERLY CLIENT		TOTAL INFERRED WORTH
NUMBER OF VISITS	CONTRIBUTION TO INFERRED WORTH	NUMBER OF VISITS	CONTRIBUTION TO INFERRED WORTH	
5	-0.04	0	-∞	-∞
4	-0.13	1	-1.00	-1.13
3	-0.30	2	-0.20	-0.50
2	-0.80	3	-0.05	-0.85
1	-3.50	4	0	-3.50
0	-∞	5	+0.02	-∞

The Rationing of a Scarce Resource between Two Competing Clients as Represented in the Inferred Worth Model. (The curves depict the function $h_{i\ell k}(u_{i\ell k})$, for illustrative parameter values $F_{ik} = 1/3$ and $C_k = 1/30$.

2.5. Collection of Replies to Questionnaires

This section contains descriptions of the various models. In most cases the descriptions are written by the authors themselves, as replies to our questionnaire (see Appendix 3). In a few cases we did not receive replies in time, and we have written descriptions of the models ourselves. These models include numbers C2, U7, and U8.

A1 - AUSTRIA

The Model	Author: P. Fleissner, Austrian Academy of Sciences, Institute of Research for Socio-Economic Development, Vienna. Publications: An Integrated Model of the Austrian Health Care System, in N. Bailey and M. Thompson, eds., *Systems Aspects of Health Planning*, North-Holland, Amsterdam, 1975. For the general framework see: Naschold, F., et al., *Systemanalyse des Gesundheitswesens in Oesterreich*, Institute for Advanced Studies, Vienna, 1975 (5 Volumes).
System Described	The Austrian HCS in interaction with national economy, demographic system and health politics. HCS includes preprofessional morbidity episodes, sick-leaves, indoor morbidity, mortality; HCS-system resources (doctors, nurses, beds); costs of medical care for outpatient and inpatient care, drugs.
Area — Time	1961-1995, annual extrapolations.
Area — Space	The whole of Austria.
Motivation	Impetus: The model was used as a clarifying instrument in a verbal large-scale and long-term study of the Austrian HCS. Goals: (1) Illustration of main trends of HCS-development under different political conditions; (2) Learning tool for HC-planners; (3) Framework for assessment of political measures inside or outside the HCS (e.g. economy, population).
Methodology	Descriptive two-level-hierarchical model, ~500 equations. Fifty-six of them form a simultaneous nonlinear equation system, solved by GAUSS-SEIDEL's method with AITKEN's Δ^2-algorithm to speed up convergence. As far as possible with the data available, ordinary least squares estimates were used. Statistically and theoretically suitable equations were selected according to their long-range behavior. The project team decided on equations where no time series were available.
Sequence of Computation	For every model year, the necessary demographic data, including morbidity, sick-leaves, and number of medical doctors are computed recursively. Then the econometric model of the Austrian economy is iteratively solved. Later, hospital statistics and costs of the HCS changes by political influences are evaluated. The program is written in FORTRAN V.

Input Data	*Economic data*: 56 time series of the national economic accounts, 1954-1970. *Demographic data*: Census 1961, HCS data usually 1960-1970; "Soft" data on political pressure groups by team assessment.
Results	Conditional forecasts for about 150 selected indicators, ex post 1961-1970, ex ante 1971-1995 under different political side conditions. Results show a tendency towards worse health performances combined with a rising percentage of GNP spent on the HCS. The gaps between the health conditions of different social strata (white/blue collar workers, male/female) widen at different speeds.
Comments	Model will be implemented by Association of Austrian Social Security Institutions on IBM 370/158. One run needs about 60 seconds CPU time.

B1 - BULGARIA

The Model	Authors: T. Zahariev, Mir. Popov, B. Davidov, Institute of Social Hygiene, Public Health Organization and Management, Sofia. Publications: On the Question of the Systemic Character of the Health System, *Hygiene and Public Health*, 6, 1975. Theoretical Approach of Developing a Model of the Regional Health Service, *Report of the Working Group on the Use of Operational Research in European Health Services*, ICP/SHS 028, WHO Regional Office for Europe, 1975.
System Described	The socialist system of public health in the People's Republic of Bulgaria is considered as an entire complex of non-medical (socio-economical, cultural, educational) and medical (health service) components. The health service is the specific component of public health and its defining subsystem which secures the health servicing (Health Care System (HCS)) of the population and determines the trends of the entire public health system.
Area — Time	Two kinds of quantities are used in the model: (a) *static*: the basic structure-defining criteria are described for structuring the object of the health service and its subsystems that are accepted as invariant in a long period of time; (b) *dynamic*: here, the parameters of the object of the health service and its functions and activities are described on the basis of real data for a sufficient period.
Area — Space	The regional public health system, including the health service (Gabrovo District) is modeled. The regularities received will be used for clarifying and improving the goals, structure, functions and activities of the health service in the Gabrovo District. At a later stage, they will be used for solving analogical problems of the national public health system. In this way, the regional model will be treated as a model of the National Model.
Motivation	Impetus: The idea of developing the model originates from a number of formulations of the Bulgarian Communist Party about the improvement of social management as an aftermath of the productive forces' rapid development in the epoch of the scientific-technical revolution, and the evermore expressed social processes among which an important place is given to urbanization. Goals: The main goal of the model is the creation of one principal pattern of public health for the future, which will be gradually realized (in an

	approximate period up to 1990) with a view to optimal satisfaction of the population's health requirements. At each stage in the model's development, the theoretical results are introduced experimentally into one district of the country (Gabrovo District) and an estimation is made of their practical meaning. The results proved in practice are applied (when the possibility arises) in the whole country. In this way, in fact two models are formed, one theoretical and one real.
Methodology	In the model described, the method of logical analysis is mainly used. On the basis of basic invariant functions, the object of the health service and the subsystems servicing it are differentiated. Every function is differentiated into many elementary functions, and their bearers-subsystems are specified. Every function is realized by carrying out a definite set of heterogenous activities. Some of them, being decisive, are observable and measurable (at the higher level, with the existing accounting system). An objective possibility for measuring the quality of the "functioning" of each subsystem and its component is obtained. The following groups of subsystems are defined: object, functional, institutional, subject (problem), servicing.
Sequence of Computation	At this stage, consideration has not yet been given to putting the model onto a computer. After receiving the required results, it will be possible in the next stages to create: (a) a machine data bank on the health state of the contingent of population - by data from routine statistics; (b) an imitation computer model of a given subsystem, including: - a formalized description of the health state of the contingent of population - object of this subsystem; - volume of activities (by kinds) produced by the subsystem's elements; - volume of resources invested for this purpose. Using this computer model, the consequences of index variations between groups can be overcome and regularities can be sought - with real and imitated data.
Input Data	A wide range of data about the following conditions is used: - condition of the environment; - condition of the living standard; - demographic conditions, health state of the population; - field of servicing (living, transport, cultural, etc.); - condition and activity of the health service.

	Data have been received from: - routine statistics; - purposeful studies.
Results	The main results will be expressed in the formalized description of the health service as an aggregate of subsystems having functions of their own (structure, goals, object, resources). For each subsystem, it will be possible to make a "written" technology of its functioning and its contact with others (in the health service and outside it). It will be possible to trace the expenditure of resources on *problems*, and not only on the institutional structure and financial items, i.e. premises will be there for a full introduction of the program-goal approach as basic means for management. Hence, it will be possible to seek optimal distribution of resources on problems, subsystems, and in time intervals.
Comments	An important peculiarity of the developed model is its aim: not so much to establish the possibilities of the actual public health system, but to establish the form and content of its development with a view to the optimal satisfaction of the population's health requirements. Parallel to receiving the model's basic results, the following possibilities will also arise (in our opinion): - an onset of using models for optimal allocation and investment of resources; - trends for improvement of the information system (district and national), creation of data banks and data bases, introduction of rudiments of information language, improvement in the system of documents; - creation of a model of scientific servicing of the health service (regional and national); - creation of a "metamodel" of the National Health Service and Public Health System; - trends for improving the graduate and postgraduate training of health specialists, depending on the functions of the units in which they work (will work); - creation of a morphological model ASUZ (regional and national level); - trends for a system for specializing medical personnel.

C1 - CANADA

The Model		Author: J.-M. Rousseau, Département d'Informatique, Université de Montréal, Montreal. Publications: Nguyen, H., *MEDICS: Rapport final*, Ministère des Affaires Sociales du Québec, 1975. Rousseau, J.-M., *La modèlisation d'un système de santé: L'expérience du projet MEDICS*, 1975. (*Modeling a Health Care System: Experience of the MEDICS Project*, to appear both in English and in French in the proceedings of the Canadian IIASA meeting.) Milsum, J., et al., On the Modeling of Large-Scale Health Care Systems, *Behavioral Science*, 19, 6 (1974), 407-414.
System Described		A series of interacting models of the Quebec health system are developed, including a demographic model, a resource allocation model, and a set of evaluation models for the efficiency of hospitals, the analysis of disease treatment dynamics, and the estimation of the socio-economic factors affecting health resource consumption. The principal model is a classic economic model which performs the allocation of projected resources (supply) to projected demand.
Area	Time	10-15 years.
	Space	Province of Quebec.
Motivation		To eventually arrive at a health system model to support medium- to long-range planning, evaluate the data collected for this purpose, and provide a framework for the investigation of health system models.
Methodology		Most of the models are programmed in FORTRAN. In addition, we use MPS (the IBM Mathematical Programming System package) for the linear programming allocation model. In the main system, both the projected demands and projected resources must be estimated (FORTRAN) before the linear programming model (MPS) can perform the allocation.
Input Data		Data from the hospital sector (one record with medical information on each hospitalization) and from the medical care sector (one record per M.D. visit with medical and demographic information) are used. The organization of these large data banks was also performed by the project team and is an important output of the project.
Results		At this stage, several of the models are being implemented within the Department of Social Affairs of the Quebec Government. These include:

	- the demographic model on a regional basis; - a model to calculate a relative stay index for hospitals; - a model to evaluate the production effeciency of radiology and laboratory departments in hospitals; - the organization of the data bank to easily extract any needed information. At the planning level, the models and the data permit the formulation of new working hypotheses. For example, it has been recognized that the demand for health services is quasi-infinite and is limited only by resource availability. This has shifted the focus of planning from a concern for the evaluation of the health services demand (or need), towards the goal of equalizing the distribution of available resources across all the regions of Quebec.
Comments	Although some modeling activity remains, the funding agencies have not renewed their support. The development will be continued at a slower pace at the University of Montreal, Department of Informatique. For more information, contact: Dr. Jean-Marc Rousseau, Dept. Informatique, Université de Montréal, C.P. 6128, Montréal, Québec.

C2 - CANADA

The Model		Authors: A.P. Contandriopoulos, Département de'administration de la santé, Université de Montréal, Montreal; J.M. Lance, Long Range Planning, Health and Welfare Canada, Ottawa. Publications: *A Model of the Economic Behavior of Physicians Within a General Health Insurance System*, mimeographed paper, supported by the Department of National Health and Welfare and by the Professional Corporation of Physicians of Quebec.
System Described		System of Quebec's physicians, divided by specialities, age, hours of work, type of practice, etc. A utility function, dependent on net income and leisure time of a physician, is maximized.
Area	Time	1972
	Space	Quebec, Canada
Motivation		Analysis of the optimal allocation (in terms of doctors' income) of professional activities between the ambulatory and hospital settings, number of allied manpower, which determines the costs of the system.
Methodology		Nonlinear optimization under constraints. Parameter estimation by ordinary least-squares method, equation by equation. 10-equation system, only 8 coefficients to be determined.
Sequence of Computation		After choosing values for exogenous variables (weekly salaries of staff employed by the physician, number of hospital beds, elasticity of income tax in relation to taxable income, etc.), the optimal values of the endogenous variables (especially net income) are determined.
Input Data		1972 computer file of data collected by the Professional Corporation of Physicians of Quebec, combined with statistics of the Quebec Health Insurance Board on the services rendered by each physician.
Results		(1) Optimal distribution between ambulatory and hospital settings is similar to the observed distribution. (2) Individual physicians do not gain by employing allied health manpower. (3) Physicians could produce more medical services if they overlooked their self-interests (i.e. net income).

