MODELING HEALTH CARE SYSTEMS

PROCEEDINGS OF A IIASA WORKSHOP, MARCH 28-29, 1977

E. N. SHIGAN and R. GIBBS, Editors

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International Institute for Applied Systems Analysis
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PREFACE

The biomedical task at IIASA is part of the Research Area, Human Settlements and Services. The aim of the task is to build a national health care system model and to arrange for it to be applied at national centers so as to assist decisionmakers there. In this task, it has always been recognized that the IIASA team must collaborate closely with the national teams who are most active in this field. Accordingly, the IIASA Research Plan 1977 envisages a variety of modes of collaboration of which the most important is a continuing sequence of workshops and conferences.

This workshop, held on March 28-29, 1977, was organized by the IIASA biomedical group and was dedicated to the following problems:

- coordination of IIASA investigations with the studies of different countries, especially with those countries with which IIASA has had no previous contact;

- discussion about future research programs from the position of application of the models and orientation to real public health administrative users;

- discussion about the November 1977 conference to be sponsored by IIASA, WHO, and national centers.

The proceedings contain all presentations that were made by the biomedical group, by other scientists of IIASA, and by representatives from national centers.

E.N. Shigan
June 1977

Contents

Welcoming Address

R.E. Levien

Before you begin your workshop today, I would like to tell you a little about IIASA. This is one way in which I can welcome you here and welcome your participation at IIASA. You know, once you have been to a workshop, we consider you a member of the IIASA family, and hope that you will maintain the association as long as we have common interest. And second, by telling you about what IIASA is doing in general, we may help you to form a clearer picture of how our work in health care systems should be shaped.

IIASA is now four and a half years old. We will reach our fifth birthday in October 1977, having been formed by 12 scientific organizations meeting in London in October 1972. Since then, our membership has grown to 17, from both East and West. All the countries you come from have member organizations--and let me emphasize that they are member organizations, not member countries. We are a nongovernmental institution, which significantly affects the way in which we do our work. IIASA scientists do not come as national representatives, they are not delegates of their nations; they come as individuals who work as members of international teams.

Now there are in our name two phrases that are important: "international applied", and "systems analysis". Each of those suggests one aspect of our work. "International applied" means that we deal with problems of international importance, *real* problems of international importance, of which we distinguish two kinds. The first are *global* problems--topics such as energy, food, climate, the oceans--which cannot yield to the actions of single nations, but inherently involve international collaboration. In one study, we are looking 15 to 50 years into the future to estimate global energy supply and demand; and we have just begun a similar program for global food supply and demand. The second category is *universal* problems: problems that lie within national boundaries and can be resolved by the action of single nations, but that all nations share. Here IIASA can play an important role in the exchange of experience among nations. That is why you are here. Health care system planning is a universal problem; all nations have it. But because you represent nations that have solved these problems in quite different ways, we can learn from each other, both in the methodology of health care system planning and eventually perhaps in the exchange of policies. IIASA, by spanning East and West, by spanning socio-economic and political groupings, can facilitate the exchange of the wide range of experience that mankind, under a diversity of organizational forms, has developed across the globe. So these two types of international problems--global and universal--are one focus of IIASA.

The second comes from the phrase "systems analysis". Now that is a term which means everything or nothing, and quite different things in different countries. I can, if I must, give you a definition; but what is important for us is that systems analysis is what IIASA does. We are not trying to choose a definition and then make it be what IIASA does; IIASA does something, and by virtue of being done at IIASA it becomes systems analysis. More seriously, we feel an obligation as systems analysts to study policy questions in a comprehensive way. That means not to define a problem by the boundaries of a Ministry. For example, the way a Ministry of Health sees the health care problem is really, in a more comprehensive view, only a part of that problem of any country. The full problem involves the responsibilities of the Ministries of Environment, of Agriculture, of Housing, and so on. So ministerial boundaries are not what we use in circumscribing a problem. So too, the physicians' view of the health problem is only a part of the systems problem, as is the nutritionists'. IIASA tries to draw a boundary around the problem that includes the components appropriate to solving a particular policy question.