C3 - CANADA

The Model	Author: L. Fazekas, Ministry of Health of the Province of Ontario, Toronto.
System Described	The model has the following main parameters: population described by age and sex; demand for various kinds of medical services provided by different specialities; number of physicians in each speciality; and amount of services rendered by a "typical" physician in each speciality. Using this information, taking variation in the total population as well as in its composition, and estimating changes in services, the number of physicians by speciality can be calculated - while minimizing the cost of provision of care.
Area — Time	1972-1990, annual extrapolation
Area — Space	Province of Ontario.
Motivation	Impetus: The model was constructed for planning in the Provincial Government. Goals: To gain a better understanding of the current system by analyzing and quantifying services; to get a more accurate estimate of future medical manpower requirements.
Methodology	There are two distinct models to serve the same purpose. The simple model assumes that the service pattern in the future will be constant but that the size and composition of the population (age and sex) will change in time. The model calculates the consequences of the changes as far as medical manpower is concerned. The second model allows the service pattern of the specialities to change as well, and the result is dependent on both variables. Since there is an overlap in services rendered by various specialities, the same type of service has different costs, depending on who renders it. The LP model, while solving the simultaneous equations, selects the cheapest solution as well.
Sequence of Computation	Yearly calculations with the simple model considering the yearly population growth estimates. The LP model is more effective doing monthly calculations because it can take seasonal fluctuations into account. Requirements for high and low demand months can be calculated and the plan devised accordingly.

Input Data	*Economic data*: Physicians' services information for the period of 1972-1975, by specialities. *Demographic data*: Population estimate of the provincial government for the period of 1976-1990 by age and sex.
Results	Test runs, changing demographic descriptors, service patterns and ratio of physicians in different specialities, proved that the set-up of both models is correct. Calibration runs showed encouraging results. Predictions for future conditions have not yet been tested.
Comments	There is no plan for the utilization of the models in Ontario at this point in time. For this reason, no update was done on the data. However, if there is a demand, it can be put into operation in a relatively short time.

C4 - CANADA

The Model	Author: D.W. Paine, Institutional Services Division, Health Consultants Directorate, Health and Welfare Canada, Ottawa. Publications: The Determination of Acute Care Bed Requirements for Provincial Acute Care Hospital Regions, in N. Bailey and M. Thompson, eds., *Systems Aspects of Health Planning*, North-Holland, Amsterdam, 1975.
System Described	The model currently focuses upon the acute care component of the health care delivery system in each province. It should be noted that the components that constitute each provincial health care delivery system vary in composition and magnitude. Consequently, to date, priorities have been assigned to those components of the system that require analysis for decision making purposes.
Area — Time	1971, 1972, 1973, and 1974
Area — Space	The provinces of Alberta, Manitoba, New Brunswick, and Prince Edward Island.
Motivation	Impetus: To enable one to ascertain how the acute care hospital system is functioning under current modes of practice. Goals: The primary goal was to determine whether the institutional component of the health care delivery system could be structured more equitably, effectively and efficiently, subject to financial and non-financial constraints that prevail, by elimination, reduction or redistribution of existing resources as well as through the allocation of new resources, while at the same time ensuring that an acceptable standard or level of care is maintained.
Methodology	An empirical patient-flow model that incorporates age, sex, diagnosis (ICDA), length of stay, and place of residence was constructed to indicate patient-flow patterns attributable to each acute care hospital and geographic area within each province. Simple and multiple linear regression models were used for cost analysis purposes. In addition, population projections were based upon time-series analysis.
Sequence of Computation	The patient-flow patterns are determined by a computer program that can be run on an annual basis. The computer language used varies between provinces, but the original program was written in COBOL.

Input Data	The principal input data consist of provincial hospital admission-separation records, federal and provincial population data, census data, and the annual provincial hospital returns that contain facilities and services as well as financial information. The federal and provincial governments provide this data, which has been placed on computer magnetic tapes.
Results	The model indicated the following: - how the acute care hospital system was functioning in each province; - the imbalance in the distribution of health care resources; - the current and future surplus or deficiency of health care resources; - the operating costs attributable to acute care institutions; - other components of the health care delivery system that require analysis; - how it can be used to determine the extent to which the acute care hospital system has changed over time; - how the analytical results could assist in the establishment of standards or norms; - obsolete or inadequate planning and evaluation criteria current in use; and - how it can be used to determine the anticipated effect of a planned change or the actual effect of an unplanned change that has been introduced into the health care delivery system. In general, one was able to see how the model could provide information related to health care delivery planning, evaluation, program development, and resource allocation in order to assist the decision making process, and answer six basic areas of inquiry: what?, why?, when?, where?, who?, and how?, which every decision maker must be prepared to answer.
Comments	The model should be incorporated into a larger model that comprises other components of the overall health care delivery system. However, the cost of constructing a larger model must be examined carefully with respect to its usefulness for decision making purposes.

C5 - CANADA

The Model	Authors: J.H. Milsum, I. Vertinsky, C.A. Laszlo, D. Uyeno, University of British Columbia, Vancouver; A.B. Hurtubise, Département des Affaires Sociales, Gouvernement du Québec, Quebec; P. Belanger, M.D. Levine, McGill University, Montreal. Publications: On the Modelling of Large-Scale Health Care Systems, *Behavioral Science*, 19, 6 (1974), 407-414. See also: *Hospital Administration in Canada*, 16, 2 (1974), 30-36.
System Described	The model is based upon five sub-models concerned with population, morbidity, illness-resource matrix, resources model, and allocation and performance. In turn, this is broken down into many further "blocks". Several techniques have been used for allocation of resources, including linear programming and heuristic allocation of priorities. The model is of the macro type and only average "flows" of patients and resources have been used. The basic time increment for running the model so far has been one year, although a shorter period is more desirable. Projections over a 10-20 year period are considered.
Area — Time	The basic time interval is one year, although in later versions a shorter interval would be preferable, namely one month.
Area — Space	This is a regional-type model typically designed for the order of ten million people or more.
Motivation	The original impetus for creation of this model was as part of an overall socio-economic model for the Greater Vancouver Regional District. Subsequently, it was developed much further in detail as a stand-alone model of the Quebec health care system under the rubric "MEDICS". The goal of the modeling has been to explore resource allocation, especially in terms of whether better allocations are possible.
Methodology	There is nothing particularly special about the methodology. Certain relatively arbitrary definitions had to be made, however. The incidence-prevalence differentiation was essentially side-stepped by counting "episodes" whenever a given person was treated for a given diagnostic in a given time period. In the MEDICS model, approximately one hundred different diagnostics were used, and while the model was not complete, there were about ninety-eight different uses of resources. Parameters were estimated from the Quebec Government computer tapes of billing records. Objective functions are still being developed and related to untreated cases of illnesses, unused resource facilities, etc.

Sequence of Computation	FORTRAN language. Nothing particular about the computer program.
Input Data	Quebec Government magnetic tapes of use of resources.
Results	The MEDICS model has essentially ceased development as of April 1976. The main results obtained involved calibrations of the model against 1971 data and some projections.
Comments	The model is capable of much further development, which also, however, involves significant further cost. At present, governments in Canada do not seem ready to utilize these simulation models.

C6 - CANADA

The Model	Author: C. Tilquin, Department of Health Administration, University of Montreal, Montreal. Publications: A Conceptual Framework for Patient Classification According to Nursing Care Requirements, in *Systems Science in Health Care* (proceedings of the N.A.T.O Conference on Systems Science in Health Care, held in Paris, France, July 5-9, 1976), Taylor & Francis, London (forthcoming). Chagnon, M., L.-M. Audette, L. Lebrun, and C. Tilquin, *PRN 74: A Classification System for Pediatric Patients*, Research Report, Sainte-Justine Hospital, Montreal, 1975.
System Described	The management and planning of nursing resources in individual institutions and health care programs and at the provincial level. *Components*: (a) Patient classification system by level of nursing care (all health care institutions and programs): pediatrics (completed); medicine-surgery (in progress); long-term care (in progress); psychiatry and home care (to be developed). (b) Nursing resource management system for the delivery of care in institutional settings (in progress) and at home (to be developed). (c) Patient admission control system in view of regulating nursing care demand (will be developed shortly). (d) Model for the planning of nursing manpower in Quebec (to be developed).
Area — Time	1974 onwards.
Area — Space	- Health care institutions and programs. - Province of Quebec
Motivation	Impetus: Scarcity of nursing resources and increasing costs of nursing care. Goals: (a) Rationalization of nursing resource distribution within and among institutions and programs. (b) Forecast nursing resource needs.
Methodology	Operations research methodology.
Sequence of Computation	At present, the classification system and a preliminary nursing resources management system are used at the institutional level only (in a pilot institution). The classification system is applied manually three times a day and the program for the management system is run every four weeks. The language is FORTRAN.

Input Data	- Class of patients, daily. - State of nursing resources, daily.
Results	(a) Provide quantitative data to serve as a basis for daily staffing of nursing units, mid-term scheduling and long-term planning of necessary resources (system in operation in pediatric hospital units). (b) Forecast nursing manpower needs at the provincial level (to be developed).
Comments	The components of the overall system are being developed. The patient classification system, applicable to all health care institutions and programs, should be completed in 1978-1979. The nursing resources management system for the delivery of care in institutions and at home, as well as the patient admission control system, should be completed at the same time. Only when the patient classification system is fully implemented in all the hospitals of the province will it be possible to apply the nursing resources planning system on a provincial basis.

C7 - CZECHOSLOVAKIA

The Model	Author: R. Miksl, CSc, ředitel Krajské hygienické stanice v Ostravě, Ostrava. Publications: Miksl, R., Systematic Approach for the Measurement and the Forecasting of Human Environment, *Remesta*, 3 (1971), (in Czechoslovakian). Miksl, R., Systémová syntéza a analýza životního prostředí, in *Sborník referátů ČSVTS*, Ostrava, 1974.
System Described	The environmental system is surrounded by a system of economy, politics and science. The system of politics is simultaneously a control one, applicable to all other systems. The environmental system contains material subsystems (environmental settlements, work and recreation) and functional ones (social activity, art and services). The criterial function of the system is represented by the survival quality (health index) of the population, being influenced by ecological factors (physical, chemical and biological ones) and social factors (socio-economical and psychosocial ones).
Area — Time	1970 - unlimited for the time being.
Area — Space	The civilized world.
Motivation	Impetus: The safeguard of the environment before deterioration, the projection of healthy conditions of life, the economics of arrangements, serving to project and improve the environment. Goals: Simulation of inputs (stimuli) relating to the environment and modeling of their effects (outputs), concerning the economy, the politics and the health state of the population. An optimal strategy of investments, referring to the environment.
Methodology	Semantic-iconic model. A mathematical model for determining the tightness and dependence between environmental factors by means of a multiple regression and a factor analysis.
Sequence of Computation	In order to find out about environmental factors, expressive units have been patterned and evaluated, and a so-called health index has been calculated. The environmental factors are assumed to be independent, the health state being the dependent variable. For processing the model and the simulation relations, a set of programs referring to computer Tesla 200 and EC 1021 has been worked out.

Input Data	*Economic data*: Sixteen factors or factor complexes of environment, e.g. soil, water, air, services (health matters, system of schools, traffic) and their quality (equipment). *Health data*: Data about the health state of the population, established by means of a Cornell's anamnestic questionnaire. Data processing is irregular, discrete.
Results	The continuity between variables and independent variables is established, being a consequence of the interpretation of results and the function of environmental factors, concerning the health state of man and the economic evaluation of interventions in order to improve that state.
Comments	The model has been accepted by the Czechoslovak Academy of Sciences, serving for another investigation of the Sixth Five Year Plan, and by the District Committee in Ostrava for stimulating the development of an industrial agglomeration in Ostrava.

C8 - CZECHOSLOVAKIA

The Model	Author: R. Jiroušek, Institute of Haematology and Blood Transfusion, Prague. Publication: The lecture about this system (MANDAT --MANipulation of DAta) was read at the Second Czechoslovak Conference, "Decision Making Process in Clinical Medicine".
System Described	This system allows maximal use of clinical data for logical statistic analysis, and for support of medical decision making.
Area — Time	Not indicated.
Area — Space	Medical establishments.
Motivation	Impetus: With respect to difficulties which are linked with obtaining valid data, all data should be used as much as possible. Also, steps in which errors occur should be excluded. Goals: (1) The recording of data on magnetic tape. (2) Check and correction of data. (3) Preparation of data for different usages. (4) Statistical analyses of data. (5) Logical analyses of data.
Methodology	All programs of the system allow easy and quick manipulation, simultaneously with the possibility of varying the input parameters. The programs are independent and one can choose an arbitrary sequence of computation.
Sequence of Computation	All programs are written in FORTRAN. Their sequence of computation depends only on the requirements of the user. The system consists of the following: (1) program for setting archive files on magnetic tape; (2) listing program; (3) correcting program; (4) transformational program: (5) statistical programs; (6) programs for logical analysis of data.
Input Data	The system is proposed for processing medical data for research purposes. But it may be used also for other types of data, under the condition that they are coded by numerical code. Usually the data are obtained by filling out questionnaires.
Results	Prime outputs of the system are data files on magnetic tape which are prepared as input for other program systems. As a by-product the following information may also be obtained: (1) several types of data lists; (2) statistical characteristics of data files; and (3) results of logical analysis.
Comments	The system is implemented on IBM 370. It is proposed for research use and other programs will be joined according to the immediate requirements.

C9 - CZECHOSLOVAKIA

The Model		Authors: J. Radkovský and E. Švandová, Institute of Hygiene and Epidemiology, Prague. Publications: Švandová, E., and I. Sutherland, *Models of Tuberculosis Reinfection and Reactivation*, paper presented at International Tuberculosis Conference in Mexico City, 1975. Radkovský, J., *Epidemetric Model of Tuberculosis*, unpublished paper. Radkovský, J., A Model of the Eradications of Tuberculosis in Cattle, *Veterinární medicina* (1966), 59-72.
System Described		The simulation of tuberculosis incidence and prevalence by age and sex. Formulation of epidemiological groups and transfer rates. Formulation of the factors and the prediction in the eradication of tuberculosis in cattle.
Area	Time	(1) 1910-1980, in 5-year intervals. (2) 1959-1968, annual extrapolations.
	Space	(1) Czechoslovakia, Sri Lanka, The Netherlands (2) Czechoslovakia
Motivation		(1) Clarification of the epidemiology of tuberculosis. Estimation of some transfer rates between epidemiological groups. (2) The planning of tuberculosis eradication in cattle.
Methodology		(1) Conditional forecasts on the basis of the prevalence of infection in the population, 16 equations for 16 epidemiological subgroups. (2) Conditional forecasts on the basis of the prevalence of infected cows.
Sequence of Computation		(1) Necessary demographic and morbidity data, prevalence of infection, death rates. Analysis of the risk of infection. Retrospective analysis, estimation of some transfer rates. Iteration of tuberculosis models. (2) Retrospective analysis of tuberculin positivity in cattle. The iteration of the model under different conditions, with the aim to eradicate the tuberculosis up to 1968.
Input Data		(1) Health statistics in Czechoslovakia, tuberculosis statistics in The Netherlands and Sri Lanka. (2) Tuberculin positivity in cattle, 1960-1964.
Results		(1) Estimation of the risk of reinfection and reactivation of tuberculosis. (2) The limitations in the planning of tuberculosis eradications in cattle.

C10 - CZECHOSLOVAKIA

The Model		Author: J. Radkovský, Institute of Hygiene and Epidemiology, Prague. Publication: Application of the Monte Carlo Method to the Study of the Spread of Infections, in *Statistika a demografie VIII*, Academia, Prague, 1968, 151-186 (in Czechoslovakian).
System Described		The simulation of epidemics using basic epidemiological characteristics: the time of infection, the incubation period, the manifestation rate, the risk of infection and susceptibility.
Area	Time	Depends on the characteristics (infection and incubation period).
	Space	Limited epidemics in schools, small villages.
Motivation		Study of the epidemiology of infectious hepatitis and poliomyelitis. Estimation of the unknown characteristics, e.g. the risk of infection.
Methodology		Formulation of the type of each epidemiological characteristic. Simulation of the stochastic epidemic process by Monte Carlo methods. Comparisons with the deterministic method.
Sequence of Computation		Simulation of different epidemics using different input data. The program is written in FORTRAN IV.
Input Data		The known characteristics from the epidemiological studies. The estimates of unknown by the iteration.
Results		Estimation of the unknown characteristics in the study of the epidemiology of infectious hepatitis, pertussis and parapertussis, poliomyelitis, influenza. Learning tool for the students and epidemiologists in the Faculty of Hygiene and in the Postgraduate Medical School.

C11 - CZECHOSLOVAKIA

The Model		Authors: K. Žáček, J. Radkovský, Z. Roth, Institute of Hygiene and Epidemiology, Prague. Publication: *Monitoring of Alimentary Infections*, unpublished paper.
System Described		Daily monitoring of alimentary infections. Comparison of their incidence in areas where some "risk" foods are supplied. Evaluation of bacteriological findings.
Area	Time	Daily monitoring from September 1973.
	Space	One district with 130,000 population.
Motivation		Study of the control of alimentary diseases - infections.
Methodology		Evaluation of the incidence of alimentary infections in different population groups.
Sequence of Computation		Daily monitoring of the incidence of alimentary infections by each health institution, by teletype to the computer center. Comparison with the supply table of "risk" foods. Weekly monitoring of the bacteriological findings.
Input Data		See "Sequence of Computation".
Results		Indication about the higher incidence of alimentary diseases caused by the supply of some foods.
Comments		The system is currently being developed to include the following: (1) the weekly monitoring of respiratory diseases - infections and monthly evaluation of the follow-up of SO_2 and dust particles; (2) weekly data processing on the computer with the evaluation of the incidence of infectious diseases on the basis of the last five years and calculations of the incidence for the next week. (Holáň-Pechlát, Computer Center of the Regional Institute for National Health, Ostrava.)

F1 - FRANCE

The Model	Authors: J. Chaperon, P. Le Beux, C. Chastang, Institute for Health Information Systems, Unité de Recherche Biostatistiques, CHU Pitié Salpétrière, Paris. Publication: Un modèle dynamique du système de santé, in *Medical Data Processing Symposium - Toulouse 1976*, Taylor and Francis, London, 1976.
System Described	The French Health Care System in relation with population tendencies, health needs, the economic and social system, health care resources and the environment. The general structure of the model could be used for other countries as well.
Area — Time	1960-19...
Area — Space	France (metropolitan)
Motivation	Goals: (1) Build a model to compare and evaluate prevention programs in health care. (2) Prospective tool for health care planning. (3) Better understand the dynamics of the health care system.
Methodology	A combination of systems dynamics models (Forrester) and hierarchical and regionalized models.
Sequence of Computation	The model is divided into several sectors: demography, needs, health care resources, economy, environment. The model is built by interrelating these sectors into several causal loops to study the behavior of the system. The model is still in the development phase. Simulation runs will be made to validate the model on past data and then it will be used for prospective analysis.
Input Data	Economic and demographic data are available from the Frence "INSEE" (Institut National de Statistiques). The other data will be extrapolated from data available in some representative samples.
Results	We are still in the implementation phase of the model and we have not yet completed the programming and evaluation phase of the model.
Comments	This work is partially supported by a grant from the CNRS (Centre National de la Recherche Scientifique).

F2 - FRANCE

The Model	Author: A. Letourmy, Centre de Recherche sur le Bien-Etre (CEREBE), Paris. Publications: Some Aspects of the Relationship between Mortality, Environmental Conditions and Medical Care, in N. Bailey and M. Thompson, eds., *Systems Aspects of Health Planning*, North-Holland, Amsterdam, 1975. For original study see: Gilbert, F., and A. Letourmy, *Santé, environnement et consommations médicales*, Rapport CEREBE, 1974.
System Described	The French HCS in interrelations with mortality conditions, characteristics of the way of life, general living conditions and socio-economic indices. HCS is described through various types of medical resources (doctors, beds, technical equipment). Environmental conditions are represented by numerous indicators drawn from various sources and suggested by epidemiological results.
Area — Time	1968
Area — Space	85 French administrative and geographical areas (départements).
Motivation	Impetus: Evaluation of the effectiveness of HCS. Goals: (1) To express in a model the usual discrimination between environment and medical care as determinants of the health status of any population. (2) To show the contradiction between the planning actions in the health field and the overall effectiveness of medical care.
Methodology	Definition of a structural model involving two types of equations. Descriptive study of the available data through Principle Component Analysis. Estimation of different specifications for every type of equation and use of backward regression. Choice of a demonstrative specification with four equations and estimation by two-stage least squares.
Sequence of Computation	Data were standardized to offset the differences of age/sex structures. The different phases use classical programs.
Input Data	*Demographic data*: 1968 census. *HCS*: mainly from national surveys. *Socio-economic and environmental data*: various sources (specific surveys, administrative sources, etc.).

Results	Mortality discrepancies are chiefly explained by differences in ways of life (alcoholism, diet) and little influenced by medical care. Conversely, discrepancies in medical care expenditures are poorly explained by the supposed differences in health levels reflected by mortality conditions, but depend on differences in available medical resources.
Comments	The model is presently being tested with time series. We intend to compare several Western countries, especially The Netherlands, Sweden, Denmark, and West Germany.

I1 - IIASA

The Model		Authors: K. Atsumi, I. Fujimasa, S. Kaihara, A. Klementiev, IIASA. Publication: *An Approach to Building a Universal Health Care Model: Morbidity Model of Degenerative Diseases*, RM-77-6, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1977.
System Described		The model is one part of the morbidity model which represents the number of people in different states: healthy, unaware sick, unregistered sick, and treated sick, and the transfer rates such as morbidity rate, awareness rate, latent to register rate, recovery rate, and death rate. These numbers and rates are related to the population structure, medical, social, economical, educational, and environmental factors of a country. In the part of the model dealing with degenerative disease, morbidity is strongly dependent upon population structure.
Area	Time	No limitation
	Space	International comparison
Motivation		Impetus: Conventional health statistics provide relatively little reliable information on morbidity and disease prevalence for use by planners. Goals: (1) To provide estimates of morbidity and disease prevalence. (2) To identify interrelationships between various disease data and draw comparisons between various countries. (3) To forecast future trends of disease in various countries. (4) To estimate the effect of social, economical, educational, and environmental factors on health.
Sequence of Computation		The morbidity model of degenerative disease inherited two essential factors and two assumptions: one essential factor is the morbidity rate, the other is the interval from the onset of disease to death; one assumption is that the morbidity rate depends only upon the age, the other is that the recovery rate is equal to zero. Under these conditions, if the population structure of a country is given, the prevalence rate and the death rate can be calculated.
Input Data		The morbidity model can interact with the population projection model developed by Keyfits and Flieger. Then, if the population structure of a country or the data of the number of population, deaths, and births classified by age and sex groups are given, the prevalence rate and the death rate and also the projection data of both can be estimated.