Now these two foci--international and applied problems, and systems analysis--are reflected in the structure of the Institute. Work on major international problems we have organized as Programs. We have an Energy and a Food Program, and we may soon have a Regional Development Program. But if we are to study things in a comprehensive way, we also need a broad range of disciplines at IIASA. We need not only specialists in systems analysis, whoever they might be, but specialists in health care, in population, in environment, in technology, who can be drawn into an interdisciplinary team for a system study of the problem. So we have four organizational groupings of expertise, or Areas. The group called Resources and Environment are experts in water resources, natural resources, environment, and ecology. Human Settlements and Services is concerned with human resources--their numbers, their distribution on the globe, the health services that are provided to them, education, transportation, communications, and so on. Not all at one time--we do not have enough staff to have competence in all these topics. But we choose within that general heading certain topics of concentration at any one moment. The third Area we have is Management and Technology. This is concerned with organization and technological contributions of mankind to the natural endowment. And the fourth is System and Decision Sciences--mathematicians and computer scientists who bring to IIASA the expertise in particular tools to study complex systems. This week's task force meeting on nondifferential optimization is organized by the System and Decision Sciences Area; but the talent in optimization is applied throughout the Institute. For example, Frans Willekens is working with a member of that group to apply dynamic linear programming to migration and population issues. This linkage among experts within different Areas and between those in the Areas and Programs is a key feature of IIASA, is the way in which we form interdisciplinary and international teams to deal with real, applied problems. Each Area, in addition to its contributions to the Programs, has its own research activities, and we are meeting here to discuss one of those. It is a small task within the Human Settlements and Services Area right now. How it will develop is still unclear. If we have a Regional Development Program, then health care planning at the regional level will be very much a part of this. The Food and Agriculture Program is certainly concerned with nutritional and health questions. There could even be interaction with the Energy Program. Then there is the more general question of designing health, education, and other human resource programs at a national level into which this initial effort could grow. So we have here a seed planted in one of IIASA's Areas, Human Settlements and Services, which has potential links to other aspects of the Institute. And one of the purposes of this meeting is to see how that seed might sprout-in what directions it might grow.

I want to say only one more thing about IIASA, but it is quite important. The resources we have here are limited. There are here at the moment about 95 scientists, of whom 70 or so are paid from contributions of our National Member Organizations, which come to about 110 million Schillings each year. Another 18 million Schillings come from external sources--The United Nations Environment Programme, various foundations, government agencies, and so on--which enable us to expand our staff to about 95. But this is far too little to carry out the vast program that IIASA has set for itself. IIASA was never intended to be self-contained. You should not think of IIASA as you might a national research institution, as something that is bounded by the walls of the Schloss. We need and we use the collaboration of a network of scholars and institutions around the world. It is through this network that we hope to achieve our ambitious goals. Here in this room are Professor Atsumi, who has been working in Japan in collaboration with our group; Dr. Fleissner, who is working here in Austria; and Dr. Gibbs from the UK, who will join us in May. It is this network that forms an invisible college of collaborators around the world: sharing experience, contributing to a common goal, and therefore all benefiting and enabling IIASA to contribute to the resolution of major international problems.

HEALTH CARE SYSTEM MODELING: NATIONAL EXPERIENCE

Systems Analysis in Health Care

E.N. Shigan

The development of systems analysis has taken a firm place among the other main achievements of the last decades, e.g. cybernetics, information theory, and active computerization in management processes.

In systems methodology, such concepts as "system", "systems approach", and "systems analysis" play a leading role. Unfortunately, at this time, no commonly used definitions exist for these items; their content, however, has been determined.

"System" refers to a group of elements (persons, organizations, equipment, concepts, etc.) related to each other and to external conditions brought together by some common aim.