Results	(1) *International comparison*: Morbidity, prevalence, and death rates were estimated for eight countries. The validity of the model, as judged by death rate estimation, is better in developed countries than in developing countries. (2) *Projection of future trends*: The future trends of degenerative disease were estimated for England and Wales and Japan. The projections of the death rates and the prevelence rate are closely related to the aging of the population.
Comments	The model is already implemented on the PDP-11/45 system at IIASA. If one wishes to project the future trend of the degenerative diseases of a country, the population structure and the number of deaths and births of the country classified by age and sex groups are required. The morbidity model of another type of disease, such as infection, accidents, and malnutrition, will be developed in the future.

J1 - JAPAN

The Model	Authors: S. Kaihara and K. Atsumi, University of Tokyo, Tokyo. Publications: Planning a National Medical Information System: A Systems Approach, in N. Bailey and M. Thompson, eds., *Systems Aspects of Health Planning*, North-Holland, Amsterdam, 1975. A Simulation Model of Medical Demand in Japan, in *2nd USA-JAPAN Computer Conference Proceedings*, Information Processing Society of Japan, 1975.
System Described	Japanese HCS, especially the internal structure of medical care demands and its interaction with the supply of health care. HCS includes preprofessional morbidity episodes, hospitalization, mortality, resources, medical personnel, and cost of medical care.
Area — Time	1955-1990
Area — Space	The whole of Japan.
Motivation	Impetus: The number of patients in Japan has increased rapidly in the past 15 years. The model was first intended to analyze the underlying factors which caused this rapid increase, and to predict the future trends of medical demands in Japan by applying the results of these calculations. Goals: (1) Analyses of underlying factors which cause the changes of various health care indices. (2) Illustration of main trends of HCS development under different political conditions.
Methodology	Sets of simultaneous differential equations with feedback loops from internal (endogenous) variables as well as exogenous variables. Equations were solved by iterative methods. The main part of the calculation was performed using the computer language DYNAMO.
Sequence of Computation	The rate constants of the equations and their annual changes were calculated from the past demographic and morbidity data described in "Input Data" below, and the internal structure of HCS was established. The future trends were then calculated according to the structure and rate constants.
Input Data	Population census, National Health Survey, Patient Survey, etc.

Results	Conditional forecasts of about 100 selected indicators ex post 1955-1974, ex ante 1975-1990 under different political side conditions. The analysis of the past medical demands showed that the main cause of increase in demands was the change in the attitude of people in seeking medical care. But this factor has almost been saturated and the future increase of medical demands will be caused by different factors such as aging of population and increase in chronic diseases.
Comments	Model is run by IBM 370/155 using DYNAMO.

J2 - JAPAN

The Model	Authors: I. Fujimasa, Institute of Medical Electronics, Faculty of Medicine, University of Tokyo, Tokyo; and F. Kodama, University of Saitama, Saitama. Publication: Conflict Resolution Model - A Model for Resolving Conflict and Approaching a Consensus in Health Care System, in *The Research Report of the Medical Information System Developing Center (MEDIS-DC)*, Japan, 1975.
System Described	The model was developed by The Medical Information System Developing Center (MEDIS-DC) of Japan to reach a consensus for resolving conflict in developing the new health care system in a certain region. The two main protagonists in the conflict are the consumers of health care and the suppliers, principally physicians.
Area	A new town in which a closed circuit T.V. was installed and operated by the regional inhabitants (e.g. Tama, a new town of 400,000 people).
Motivation	The model was developed for approaching a good consensus among pressure groups of a region for developing a medical information system.
Methodology	The items of interest to each pressure group were identified. An information base was constructed with a deterministic structure about the regional medical care system and the items of interest. This base included information on demographic data, policy factors and their alternatives and resource data. From the information base, the outputs are calculated deterministically. The organized conflict takes place on the regional mass-communication media, as for example the closed circuit T.V. in a new town, in which the items of interest are proposed by the information data base. The response of a policy factor is analyzed by the Delfi method and the result is fed back to the policy factor input.
Sequence of Computation	Not computed, only structured.
Input Data	Input data is classified into three types: demographic data, resource data, and policy factors and their alternatives.
Results	Not yet validated
Comments	The model will be implemented by MEDIS-DC in a certain town in Japan, but the model is still in the development stage.

P1 - POLAND

The Model		Authors: M. Bojanczyk and J. Krawczyk, Polish Academy of Sciences, Institute for Organization, Management, and Control Sciences, Warsaw. Publications: (1) Modeling of the Health Care System in the Complex Model of Socio-Economic Development, in R. Kulikowski, ed., *System Models of Socio-Economic Development on Country Level*, Pwn Warsaw (forthcoming). (In Polish: Modelowanie Systemu Ochrony Zdrowia dla potrzeb modelu rozwoju kraju, w: *Modele Systemowe Spoleczno-gospodarczego rozwoju kraju*, Pwn Warszawa, w druku.) (2) *Modielirovanije sistiemy zdravohranienija*, to be included in the proceedings of the conference: Modelirovanije socijalnyh processov, Bucharest, May 1975.
System Described		The HCS describes mainly two activities: outpatient and inpatient care. The influence of early diagnosis and prophylaxis on the quality and level of health services is treated with special attention. The problems of demand for health services and production of health units in connection with a complex model of national economy and social development are discussed (see Kulikowski, R., Modeling of Production, Utility Structure, Prices and Technological Change, *Control and Cybernetics*, 4, 2 (1975)). The system resources, costs and effects of its activity are analyzed. The influence of HCS-activity on labor force potential is shown.
Area	Time	1966-1974
	Space	The whole of Poland.
Motivation		Impetus: A study of the Polish HCS and its interactions with the global model of the national economy (MR) (see "Input Data"). Goals: (1) Analysis of HCS activities with respect to costs, resources, and needs. (2) Prediction of demand for health services. (3) Discussion of the problems of investments and education of personnel.
Methodology		Two-level-hierarchical model (up to now static, but dynamic enlargement is possible). Cobb-Douglas type production functions are estimated for age and illness groups. The differences between demand and supply in health services (in two main activities of HCS--mentioned in "System Described") on the lower level and the time lost due to illness and bad health on the upper level are chosen as objective functions which are to be minimized. The linkage between HCS and the national economy is

	given by the national expenditures on HCS on one side and losses in overall labor on another. Identification is made by econometric methods.
Sequence of Computation	The needs for health services are defined according to the demographic data and health statistics. Some outputs from the model of the Polish Economy (MR) are used to evaluate main variables and parameters characterizing HCS activities (new health statistics, costs, etc.). FORTRAN IV.
Input Data	*Economic data*: Taken from MR--model of Polish economy. (Made in our Institute in the Laboratory for Large-Scale Systems Theory, headed by Prof. R. Kulikowski. Identified on data series from 1966-1974.) *Demographic data*: Statistic data from 1966-1974. Statistical yearbook and Ministry of Health and Social Care Statistics.
Results	We will get forecasts for the next 5, 10 year periods under different scenarios of GNP distribution and some specified programs of diagnosis. The health situation and health needs in the future will be described.
Comments	The model (cooperating with macromodel of national economy) would be used as a forecasting tool by the Ministry of Health and Social Care.

S1 - SOVIET UNION

The Model		Authors: D. Venedictov, et al., Ministry of Health, Moscow. Publications: Venedictov, D., Modeling of Health Care Systems, in *IIASA Conference '76*, Vol. 2, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1976. Venedictov, D., ed., *Health System Modeling and the Information System for the Coordination of Research in Oncology*, CP-77-4, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1977. Klementiev, A., *Mathematical Approach to Developing a Simulation Model of a Health Care System*, RM-76-65, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1976.
System Described		National health care system on the basis of a degenerative type of disease taking into account the dynamics of population sex-age structure and the dynamics of HCS resources. Some aspects of resource management within the HCS are also considered.
Area	Time	15-25 years
	Space	National level
Motivation		- Study of main HCS characteristics of some country taking into consideration various alternatives for the management of HCS resources. - Comparative analysis of the activity of different HCSs. - Elaboration of a tool to assist persons planning HCS activity.
Methodology		System of differential equations was used for HCS description.
Sequence of Computation		A forecast of the population is made for each year. Then, current morbidity is determined taking into account the number of registered and latent sick persons as well as the distribution of resources within the HCS. FORTRAN was used as the computer language.
Input Data		- Initial sex-age structure of the population. - Death rates for each sex-age group. - Fertility rates for female age groups. - Standards for physician workload. - Initial number of physicians. - Standards for screening facilities' efficiency.

Results	Some preliminary results have been obtained and validated. At present the model is being simplified with the aim of making it possible to use WHO statistics and national demographic and medical statistics.
Comments	In further development of the model, specifics of the regions of the country (i.e. migration processes, urbanizational level, climatic peculiarities, settlement over the territory) will be taken into account. This is especially necessary for countries where regions differ in the above mentioned characteristics.

S2 - SOVIET UNION

The Model	Author: A.I. Yashin, USSR Academy of Sciences, Institute for Control Sciences, Moscow. Publication: Methodological Aspects of Modeling and Decision Making in the Health Care System, in D. Venedictov, ed., *Health System Modeling and the Information System for the Coordination of Research in Oncology*, CP-77-4, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1977.
System Described	The model was created on the basis of equations describing transitions between population groups. Population groups are defined by age-sex classifications and health conditions.
Area	The model describes processes in the HCS within a time span of approximately ten years or less. It is to be applied to high level decision making.
Motivation	Estimation of the results of resource distribution at different levels of decision making. The development was aimed at the quantitative evaluation of various variants for decision making, at the development of ready-made procedures of decision making, and at the quantitative estimation of resource allocation efficiency.
Methodology	Transitions between population groups are described by means of ratios and systems of equations. In general, the ratio for each age group of population depends both on resources allocated for the HCS and on the influence of external factors. A system of partial differential equations of the first order is solved by the usual method.
Sequence of Computation	The system of equations is solved on an ICL/4-70 computer with FORTRAN 4 used as the language.
Input Data	Input data for a higher level of modeling are determined using demographic statistics or expert evaluation.
Results	Main (expected) results of the modeling are quantitative evaluation of efficiency of variants of resource distribution and of new resource allocation in the HCS.

S3 - SOVIET UNION

The Model		Authors: O.W. Barojan and L.A. Rvachow, USSR Academy of Medical Sciences, Central Epidemiological Institute, Moscow. Publications: Barojan, O.V., et al., Computer Modeling of Influenza Epidemics for the Whole Country (USSR), *Advances in Applied Problems*, 3 (1971), 224-226.
System Described		On the basis of the daily officially registered morbidity (DORM), different influenza epidemics are represented and the epidemic process is predicted, using, in addition, information about passenger travel.
Area	Time	178 influenza outbreaks were covered for the last 15 years.
	Space	43 of the largest cities of the USSR. Applicable for any developed country.
Motivation		To create a predicting tool.
Methodology		Parameter estimation, simulation model.
Input Data		DORM, Population of a city, passenger travel information, corrections for weekends.
Results		Predictions of cause of epidemics; average mean square deviation ~11%.