"Systems approach" is the emphasis placed on the significance of the complex interdisciplinary nature of the problem, process, or investigation. It pays special attention to the inadequacy of only considering locally isolated situations where one runs the danger of losing sight of the original object. The approach is based on a well-known dialectic law concerning the interrelation and interdependence of events, requiring that each event and object be considered not only as a specific system, but also as a subsystem of the large system. Thus, the systems approach emphasizes the necessity to consider socio-economic, ecological, and other conditions; in other words, the functioning of the system under study.

"Systems analysis" refers to any formal analysis whose purpose it is "to suggest a course of action by systematically examining the objectives, cost, effectiveness, and risks of alternative policies or strategies--and designing additional ones if those examined are found wanting"* (Grundy and Reinke, 1973).

The International Institute for Applied Systems Analysis is a scientific center for the development of systems analysis methodology. In this Institute, the different specialized research scientists from many countries are working on the basis of the universal methodological principles, modern mathematical methods, and computers.

*The definition quoted is by E.S. Quade.

IIASA's biomedical group is working on the development and application of systems methodology for the solution of *health care problems of interest to many countries.*

Practical application of the systems approach is not new to health care systems. If we look to past public health practices, we can find many good examples of complex interdisciplinary investigations of the problems on the basis of a broad utilization of mathematical methods and computers. Great contributions toward the practical application of systems analysis in public health have been made by such countries as Bulgaria, Finland, the FRG, Japan, the UK, USA, USSR and many others, and especially in the WHO Headquarters and its Regional Office for Europe.

The health care system is considered a large and complex dynamic system consisting of a set of interrelated subsystems, very closely related to external systems and joined by the common aim: the health of the population (see Figure 1). Aside from the horizontal division of the system into a set of subsystems, there exist vertical hierarchical levels: population, medical establishments, district, national, regional and global (Figure 2). For each level we can find common, specific, and non-specific problems. One of the most important for public health at present is the determination of the list of indices for each level of this pyramid and environmental condition. WHO is paying a great deal of attention to these informational problems.

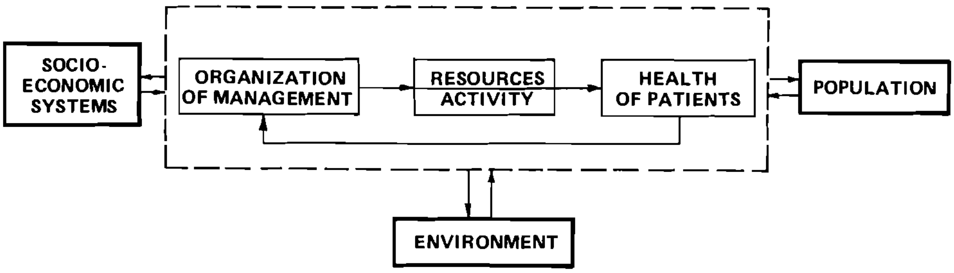

Figure 1. Block-scheme of the HCS model.

Another direction is concerned with technical problems and particularly decisions concerning hardware. There have been good technical advances in the medical field.

However, to reach solutions for management problems, the decisionmaker does not have enough information about the study's objectives and environmental situation; he must know the likely outcome of following the different alternatives.

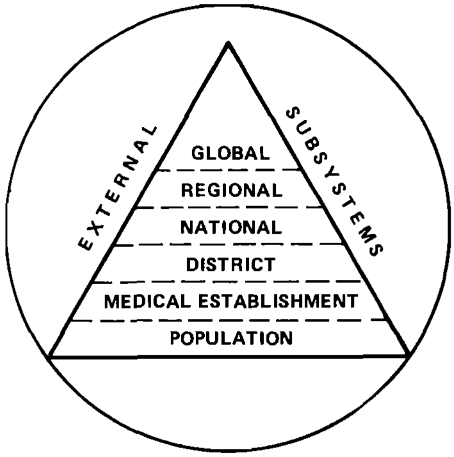

Figure 2. Different levels of HCS.

At present, the main method of evaluating alternatives is the organization of natural experiments based on real objects such as medical centers, hospitals, etc. The organization and evaluation of such experiences has become increasingly difficult due to lack of finances, the length of time involved, etc. Moreover, it is sometimes impossible to conduct a natural experiment. In those cases where such experiments are conducted, natural variants are tested. The major difficulty encountered is in making natural experiments at the highest hierarchical level (i.e. district, national, regional, or global). Decisionmakers responsible for the development of the national health care system require increasingly more mathematical models to help link many internal and external blocks.

The model helps us test alternatives, and estimate the expected aftereffects. With systems analysis, the decisionmaker must use information regarding the object of management, the external situation, and finally, a set of different mathematical models (Figure 3).

The investigation of model application in health care systems indicates that most attention is paid to local problems with good quantitative criteria. Such optimization models are mainly used for modeling the activities of health centers, hospitals, etc. However, we frequently have to deal with many criteria of which some are qualitative. In some cases, it is even impossible to determine any criteria. Therefore, as well as optimization models more and more simulation models are used for the highest hierarchical levels. Since such simulation models are used to forecast the behavior of the system and its components, they are sometimes referred to as "predictive" in different situations.

The goal of the biomedical group is to develop a national health care system (NHCS) model in collaboration with national research teams and WHO. Such a model will help decisionmakers at national level to compare different planning decisions and to choose the best alternative. Moreover, we hope the development of an NHCS model based on international experience will be a good methodological tool for the development of mathematical models for other hierarchical levels of the HCS.

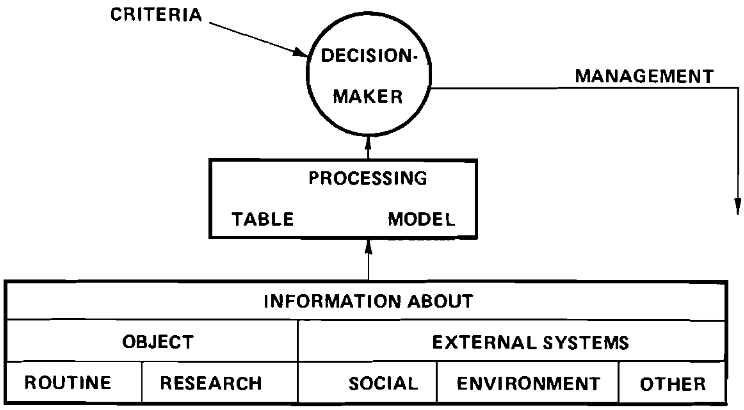

Figure 3. Decisionmaking in health care.

The study began at IIASA under the direction of Dr. D.D. Venedictov, and was conducted by the biomedical team in close cooperation with national centers. Before starting work on the model, the biomedical group studied the work done by different national centers. While working on the NHCS model, we paid more attention to the common, universal part of each national system than its specific character. As a result of the preliminary study, the main components of the model and their interrelation were defined. The biomedical group worked with official publications of WHO, the studies of different countries, and some research material. In order to develop the model and test it with real data (especially resource allocation), diseases were roughly divided into three groups: degenerative diseases, infectious diseases, and accidents.

We started with the first group--degenerative diseases--because they use a large part of the total medical resources. For building the model for this group there are reliable statistical and clinical data.

The model is considered as a set of the following consecutive submodels:

population $\rightarrow$ morbidity $\rightarrow$ supply/demand $\rightarrow$ resource allocation, and a step-by-step approach was used in its development.

- The population submodel.

  National statistics of the age-sex structure of population and its dynamics were used in developing this submodel. These have already been published (Klementiev, 1976).

- The morbidity submodel.

  The major difficulty confronting public health organizers is the estimation of the prevalence rate (including unregistered cases) which requires very expensive and time-consuming screening of the entire population.

- The demand/supply submodel.

  For the national level, decisionmakers need the prevalence rate in order to calculate the demand in medical resources.

- Resource allocation.