S4 - SOVIET UNION

The Model	Authors: V.V. Bessonenko, E.N. Granitsa, G.I. Chechenin, Siberian Department of the USSR Academy of Medical Sciences, Institute of Complex Problems of Hygiene and Occupational Diseases, Novokuznetsk.
System Described	Medical resource allocation model for large cities. This computer model consists of a set of submodels --population, health, environmental monitoring, resource supply, etc. The operations research team includes scientists of different specialities.
Area	Large cities.
Motivation	In large cities, it is very difficult to manage any kind of services, including health care. There are many medical establishments, plants, factories, and schools with their own health centers. They are all closely interrelated, and connected with the external system. The creation of a health care system model for the large city will help the health manager to test different alternatives in solving the problems of medical resource allocation.
Methodology	Systems analysis, queueing theory, etc. This model consists of several models and tasks. For all of them, different mathematical methods are used.
Input Data	*Population data*: Age, sex, residence, education, work, profession, etc. *Health data*: Outpatient visits, inpatient cases, screening, mortality, invalidity, etc. *Resource supply data*: Net of medical establishments, staff, facilities, etc. *Environmental data*: Air, water, earth indices.
Results	Implemented step-by-step in practice.
Comments	This model is one part of model S9.

S5 - SOVIET UNION

The Model		Authors: V.I. Kant, V.N. Frolov, Medical Faculty of Moldavian University, Kishinev.
System Described		This is a model for the network of medical establishments in the territory.
Area	Time	Not indicated.
	Space	Region
Motivation		For the local planning process, as well as for the estimation of resource needs and their allocation in the territory of the region, the health manager needs much interrelated data--about population and its dynamics, density, traffic, roads, health indices, network of medical establishments, etc. The model is one good method for testing different alternatives.
Methodology		Linear programming.
Input Data		*Population data*: Age, sex, residence, density, etc. *Health indices*: Roads, distances, transport supply, speed, etc.
Results		A regional medical establishment allocation model was suggested and applied. The construction and allocation of all new medical establishments in this region are planned on the basis of these results.
Comments		This model is one part of model S9.

S6 - SOVIET UNION

The Model		Author: A.S. Kiselev, Serbsky Institute of Forensic Psychiatry, Moscow.
System Described		Model includes two submodels: submodel of the chronic disease development, and submodel of mental service.
Area	Time	1968-1970
	Space	National level.
Motivation		Computer model allows for testing different alternatives for resource allocation.
Methodology		- Linear and nonlinear programming for optimization of resource allocation. - Differential equations. - Markovian chains. - Statistical decision theory.
Sequence of Computation		The data about age, sex, education, profession, and their dynamics are used for modeling. Prevalence submodels deal with prevalence rate estimation, the hospital and nonhospital health care service, and the estimation of disability and invalidity.
Input Data		Bank of information about all mental patients led to receiving all kinds of information about patient, treatment, consultation, etc. Real clinical data about development of health status.
Comment		This model is one part of model S9.

S7 - SOVIET UNION

The Model		Authors: Y.M. Komarov, Y.U. Djuravlov, A.G. Tsercovny, USSR Academy of Medical Sciences, Department of Biophysics, Moscow.
System Described		On the basis of statistical studies and mathematical methods, a model was created for estimating risk, severity of disease, and medical recommendation.
Area	Time	(Not indicated.)
	Space	National and regional.
Motivation		For the estimation of medical resource demands, it is necessary to have data not only on symptoms, diseases, etc., but also on socio-economical and environmental conditions. The creation of this informational, taxonometrical model will help the health manager to classify population according to the different risk groups, and to determine resource demands for each of them.
Methodology		Heuristic taxonometrical model; computer model.
Input Data		*Personal data*: Age, sex, profession, education, salary, housing, job, work, outpatient visits, inpatient cases, disease symptoms, tests, screening, physical development, medical recommendation. *Medical resource supply data*: individual and group.
Results		Dynamic model of health testing treatment processes, risk classification of the population, and resource allocation are proposed.
Comments		This model is one part of model S9.

S8 - SOVIET UNION

The Model		Author: V.M. Timonin, Semashko Institute of Social Hygiene and Public Health Organization, Moscow.
System Described		The network of out-patient and in-patient establishments, all connected with a central ambulance station, and a group of ambulance substations in different parts of a large city.
Area	Time	1968-1973
	Space	Large city, of about one million population.
Motivation		In large cities, it is very difficult to select the optimal hospital for each ambulance case because it is necessary to take into account not only the health of the patient, but also distance, time, type of bed, etc. This model will recommend optimal place of hospitalization.
Methodology		Queuing theory, linear programming.
Sequence of Computation		Computer model, including data about the network of medical establishments and their allocation, ambulance teams and their allocation, allocation of patient's call, etc. Two regimes of modeling: - minimization of distance from place of the patient's call to hospital; - selection of optimal hospital from many others.
Input Data		- Poisson distribution of patient's calls. - Detailed description of the network of medical establishments. - Data about beds, ambulance teams. - Coordination of patient's call, type of ambulance team, diagnosis.
Results		- Recommendation about optimal place for hospitalization. - Forecasting of different alternatives on the basis of the model.
Comment		This model is one part of model S9.

S9 - SOVIET UNION

The Model	Authors: A.F. Serenko, V.M. Timonin, and L.G. Sudarikov, The Semashko Institute of Social Hygiene and Public Health Organization, Moscow. Publications: Serenko, A.F., et al., An Approach to the Public Health Management from the Standpoint of Organization, *Sovetskoe zdravookhranenie*, 7 (1976), 3-7. Timonin, V.M., Automatized System of Planning and Management in Health Care, *Farmatsia*, 3 (1976), 8-12. Timonin, V.M., Modern Computer Technique in Solving Problems of the Public Health Management, *Sovetskoe zdravookhranenie*, 12 (1976), 3-6.
System Described	Structure of model: (a) Five levels--national, republic, regional, district, and medical establishment. (b) Subsystems--health care service, sanitary-epidemiological service, planning, finance, etc. (c) All tasks in each subsystem are divided according to priority.
Area — Time	1969-1980
Area — Space	The whole of the USSR.
Motivation	Impetus: Difficulty in management of public health system connected with information problems, the necessity of taking into account both external and internal information, and the problem of allocating resources with regard to their dynamic effects. Goals: (1) Estimation of the public health system activity for different levels and subsystems. (2) Prediction of demand for each level, subsystem, and task. (3) Resource allocation.
Methodology	Main principles: - systems approach and analysis; - standardization of information, technique, etc.; - order and discipline in the development of this automatized system; - linkage between different levels, subsystems, and tasks.
Sequence of Computation	Sequence of computation and input parameters depend on the type of subsystems and tasks. From the mathematical point, different methods of modeling are used--simulation, optimization, etc.
Input Data	Routine statistics; data from surveys about medical staff and institutions.

Results	Data bank of medical information (population, personnel, institutions, etc.); computer models for each subsystem; tables.
Comments	This automatized system is created for different levels, subsystems, and tasks. For each of them there is a special medico-computer center, working team, and research institution. All these investigations are coordinated and supervised by the Ministry of Health of the USSR. As examples, some of them are illustrated (see S4, S5, S7).

U1 - UNITED KINGDOM

The Model	Authors: Members of the Operational Research Service (ORS) of the Department of Health and Social Security (DHSS) and of the Scientific Control Systems Ltd., London. Current project leader is Dr. R.J. Gibbs of DHSS, London. Main Publications: McDonald, A.G., G.C. Cuddeford, and E.M.L. Beale, Balance of Care: Some Mathematical Models of the National Health Service, *British Medical Bulletin*, 30, 3 (1974). McDonald, A.G., and R.J. Gibbs, Some Requirements for Strategic Models of Health Services Illustrated by Examples from the United Kingdom, in D. Venedictov, ed., *Health System Modeling and the Information System for the Coordination of Research in Oncology*, CP-77-4, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1977.
System Described	Resource allocation in the Health and Personal Social Services in the U.K. The model represents the way in which resources are deployed in terms of three main types of variables: (a) *cover*, the numbers of patients or clients in different categories who receive treatment; (b) *modes*, the methods of treatment or care employed; and (c) *standards*, the average amount of each resource used for patients in each mode. The resources represented range from hospital and residential facilities through to community based services such as domiciliary visits by a nurse or social worker. The patient representation consists of a number of categories within each of the following client groups: acute surgical and medical, maternity, mentally ill, mentally handicapped, younger physically handicapped and the elderly disabled.
Area	The model deals with a single time period of one year's duration and a single spatial area. Using alternative sets of input data the model has been used on the one hand to simulate the behavior of the service in the past (1973) and the present (1975) and on the other hand to explore the behavior of the service in a future year (1979, 1980) as a function of alternative policies for resource development. It has been used both at the national level, (England), and for a county, (Devon), of one million inhabitants.
Motivation	Impetus: The DHSS wished to explore the consequence of changing the balance of care both between and within institutional and community-based care across the entire range of Health and Personal Social Services.

	<u>Goals</u>: To illuminate the likely consequences, in terms of cover, modes, and standards (see "System Described") of alternative policies for resource development, to suggest the most effective pattern of resource development within financial constraints and thus, by performing runs of the model as part of a dialogue between ORS and planners in DHSS and locally, to assist planners in testing out policy options and so help them arrive at policy decisions.
Methodology	A non-linear mathematical program. The variables are the numbers of patients, by category, to be treated in each alternative mode, and the standards achieveable in each mode. The objective function, "net inferred worth", consists of the sum of terms representing the utility of treating different numbers of patients, by category, and the utility of achieving different standards net of resource cost. There are constraints representing financial limits, the limited availability of resources, restrictions in the use of resources and lower bounds on the numbers of patients to be treated.
Sequence of Computation	The model is solved using a mathematical programming package, SCICONIC, and run on a Univac 1108 computer owned by Scientific Control Systems Ltd.
Input Data	Data on numbers of patients from DHSS official returns and from special surveys conducted by non-DHSS researchers (for their own purposes) with whom ORS collaborates. Data on resource availabilities and costs, from DHSS official returns and from the DHSS Program Budget. Data on alternative modes of care and "ideal" levels of standards partly from the literature but mainly from the personal judgements of professional colleagues in DHSS which, to some extent, have subsequently been validated or modified by field work. Data on the elasticity parameters of the inferred worth functions have been derived from fitting values to give the best fit of the model output to actual resource allocation in a past year (1973).
Results	Predictions of the cover and standards of care that can be achieved under alternative resource assumptions for a five year planning horizon, and suggestions for an optimal pattern of resource development.
Comments	Typical model run takes 35 seconds of central processor time on a Univac 1108.