IIASA's biomedical team has developed a mathematical model for prevalence estimation proceeding from the available data on the age-sex distribution structure of the population, mortality cases, and clinical research data. The results of this research have been published (Kaihara, et al., 1977).

We do, however, realize that this prevalence estimation submodel is too simple an approach to all degenerative diseases. For this reason, one of the most pressing and important problems is the testing of a mathematical prevalence estimation model and its correction from data for different diseases. Upon conclusion of this step we will proceed to the resources submodel, and so on.

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Grundy, F., and W. Reinke (1973), *Health Practice Research*, PHP 51, p. 21.

Kaihara, S., et al. (1977), *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.

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A Short Survey of National Health Care System Models

P. Fleissner and A.A. Klementiev

Health care is becoming an increasingly complex task. New types of illness have changed the spectrum of morbidity and mortality. Higher costs of the health care system, combined with a leveling off of life expectancies in many countries, cry for more efficient planning tools for the health/illness sector. Mathematical simulation models are currently being developed on a national or regional basis to provide better and more integrated information for health care management.

In December 1975, the participants of an international conference on public health care modeling, conducted by WHO and IIASA's biomedical group, agreed to initiate a survey on the current state of the art in health care models (HCMs). At IIASA, this work was started in spring 1976 and has now been completed. The results are described in detail in an IIASA Research Memorandum which will be published this year. Only a brief summary is given here.

Thirty-eight HCMs were collected and classified from eleven countries and WHO (see Table 1). From these models, from international literature and from IIASA's own experience in model building, the main lines along which a mathematical model is constructed were derived.

The different steps, described in detail, are as follows (see Figure 1):

- Problem statement;
- Conceptual framework;
- Graphical representation;
- Choosing the modeling method (see Figure 2);
- Data, estimation and tests;
- Computer programming;
- Running the model;
- Evaluation;

- Implementation.

At each step, the results of the review are added.

To illustrate the more abstract concepts of model building, three examples of actual models in use are described briefly, namely: a macroeconometric model (U8), a systems dynamics model (J1), an optimization model (U1). The different methodologies and different types of applications are explained.

Table 1. List of model codes.

Model Code	Author(s)
A1	P. Fleissner, Austrian Academy of Sciences, Institute of Research for Socio-Economic Development
B1	T. Zahariev, Mir. Popov, B. Davidov, Institute of Social Hygiene, Public Health Organization and Management, Sofia
C1	J.-M. Rousseau, Département d'Informatique, University of Montreal
C2	A.P. Contandriopoulos, Department of Health Administration, University of Montreal
C3	L. Fazekas, Ministry of Health of the Province of Ontario
C4	D.W. Paine, Institutional Services Division - Health Consultants Directorate, Health and Welfare Canada
C5	J.H. Milsum, I. Vertinsky, C.A. Laszlo, D. Uyeno, University of British Columbia; A.B. Hurtubise, Department of Social Affairs, Quebec Government, P. Bélanger, M.D. Levine, McGill University
C6	C. Tilquin, Department of Health Administration, University of Montreal
C7	R. Miksl, CSc, ředitel Krajské hygienické stanice v Ostravě
C8	R. Jiroušek, Institute of Hematology and Blood Transfusion, Prague
C9	J. Radkovský, E. Švandová, Institute of Hygiene and Epidemiology, Prague
C10	J. Radkovský, Institute of Hygiene and Epidemiology, Prague
C11	K. Žáček, J. Radkovský, Z. Roth, Institute of Hygiene and Epidemiology, Prague
F1	J. Chaperon, P. LeBeux, C. Chastang, Institute for Health Informations Systems, Unité de Biostatistiques CHU Pitié Salpétrière

F2	A. Letourmy, Centre de Recherche sur la Bien-Etre (CEREBE)
I1	K. Atsumi, I. Fujimasa, S. Kaihara, A. Klementiev, IIASA
J1	S. Kaihara, K. Atsumi, University of Tokyo
J2	I. Fujimasa, University of Tokyo; F. Kodama, University of Saitama
P1	M. Bojanczyk, J. Krawczyk, Polish Academy of Sciences, Institute for Organization, Management and Control Sciences, Warsaw
S1	D.D. Venedictov, et al., USSR Academy of Sciences, Moscow
S2	A.I. Yashin, USSR Academy of Sciences, Institute for Control Sciences, Moscow
S3	O.W. Barajan, L.A. Rvatschow, USSR Academy of Medical Sciences, Central Epidemiological Institute, Moscow
S4	V.V. Bessonenko, E.N. Grauitsa, G.D. Tchetchenin, Siberian Department of the USSR Academy of Medical Sciences, Institute of Complex Problems of Hygiene and Occupational Diseases, Moscow
S5	W.I. Kant, W.N. Frolow, Medical Faculty of Moldavian University
S6	A.S. Kiselev, USSR Ministry of Health, Serbsky Institute of Forensic Psychiatry
S7	J. Komarov, et al., USSR Academy of Medical Sciences, Institute of Biophysics
S8	V.M. Timonin, USSR Ministry of Health, Serbsky Institute of Forensic Psychiatry
S9	A.F. Serenko, V.M. Timonin, L.G. Sudarikov, Sematschko Institute for Social Hygiene and Public Health Organization
U1	Members of the Operational Research Service (ORS) of the Department of Health and Social Security (DHSS) and of Scientific Control Systems Ltd. Current project leader is R.J. Gibbs of DHSS.
U2	R.B. Fetter, Yale University, Center for the Study of Health Services, Institution for Social and Policy Studies
U3	C.D. Flagle, R.D. Parker, M.H. Brenner, The Johns Hopkins University, Operations Research Division, School of Hygiene and Public Health
U4	W.Gudaitis, R. Brown, M. Kirshiyama, University of Alabama in Huntsville, Department of Industrial and Systems Engineering
U5	J.P. Newhouse and C.E. Phelps, The Rand Corporation
U6	R.M. Thrall, Rice University, Department of Mathematical Sciences; D. Cardus, Texas Institute of Rehabilitation and Research

U7	D.E. Yett, L. Drabek, M.D. Intriligator, L.H. Kimbell, University of Southern California, Human Resources Research Center
U8	D.E. Yett, L. Drabek, M.D. Intriligator, L.H. Kimbell, University of Southern California, Human Resources Research Center
W1	G.J. Deboeck, World Bank, Division of Rural Development (Former staff member Project Systems Analysis, World Health Organization, Geneva)
W2	M.S. Feldstein, Harvard School of Business; M.A. Piot, WHO; T.K. Sundaresan, WHO

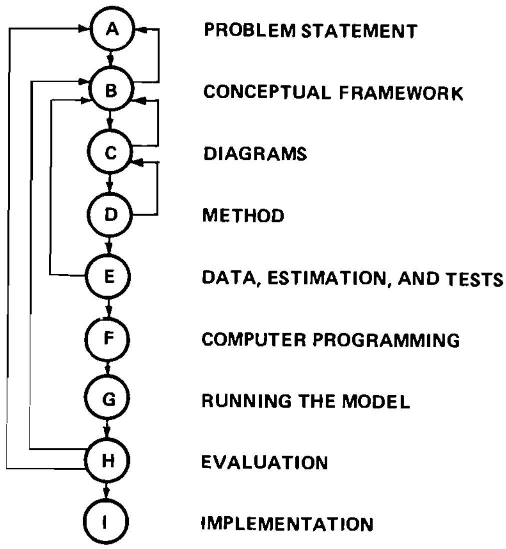

Figure 1.

	SIMULATION MODELS	ECONO-METRIC 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			

Figure 2. Methods used.

Modeling the Prevalence of Degenerative Type Disease

A.A. Klementiev

Some recent results of the biomedical team's activities are presented here, namely, the latest version of the morbidity model. The first version was published in [1].

WHY MORBIDITY MODELING?