U2 - UNITED STATES

The Model	Author: R.B. Fetter, Yale University, Center for the Study of Health Services, Institution for Social and Policy Studies, New Haven, Connecticut. Publications: Modelling Health Care Delivery Systems, in M. Collen, ed., *Proceedings of an International Conference on Health Care Technology Systems*, San Francisco, November 1974. Interactive Modelling of Health Care Delivery Systems, in *Systems Analysis of Public Service Systems*, Univ. of Montreal, January 1975. Also see Deboeck, G., *User Oriented Modelling for Health Planning and Programming*, paper presented at IIASA Conference on Systems Aspects of Health Planning, August 1974; Mills, R., R. Fetter, and R. Averill, *CML User's Manual*, Yale Univ., Center for the Study of Health Services, New Haven, 1975.
System Described	The equations describe a population sector by population type and region and model the dynamics of births, aging and deaths among these populations. Incidence and program eligibility rates connect this sector to the service delivery sector in which the health services identified by the user are delivered to populations eligible for such services. The effects of delivery on population are fed back to the population sector with allowance for lagged relationships. Finally a resource sector is modeled which allows for the production and utilization of various resources as specified by the user and required by the service delivery sector. Budgets for both current costs and resource development costs are explicitly modeled.
Area — Time	Any set of time periods and
Area — Space	set of regions as specified by the user may be modeled.
Motivation	The modeling system was developed to allow a user to specify the characteristics of a regional health care delivery system and observe the effect on population dynamics of allocation of scarce resources to the delivery of health services. Single or multiple criteria may be specified to motivate the allocation process.
Methodology	The model is a mathematical (linear) program. A class of models as described in "System Described" is specified utilizing the Conversational Modeling Language (see reference above). A user may then describe the structure of any model within that class and provide values for parameters and as desired some of the variables using a special set

	of syntax within CML. He may cause the computer then to formulate the specific equations, display them, and evaluate them. He can cause the computer to generate an input data set and submit it to an LP solution code (e.g. MPSX), retrieve the results decoded into the names and name phrases he has assigned to model variables, and display the results using a simple table generation syntax. If the user has specified values for variables such that by ordering properly the solution of the equations, the system can be solved resursively, this can be accomplished by specifying the solution sequence.
Sequence of Computation	As described above, this is under the control of the user and may be modified interactively.
Input Data	As required by the user's particularization of the model.
Results	Population dynamics over time, generation of resources, uses made of resources (health services delivered), uses made of budgets provided (or calculation of budgets necessary), and amounts of service of each type delivered to each population type in each facility type in each region in each time period.
Comments	Modeling system is currently implemented on IBM 360 and 370 equipment using either TSO or CMS for time sharing. A batch version is also available and can be implemented under any IBM operating system (OS, DOS, VM) on 360 or 370 equipment. A systems installation manual is available for CML. Installation, training, modeling consultation, and system maintenance are available from Puter Associates, Inc., 345 Whitney Ave., New Haven, Connecticut 06510.

U3 - UNITED STATES

The Model	Authors: C.D. Flagle, R.D. Parker, M.H. Brenner, Operations Research Division, School of Hygiene and Public Health, The Johns Hopkins University, Baltimore, Maryland. Publications: Flagle, C.D., The Evolving Recognition of Systems Aspects of Health Services, in C.K. Blong, *Systems Thinking and the Quality of Life*, Society for General Systems Research, Washington, D.C., 1975. Brenner, M.H., The Impact of Economic and Socio-Demographic Systems on Physical and Mental Health, in C.K. Blong, *Systems Thinking and the Quality of Life*, Society for General Systems Research, Washington, D.C., 1975. Parker, R., and J. Ortiz, *Application of the Birth-Life-Death Model to Tumor Prediction*, Pan American Health Organization, Washington, D.C., 1975.
System Described	The system considered relates a human population in a physical and economic environment to numbers of persons in a set of health states or in a set of health services. Knowledge of unit resource requirements permits prediction of total resource requirements under assumption of levels of care provided.
Area — Time	The model in the abstract is limited in time span only to the ability to predict demographic factors such as birth rate.
Area — Space	The model, unlimited to population size, has been applied to the population of Costa Rica, USA, the State of Maryland, and a region within the State.
Motivation	The model evolved naturally as our research interests grew from institutional to regional and national problems. The main impetus in the U.S. has been legislation in comprehensive health planning.
Methodology	The model deals with a population distributed among a number of health states; it can be expressed in deterministic or stochastic form, with linear or interactive projections. Most applications have been aspatial, dealing with classes of services in a region, e.g. hospitals, clinics; some have been spatial, dealing with location of a facility.
Sequence of Computation	Depending upon application, population distributed initially in a set of states is predicted for next time periods - usually one or five year intervals.
Input Data	We began with a population described by age, sex, socio-economic variables, morbidity and mortality, and unit resource requirements for treating morbidity states.

Results	The general planning application result is a set of predictions of future resource requirements - hospital beds, physicians, nurses and other health workers. The forecasting results have predicted the timing of increasing chronic disease mortality in a Latin American country with control of population and infectious diseases (Parker and Ortiz). Consolidation of past data are yielding methods of predicting morbidity and mortality responsive to economic conditions.
Comments	Current efforts are directed at prediction of results of expanded health insurance and expanded primary care and health education.

U4 - UNITED STATES

The Model		Authors: W. Gudaitis, R. Brown, M. Kishiyama, Department of Industrial and Systems Engineering, University of Alabama in Huntsville. Publications: Gudaitis, W., and R. Brown, Modeling a Hospital Organization, *IEEE Transactions on Systems, Man, and Cybernetics*, SMC-5, 4 (1975), 441-446. Gudaitis, W., *A State Variable Matrix Model to Simulate a Hospital Organization*, unpublished thesis, Department of Industrial and Systems Engineering, University of Alabama in Huntsville, 1972. Kishiyama, M., *A System Model for Simulating a Hospital Organization*, unpublished thesis, Department of Industrial and Systems Engineering, University of Alabama in Huntsville, 1975.
System Described		A multi-dimensional, input-output, state-variable matrix model of a hospital viewed as a collection of five interacting sectors: patient, medical services, non-medical services, personnel and physical facilities.
Area	Time	Any time period desired.
	Space	The entire hospital, including staff and patients.
Motivation		Impetus: A management model for long-range planning, resource allocation, and profitability determination. Goal: Real-time tracking of patients, materials, services, and costs.
Methodology		Five interacting sectors are described by sets of equations which characterize the relationship of resources to services demanded by the patient population and, based on these, the associated unit costs of services performed. The patient sector is described in terms of the distribution of patients among the various hospital departments and medical categories and the demand of such patients for medical and non-medical services. A patient transition matrix accounts for the probability of patient transfer between medical categories during hospital stay.
Sequence of Computation		The patient sector is modeled based on hospital admission, transfer probability and discharge matrices which are updated with real-time data. Based on this, the demand for medical and non-medical services is derived, including not only nursing care and laboratory and clinical support, but housekeeping and record-keeping services as well. Finally, unit cost data for the services performed are determined and from this the profitability of the various hospital components can be determined.

Input Data	Admission Office Log, Patient Transfer Log, Discharge Log, Daily Patient Condition Report, Medical Statistics, Medical Records File, Daily Analysis Report, Daily Revenue Summary Report, Monthly Financial Statement, Hospital Administrative Services Report.
Results	Daily Patient Census Report; Daily Imputed Value Report; Staff Scheduling; Resource Allocation; Profitability Determination of Patients, Nursing Staffs, Departments and Laboratories; Cost Control.
Comments	Model initially described by W. Gudaitis was programmed on a UNIVAC 1108 at the University of Alabama in Huntsville by M. Kishiyama. A proposal is being prepared for implementation of the model at the Huntsville Hospital.

U5 - UNITED STATES

The Model	Authors: J.P. Newhouse and C.E. Phelps, The Rand Corporation, Santa Monica, California. Publications: Phelps, C.E., and J.P. Newhouse, Coinsurance, the Price of Time, and the Demand for Medical Care, *Review of Economics and Statistics*, LVI, 3 (1974), 334-342. Phelps, C.E., and J.P. Newhouse, *Coinsurance and the Demand for Medical Services*, R-964-1-OEO/NC, The Rand Corporation, October, 1974. Newhouse, J.P., and C.E. Phelps, Price and Income Elasticities for Medical Care Services, in M. Perlman, ed., *The Economics of Health and Medical Care*, John Wiley, New York, 1974. Newhouse, J.P., and C.E. Phelps, New Estimates of Price and Income Elasticities for Medical Care, in R. Rosett, ed., *The Role of Health Insurance in the Health Services Sector*, a Universities-NBER Conference volume, forthcoming. Newhouse, J.P., A Design for a Health Insurance Experiment, *Inquiry*, March, 1974. Keeler, E.B., J.P. Newhouse, and C.E. Phelps, *Deductibles and the Demand for Medical Services: The Theory of the Consumer Facing a Variable Price Schedule under Uncertainty*, R-1514-OEO/NC, The Rand Corporation, December, 1974.
System Described	Model of demand for medical care. Supply not included in model. Role of time allowed for. Keeler, et al., allow for nonconvexity in budget line introduced by deductible. Health insurance experiment data will permit estimation using episode of illness as unit of observation.
Area	Estimation with existing data has been static. Estimation with experiment data based on dynamic programming model in Keeler, et al. Data are principally, though not exclusively, from U.S., and principally are observations on consumers.
Motivation	To predict demand under alternative national health insurance plans.
Methodology	Model is positive, not normative. Derived from neoclassical economic theory. Generalizes 1972 model of Grossman in that insurance is treated as endogenous (except in experimental setting).
Sequence of Computation	In episodic model, simulation to move household through time toward deductible.
Input Data	In health insurance experiment, running own insurance company. Otherwise, Center for Health Administration Studies (CHAS) survey data; insurance premiums, literature. CHAS data available from National Technical Information Service, Springfield, Virginia, U.S.A.

Results	In episodic model, consequences for demand of changing deductible, accounting period, or scope of covered services.
Comments	Experiment data is not available until early 1980s.

U6 - UNITED STATES

The Model	Authors: R.M. Thrall, Department of Mathematical Sciences, Rice University, Houston, Texas; and D. Cardus, Texas Institute of Rehabilitation and Research, Houston, Texas. Publications: (1) Twelve reports issued by Texas Institute for Rehabilitation and Research under the acronym AARPS (Analytic Aid for Research Project Selection), 1973. D. Cardus, Principal Investigator. (2) Thrall, R.M., and D. Cardus, Benefit-Cost and Cost-Effectiveness Analyses in Rehabilitation and Research Programs, *Methods of Information in Medicine*, 13 (1974), 147-151. (3) Thrall, R.M., and D. Cardus, Benefit-Cost Modeling in the Presence of Multiple Decision Criteria, in D. Venedictov, ed., *Health System Modeling and the Information System for the Coordination of Research in Oncology*, CP-77-4, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1977. (4) Cardus, D., and R.M. Thrall, The Concept of Positive Health and the Planning of Health Care Systems, in D. Venedictov, ed., *Health System Modeling and the Information System for the Coordination of Research in Oncology*, CP-77-4, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1977. Thrall, R.M., Benefit/Cost Estimation, Alternatives, Requirements, Advantages and Disadvantages, to appear in the proceedings of a Conference on Computer Applications in Health Care Delivery sponsored by the Society for Advanced Medical Systems in cooperation with the Office of Continuing Education, Baylor College of Medicine, and held in Houston, 3-5 November, 1975.
System Described	The model described in (1) and (2) was designed to aid SRS in selection of R&D projects for funding. Paper (3) is a theoretical contribution. Paper (4) advances a philosophical position and is only tangentially related to the others. Paper (5) is closely related to Paper (3) and some of the results in (5) will be incorporated in the final version of (3).
Area — Time	No limits on time.
Area — Space	No limits on space.
Motivation	Impetus: The first model (1,2) was developed for determining priorities of R&D project proposals. The version discussed in (3) and (5) is for general health care systems although most of its concepts are more broadly applicable, for example to energy and ecology problems. Goals: A major goal is to provide a basis for benefit/cost models which will be more generally accepted than has been the case in the past.

Methodology	The major methodological contribution is the use of subdivisions of objectives, and of their evaluations to obtain units small enough to facilitate agreement among the major parties concerned. In matters where agreement in evaluation cannot be expected, final judgement is left for the ultimate decision maker.
Sequence of Computation	Not applicable as yet.
Input Data	Not applicable as yet.
Results	Not applicable as yet.
Comments	The model is still in a formative stage and its development is awaiting sponsorship.