There are two principal reasons for this. Firstly, data concerning estimated prevalence are important for health planning. There have been two ways to estimate these data--from available incidence data or by special health investigations. The method discussed here could be considered as a supplementary one and for the estimation of prevalence for some diseases the method could be a more precise technique if the input data were relatively precise.

Secondly, the model provides not only the estimation of prevalence for which direct data is lacking, but also shows the interrelationships between certain aspects of morbidity, prevalence, and mortality.

THE MODEL

Let us consider now a given degenerative type disease. An individual is considered *healthy* if he has not contracted the disease under consideration; otherwise, he is considered *sick*. The population is divided into N age strata. Some corresponding notation is given below:

p_i is the number of individuals in the ith stratum, $i = \overline{1,N}$;

h_i is the number of healthy individuals;

μ_i is the incidence, specified by sex, per 100,000 healthy individuals from the ith stratum;

$\tilde{D}_i$ is all causes death rate, specified by sex, per 100,000 population;

D_i^* is the death rate according to cause (given disease), specified by sex, per 100,000 population;

d_{ij} is the *specific death rate* and is defined to be the number of deaths per 100,000 sick individuals who contracted the disease in the ith stratum j years ago.

$$D_i = \tilde{D}_i - D_i^* \quad , \tag{1}$$

$$\beta_{ij} = D_{i+j} + d_{ij} \quad . \tag{2}$$

The flow diagram for the prevalence is presented in Figure 1. It can be seen from the diagram that the number of healthy people in the first stratum is equal to h_i. During one year, $\mu_1 h_1$ healthy people contract the disease. In the following year, $\mu_1 h_1 (1 - \beta_{11})$ are still alive, and so forth. Thus, one could see that for each stratum, balance equations, describing that the number of individuals in the ith stratum is equal to the sum of healthy and sick individuals, could be written as follows:

$$p_1 = h_1 \tag{3.1}$$

$$p_2 = h_2 + \mu_1 h_1 \tag{3.2}$$

$$. \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; .$$

$$p_i = h_i + \mu_{i-1} h_{i-1} + \sum_{j=2}^{i-1} \mu_{i-j} h_{i-j} a_{i-j,j-1} \quad , \quad i=\overline{3,N} \tag{3.i}$$

$$. \; ,$$

where

$$a_{ij} = \prod_{k=1}^{j} (1 - \beta_{ik}) \quad , \qquad i=\overline{1,N-2} \quad ; \quad j=\overline{1,N-2} \quad . \tag{4}$$

In addition to system (3), balance equations for the number of deaths in each stratum could be written as follows:

$$p_1 \tilde{D}_1 = h_1 D_1 \tag{5.1}$$

$$p_2\tilde{D}_2 = h_2D_2 + \mu_1h_1\beta_{11} \tag{5.2}$$

. . . .

$$p_i\tilde{D}_i = h_iD_i + \mu_{i-1}h_{i-1}\beta_{i-1,1} + \sum_{j=2}^{i-1} \mu_{i-j}h_{i-j}a_{i-j,j-1}\beta_{i-j,j} \;, \quad \overline{i=3,N} \tag{5.i}$$

. . . .

Systems (3) and (5) could be solved with respect to the unknown variables μ_i and h_i in the following way. From (3.1)