U7 - UNITED STATES

The Model		Authors: D.E. Yett, L. Drabek, M.D. Intriligator, and L.J. Kimbell, Human Resources Research Center, University of Southern California, Los Angeles. Publications: A Microeconometric Model of the Health Care System in the United States, *Annals of Economic and Social Measurement*, 4, 3 (1975), 407-433. A Microsimulation Model of the Health System: The Role of the Hospital Sector, *Applied Mathematics and Computation*, 1 (1975), 105-130.
System Described		Consumers' (by age, sex, race, income, and diagnosis) demand for physician and hospital services (patient visits resp. patient days). Physicians are determined by a second submodel (by age, specialty, activity, and country of graduation). The demand for non-physician manpower is derived from physicians and hospitals (ownership, size, length of stay). Markets for health services coordinate supply and demand. Non-physician manpower supply is created by another submodel (registered nurses; licensed practical nurses; allied health professionals; other personnel).
Area	Time	1960-1980, annual data
	Space	U.S.A.
Motivation		Concentrating on individual behavioral units, the model should allow one to study the effects of a change in one sector transmitted over time to other sectors of the health care system.
Methodology		Microsimulation or microeconometric model; more than 99% of the parameters are estimated by classical statistical techniques.
Sequence of Computation		First the distribution of consumers over age, sex, income, race, etc., is determined. Physician and hospital services are derived by consumers, physicians, and hospitals. A non-physician manpower model creates the supply of this sector.
Input Data		National Center for Health Statistics Health Interview Survey data, family income data by race from the Current Population Survey, U.S. Bureau of Census (1972). Physicians' data from Public Health Service publication. Often data of other studies were used.

Results	(1) The demand for health services is effectively explained by a combination of demographic factors, services and health conditions. (2) The distribution of population is very important for the composition of health services provided. (3) Foreign medical graduates are a critical factor in meeting the demand created by National Health Insurance (NHI). (4) Productivity of physicians and other labor inputs is of fundamental importance to NHI. (5) High importance of organizational factors (shifts from solo to group practices, mix of types of hospitals, etc.).

U8 - UNITED STATES

The Model	Authors: D.E. Yett, L. Drabek, M.D. Intriligator, L.H. Kimbell, Human Resources Research Center, University of Southern California, Los Angeles. Publications: A Macroeconometric Model of the Production and Distribution of Physician, Hospital, and Other Health Care Services, in D. Venedictov, ed., *Health System Modeling and the Information System for the Coordination of Research in Oncology*, CP-77-4, International Institute for Applied Systems Analysis, Laxenburg, Austria, 1977.
System Described	Entire personal health care system, excluding mental health services, drugs and dental care.
Area — Time	1968-1980
Area — Space	California
Motivation	To provide state and local health planning agencies with a forecasting tool for likely effects of policy options and trends beyond policy control. The macro-approach is relatively uncomplicated and sufficiently detailed to be useful to health policy makers. The model can be implemented at both the state and the local levels, using available data.
Methodology	Parameters of "generalized" model were estimated by 1970 cross-sectional data by regression analysis. Initial values of endogenous variables were set equal to their 1967 levels for the State of California.
Sequence of Computation	A simultaneous system of equations must be solved each year of simulation.
Input Data	Cross-sectional data 1970, State of California; initial data 1967.
Results	Simulation experiments were performed with the model, e.g. to hold the ratio of total hospital beds per capita constant at the 1972 level through certificate-of-need regulations. Since hospital beds increased less rapidly than utilization, the average occupancy rate rises in comparison with the baseline projection. There is also a modest increase in outpatient visits. Generally speaking, the direct effects of the performed experiments were partially offset by secondary effects elsewhere in the model. This reinforces the importance of forecasting the secondary as well as the primary effects of policy changes.

W1 - WORLD HEALTH ORGANIZATION

The Model	Author: G.J. Deboeck, Division of Rural Development, World Bank, Washington, D.C., U.S.A. (Formerly, staff member Project Systems Analysis, World Health Organization, Geneva.) Publication: *User Oriented Modeling for Health Planning and Programming*, paper presented at IIASA Conference on Systems Aspects of Health Planning, August, 1974.
System Described	HPMOD is a general class of resource allocation models for health program planning, which can be implemented in interactive mode using Conversational Modeling Language. HPMOD is a model primarily designed for the simulation of alternative allocations of resources and their optimal allocation among health programs and development projects. The basic logic of the model considers a set of health and health-related conditions described by incidence rates with respect to each of several described populations. These give rise to discrete classes of eligibles to whom service activities may be delivered. Service activities utilize existing resources and might require additional resources. The additional required resources absorb the outcome of development activities (e.g. training of manpower). The service and development activities generate, respectively, recurrent and development expenditures. The effects of delivering service activities in the course of population growth and/or future incidence of any condition can be taken into account explicitly. Two solution models are available for dealing with HPMOD. In simulation mode, the user specifies the level at which each service activity computes the consequences over some specified horizon. In this way the effect on population, mortality, births, incidence, resource consumption, facility utilization, and the like, can all be predicted, given complete specification of the coverage and distribution among facilities of the various activities considered within the model. In optimization mode, the service and development activities are left free to vary. Measures of effectiveness can be specified as a function of the service activities delivered. The selection of service activities, and the resulting development activities, is motivated by the objective function based on values specified by the user, and constraints such as budgets, minimum and maximum coverage with health services to be achieved, etc. The model then computes as in simulation mode, the consequences over time of delivering an optimal number of health services.

Area	Time	Any period selected by the user: one to n years.
	Space	Any country selected by the user.
Motivation		Impetus: The model was developed as an *illustrative* application of Conversational Modeling Language in a workshop at Yale University, June, 1974. Goals: (1) Illustration of interactive conversational modeling of the health sector. (2) Learning tool for public health administrators. (3) Framework for development of modeling support to country health programming.
Methodology		Conversational Modeling Language (CML) permits the definition of interactive computer languages which allow mathematical and simulation modeling to be split into two phases. In the first phase, a decision maker and a CML programmer analyze a given problem and determine the general class of models in which the problem can be fitted. The programmer then creates a CML program to simulate this general class of models and extends the CML language to include new statements that the decision maker may use to specify a particular model within the general class. In the second phase, the decision maker, now a programmer in this special purpose language, can specify alternative structural and parametric situations and simulate or optimize the results of each. Thus a special purpose language for a general class of health resource allocation models has been created. This language allows the formulation of HPMOD for which any user can specify alternative structural and parametric situations. He can then simulate or optimize the results for each of these alternatives.
Sequence of Computation		See "System Described" and "Methodology".
Input Data		Minimum 10 data series, e.g. baseline population, resource stock, incidence rates, birth and death rates, etc.
Results		The data used was hypothetical, although it somewhat reflected the situation of the health sector in a developing country. The results from simulation and optimization are in consequence illustrative of a computer modeling procedure rather than having any value itself.

Comments	Further experimental applications of Conversational Modeling Language are being made in the WHO Regional Office of the Americas (PAHO). CML capability has been installed in Toronto University (Canada), the University of Leuven (Belgium), etc. Various applications of CML are being made in the U.S.A. For more information, contact Professor Robert Fetter, Yale University.

W2 - WORLD HEALTH ORGANIZATION

The Model	Authors: M.S. Feldstein, Professor of Public Finance, Harvard School of Business, Boston, Massachusetts; M.A. Piot, Medical Officer, WHO, Geneva; T.K. Sundaresan, Statistician, WHO, Geneva. Publication: (Published in supplement to Vol. 48, WHO Bulletin, Geneva, 1973.)
System Described	The model is a Resource Allocation model for the Public Health Sector. The model generates classes of population with specific demographic and epidemiological characteristics, and matches these with alternative health technologies according to specified eligibility criteria, so as to maximize health and other benefits under constrained resources.
Area — Time	The time frame is a one-year cycle for the resource allocation problem, but the built-in epidemiological effect of the technology is computed and aggregated over 75 years. In this way, the long-term effects of alternative short-term health investments are compared.
Area — Space	The illustration of the model, using tuberculosis as the disease problem, is primarily based on Korean data (Republic of Korea), but some technical parameters are estimated from other sources.
Motivation	The purpose of such modeling was to test the sensitivity of resource allocation decision in the health area to a variety of factors, so as to identify critical variables in a given situation. Thus, indirectly, the goal is to assist in rational decision making. The initial motivation was the observation of the apparently irrational investment pattern in the field of tuberculosis in the 1950s and 1960s.
Methodology	The model is an application of the LP algorithm. At the core of it are technology cost-effectiveness matrices. The constraints are linear and the objective function is of the type $\sum_k \sum_j V_k B_{ij} X_j$, where k is benefit type and j is activity type.
Sequence of Computation	The program is in FORTRAN, written by T.K. Sundaresan for an IBM 360/40 computer. The algorithm searches for the population class with the highest benefit, seeks the most cost-effectiveness technology for that class, assigns resources, recomputes constraints, proceeds to the second highest benefit-yielding population class, etc., until resources available are consumed. The program also computes the dual. The program requires a few seconds of core time.

Input Data	Empirical data are derived from surveys, clinical and epidemiological studies, time and motion, and cost-accounting studies (primarily from WHO sources).
Results	The sensitivity runs showed that the optimal TB control strategies are relatively insensitive to the planning horizon of the decision maker, but relatively sensitive to the internal money allocation (e.g. to supplies vs staff costs), relatively insensitive to rather wide variations in the effectiveness of the various technologies applicable to TB, and to the discount rate applied in the case of economic benefits.
Comments	Extension of the method to other and broader health fields, while feasible technically with the model above, is hampered by the poor knowledge of public health practitioners about the cost-effectiveness of the respective technologies. Study of health technology from this angle is critical to rational health decision making.

References and Bibliography

Bailey, N., and M. Thompson, eds. (1975), *Systems Aspects of Health Planning*, North-Holland, Amsterdam.

Bergwall, D.F., and S.A. Hadley (1975), *An Investigation of Modelling for Health Planning*, final report of Grant CP-T-000106-01-0, U.S. Department of Health, Education and Welfare.

Charpentier, J.-P. (1974), *A Review of Energy Models: No. 1 - May 1974*, RR-74-10, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Forrester, J.W. (1969), *Urban Dynamics*, M.I.T. Press, Cambridge, Mass.

Hogarth, James (1975), *Glossary of Health Care Terminology*, WHO, Copenhagen.

Mathematical Models for the Education Sector: A Survey (1973), OECD Technical Report, Paris.

Stranch, P.G. (1976), Modelling in the Social Sciences: An Approach to Good Theory and Good Policy, *Simulation Today*, 39.

Venedictov, D. (1976), Modeling of Health Care Systems, in *IIASA Conference '76*, Vol. 2, International Institute for Applied Systems Analysis, Laxenburg, Austria.

Venedictov, D., ed. (1977), *Health System Modeling and the Information System for the Coordination of Research in Oncology*, CP-77-4, International Institute for Applied Systems Analysis, Laxenburg, Austria.

APPENDIX 1: List of Model Codes

Model Code	Author(s)
A1	P. Fleissner, Austrian Academy of Sciences, Institute of Research for Socio-Economic Development, Vienna, Austria
B1	T. Zahariev, Mir. Popov, B. Davidov, Institute of Social Hygiene, Public Health Organization and Management, Sofia, Bulgaria
C1	J.-M. Rousseau, Département d'Informatique, Université de Montréal, Montreal, Quebec, Canada
C2	A.P. Contandriopoulos, Département de'administration de la santé, Université de Montréal, Montreal, Quebec, Canada; J.M. Lance, Long Range Planning, Health and Welfare Canada, Ottawa, Ontario, Canada
C3	L. Fazekas, Ministry of Health of the Province of Ontario, Toronto, Ontario, Canada
C4	D.W. Paine, Institutional Services Division, Health Consultants Directorate, Health and Welfare Canada, Ottawa, Ontario, Canada
C5	J.H. Milsum, I. Vertinsky, C.A. Laszlo, D. Uyeno, University of British Columbia, Vancouver, British Columbia, Canada; A.B. Hurtubise, Departément des Affaires Sociales, Gouvernement du Québec, Quebec, Canada; P. Belanger, M.D. Levine, McGill University Montreal, Quebec, Canada
C6	C. Tilquin, Department of Health Administration, University of Montreal, Montreal, Quebec, Canada
C7	R. Miksl, CSc, ředitel Krajské hygienické stanice v Ostravě, Ostrava, Czechoslovakia
C8	R. Jiroušek, Institute of Haematology and Blood Transfusion, Prague, Czechoslovakia
C9	J. Radkovský and E. Švandová, Institute of Hygiene and Epidemiology, Prague, Czechoslovakia
C10	J. Radkovský, Institute of Hygiene and Epidemiology, Prague, Czechoslovakia

C11	K. Žáček, J. Radkovský, Z. Roth, Institute of Hygiene and Epidemiology, Prague, Czechoslovakia
F1	J. Chaperon, P. Le Beux, C. Chastang, Institute for Health Information Systems, Unité de Recherche Biostatistiques, CHU Pitié Salpétrière, Paris, France
F2	A. Letourmy, Centre de Recherche sur le Bien-Etre (CEREBE), Paris, France
I1	K. Atsumi, I. Fujimasa, S. Kaihara, A. Klementiev, IIASA, Laxenburg, Austria
J1	S. Kaihara and K. Atsumi, University of Tokyo, Tokyo, Japan
J2	I. Fujimasa, Institute of Medical Electronics, Faculty of Medicine, University of Tokyo, Tokyo, Japan; and F. Kodama, University of Saitama, Saitama, Japan
P1	M. Bojanczyk and J. Krawczyk, Polish Academy of Sciences, Institute for Organization, Management, and Control Sciences, Warsaw, Poland
S1	D. Venedictov, et al., Ministry of Health, Moscow, U.S.S.R.
S2	A.I. Yashin, USSR Academy of Sciences, Institute for Control Sciences, Moscow, U.S.S.R.
S3	O.W. Barojan and L.A. Rvachow, USSR Academy of Medical Sciences, Central Epidemiological Institute, Moscow, U.S.S.R.
S4	V.V. Bessonenko, E.N. Granitsa, G.I. Chechenin, Siberian Department of the USSR Academy of Medical Sciences, Institute of Complex Problems of Hygiene and Occupational Diseases, Novokuznetsk, U.S.S.R.
S5	V.I. Kant, V.N. Frolov, Medical Faculty of Moldavian University, Kishinev, U.S.S.R.
S6	A.S. Kiselev, Serbsky Institute of Forensic Psychiatry, Moscow, U.S.S.R.
S7	Y.M. Komarov, Y.U. Djuravlov, A.G. Tsercovny, USSR Academy of Medical Sciences, Department of Biophysics, Moscow, U.S.S.R.
S8	V.M. Timonin, Semashko Institute of Social Hygiene and Public Health Organization, Moscow, U.S.S.R.
S9	A.F. Serenko, V.M. Timonin, and L.G. Sudarikov, Semashko Institute of Social Hygiene and Public Health Organization, Moscow, U.S.S.R.

U1	Members of the Operational Research Service (ORS) of the Department of Health and Social Security (DHSS) and of the Scientific Control Systems Ltd., London, United Kingdom. Current Project leader is Dr. R.J. Gibbs of DHSS, London.
U2	R.B. Fetter, Yale University, Center for the Study of Health Services, Institution for Social and Policy Studies, New Haven, Connecticut, U.S.A.
U3	C.D. Flagle, R.D. Parker, M.H. Brenner, Operations Research Division, School of Hygiene and Public Health, The Johns Hopkins University, Baltimore, Maryland, U.S.A.
U4	W. Gudaitis, R. Brown, M. Kishiyama, Department of Industrial and Systems Engineering, University of Alabama in Huntsville, Huntsville, Alabama, U.S.A.
U5	J.P. Newhouse and C.E. Phelps, The Rand Corporation, Santa Monica, California, U.S.A.
U6	R.M. Thrall, Department of Mathematical Sciences, Rice University, Houston, Texas, U.S.A.; and D. Cardus, Texas Institute of Rehabilitation and Research, Houston, Texas, U.S.A.
U7	D.E. Yett, L. Drabek, M.D. Intriligator, and L.J. Kimbell, Human Resources Research Center, University of Southern California, Los Angeles, California, U.S.A.
U8	D.E. Yett, L. Drabek, M.D. Intriligator, and L.H. Kimbell, Human Resources Research Center, University of Southern California, Los Angeles, California, U.S.A.
W1	G.J. Deboeck, Division of Rural Development, World Bank, Washington, D.C., U.S.A. (Formerly, staff member Project Systems Analysis, World Health Organization, Geneva, Switzerland.)
W2	M.S. Feldstein, Professor of Public Finance, Harvard School of Business, Boston, Massachusetts, U.S.A.; M.A. Piot, Medical Officer, and T.K. Sundaresan, Statistician, World Health Organization, Geneva, Switzerland.

APPENDIX 2: List of Participants

Prof. Kazuhiko Atsumi
IIASA
2361 Laxenburg
Austria

Prof. O.W. Barojan
USSR Academy of Medical Sciences
Central Epidemiological Institute
Moscow
U.S.S.R.

Dr. V.V. Bessonenko
Siberian Department of the USSR Academy of Medical Sciences
Institute of Complex Problems of Hygiene and Occupational Diseases
Metallurgists av. 17-34
Novokuznetsk
U.S.S.R.

Dr. M. Bojanczyk
Polish Academy of Sciences
Institute for Organization, Management and Control Sciences
Warsaw
Poland

Dr. J. Chaperon
Institute for Health Information Systems
Unité de Biostatistiques
CHU Pitié Salpétrière
91 boulevard de l'Hôpital
75013 Paris
France

Dr. A.P. Contandriopoulos
Departément d'administration de la santé
Université de Montréal
Montréal, Québec
Canada

Dr. Guido Deboeck
Division of Rural Development
World Bank
1818 H Street, N.W.
Washington, D.C. 20433
U.S.A.

L. Fazekas, P. Eng. M.B.A.
Systems Coordinator
Ministry of Health of the Province of Ontario
Information Systems Division
3rd Floor
15 Overlea Boulevard
Toronto, Ontario M4H 1A9
Canada

Martin S. Feldstein
Professor of Public Finance
Harvard School of Business
Boston, Massachusetts
U.S.A.

Prof. Robert B. Fetter
Yale University
Center for the Study of Health Services
Institution for Social and Policy Studies
77 Prospect Street
New Haven, Connecticut 06520
U.S.A.

Prof. Charles D. Flagle
The Johns Hopkins University
School of Hygiene and Public Health
Division of Operations Research
615 North Wolfe Street
Baltimore, Maryland 21205
U.S.A.

Dr. Peter Fleissner
Austrian Academy of Sciences
Institute of Research for Socio-Economic Development
Fleischmarkt 20/1/1/4
1010 Vienna
Austria

Dr. Iwao Fujimasa
Institute of Medical
Electronics
Faculty of Medicine
University of Tokyo
7-3-1 Hongo, Bunkyo-ku
Tokyo 113
Japan

Dr. R.J. Gibbs
Project Leader of
Balance of Care Work
Department of Health
and Social Security
151 Great Titchfield Street
London W1P 8AD
United Kingdom

Dr. William V. Gudaitis
8900 Camille Drive, SE
Huntsville, Alabama 35802
U.S.A.

Dr. R. Jiroušek
Institute of Haematology
and Blood Transfusion
Prague
Czechoslovakia

Dr. Shigekoto Kaihara
Hospital Computer Center
University of Tokyo Hospital
7 Hongo, Bunkyo-ku
Tokyo 113
Japan

Prof. V.I. Kant
Medical Faculty of
Moldavian University
Kishinev
U.S.S.R.

Prof. A.S. Kiselev
Serbsky Institute of
Forensic Psychiatry
Moscow
U.S.S.R.

Dr. Y.M. Komarov
USSR Academy of
Medical Sciences
Department of Biophysics
Moscow
U.S.S.R.

Dr. Alain Letourmy
Centre de Recherche sur le
Bien-Etre (CEREBE)
140, rue du Chevaleret
75013 Paris
France

Dr. R. Miksl
Kraisky Zigienek, Severo-
Moravskaia obl. Partizanskaia
pl. 7, Ostrava 1
Czechoslovakia

Prof. J.H. Milsum
Division of Health Systems
4th Floor, I.R.C. Building
University of British Columbia
Vancouver, British Columbia
V6T 1W5
Canada

Dr. Joseph P. Newhouse
The Rand Corporation
1700 Main Street
Santa Monica, California 90406
U.S.A.

Douglas W. Paine
Associate Director
Institutional Services Division
Health Consultants Directorate
Health and Welfare Canada
Ottawa, Ontario K1A 1B4
Canada

Dr. J. Radkovský
Institute of Hygiene
and Epidemiology
Prague
Czechoslovakia

Prof. Jean-Marc Rousseau
Departément d'Informatique
Université de Montréal
Montréal, Québec
Canada

Prof. A.F. Serenko
The Semashko Institute of Hygiene
and Public Health Organization
Moscow
U.S.S.R.

Prof. Robert M. Thrall
Department of Mathematical
Sciences
Rice University
Houston, Texas 77001
U.S.A.

C. Tilquin
Department of Health
Administration
University of Montreal
Montreal, Quebec
Canada

Dr. V.M. Timonin
Semashko Institute of
Social Hygiene and
Public Health
Organization
Moscow
U.S.S.R.

Dr. D. Venedictov
Deputy Minister of Health
Rachmanovski per. 3
Minzdrav
Moscow
U.S.S.R.

Prof. A.I. Yashin
USSR Academy of Sciences
Institute for Control Sciences
Profsojuznaya, 81
Moscow, V-279
U.S.S.R.

Prof. Donald E. Yett
Director
Human Resources Research Center
University of Southern
California
Los Angeles, California 90007
U.S.A.

Dr. K. Žáček
Institute of Hygiene
and Epidemiology
Prague
Czechoslovakia

Prof. T. Zahariev
Director
Institute of Social Hygiene,
Public Health Organization,
and Management
15 Dimitar Nestorov Street
Sofia
Bulgaria

APPENDIX 3: Questionnaire

Part 1

The Model	Authors, main publications, title of the model.
System Described	General description; its inner interactions described by the model.
Area — Time	Time interval for behavior investigation of the real system.
Area — Space	Region where the model is applicable. Level of aggregation.
Motivation and Goal	Impetus for creation of the model. What is the goal of the modeling.
Methodology	Main concepts of a mathematical model (not in detail). Linkage between subsystems. Objective functions. Method of equation development and parameter estimation.
Sequence of Computation	What is done by the computer program and when (in general terms). Computer language.
Input Data	Main kinds of input data. Sources of the data. How one gets the data.
Results	What are (will be) the main results of the simulating.
Comments	Arbitrary. One may note something about the future development of the model, founder, possible users, computation time, etc.

Part 2

Theories Used	Basic general theories which are used as a starting point.
Functional Diagrams and Schemes	Some general diagrams and schemes which describe the architecture of the model and main interactions.
Validity	By which methods did you evaluate the model and what were the results.
Additional Groups Carrying out Modeling Activities of which You are Aware	See the attached list of authors. The Biomedical Project is seeking to expand this list.