$$h_1 = p_1 \;; \tag{6}$$

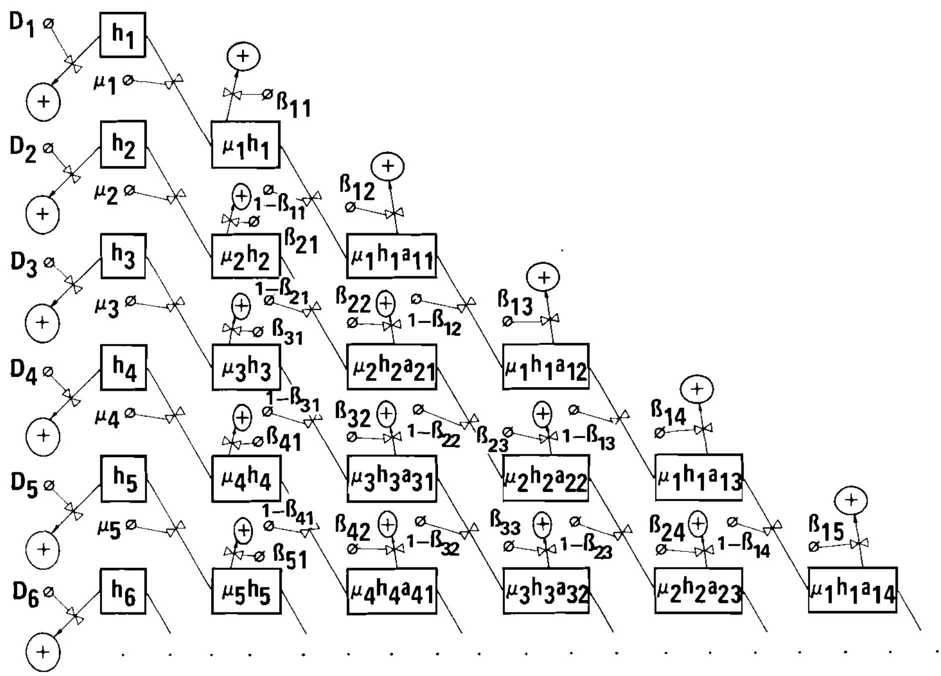

Figure 1.

then, from (3.2) and (5.2)

$$\mu_1 = \frac{p_2(\tilde{D}_2 - D_2)}{p_1(\beta_{11} - D_2)} \quad , \tag{7}$$

and

$$h_2 = p_2 \frac{\beta_{11} - \tilde{D}_2}{\beta_{11} - D_2} \quad . \tag{8}$$

Let us designate the last term in (3.i) as

$$F_i = \sum_{j=2}^{i-1} \mu_{i-j} h_{i-j} a_{i-j,j-1} \quad , \tag{9}$$

and the last term in (5.i) as

$$G_i = \sum_{j=2}^{i-1} \mu_{i-j} h_{i-j} a_{i-j,j-1} \quad . \tag{10}$$

With one more auxiliary variable

$$U_i = G_i - F_i D_i \tag{11}$$

and with (9)-(11) taken into consideration, we now have from (3.i) and (5.i)

$$\mu_{i-1} = \frac{p_i(\tilde{D}_i - D_i) - U_i}{h_{i-1}(\beta_{i-1,1} - D_i)} \tag{12}$$

and

$$h_i = \frac{p_i(\check{D}_i - \beta_{i-1,1}) - G_i + F_i \cdot \beta_{i-1,1}}{D_i - \beta_{i-1,1}} \quad , \quad i=\overline{3,N} \quad . \tag{13}$$

ALGORITHM

The unknown variables $\{\mu_i\}_1^{N-1}$ and $\{h_i\}_1^N$ are obtained as a solution of systems (3) and (5). The solution is done in the following sequence:

- $h_1 = p_1$, as it follows from (3.1);
- μ_1 is obtained from (7);
- h_2 is obtained from (8);
- in accordance with (9,10,11), auxiliary variables F_i, G_i, and U_i $(i = \overline{3,N})$ are calculated based on knowledge of the vectors $\{\mu_j\}_1^{i-2}$ and $\{h_j\}_1^{i-2}$ already obtained;
- the next unknown couple μ_{i-1} and h_i is calculated based on F_i, G_i, and U_i according to (12) and (13);
- the process is terminated if $i = N$.

RESULTS OF COMPUTER EXPERIMENTS

Estimation of malignant neoplasm* prevalence was carried out for Austria, Bulgaria, and France. [2] and [3] were used as sources of the initial data. d_{ij} was considered as independent of i (we still need survival data) and equal to 0.2.

The results of calculations are presented in Figure 2. To compare the number of deaths according to the disease with the prevalence figures for the same age group, these figures are presented alongside.

*ICD, A-List: A45-A57.

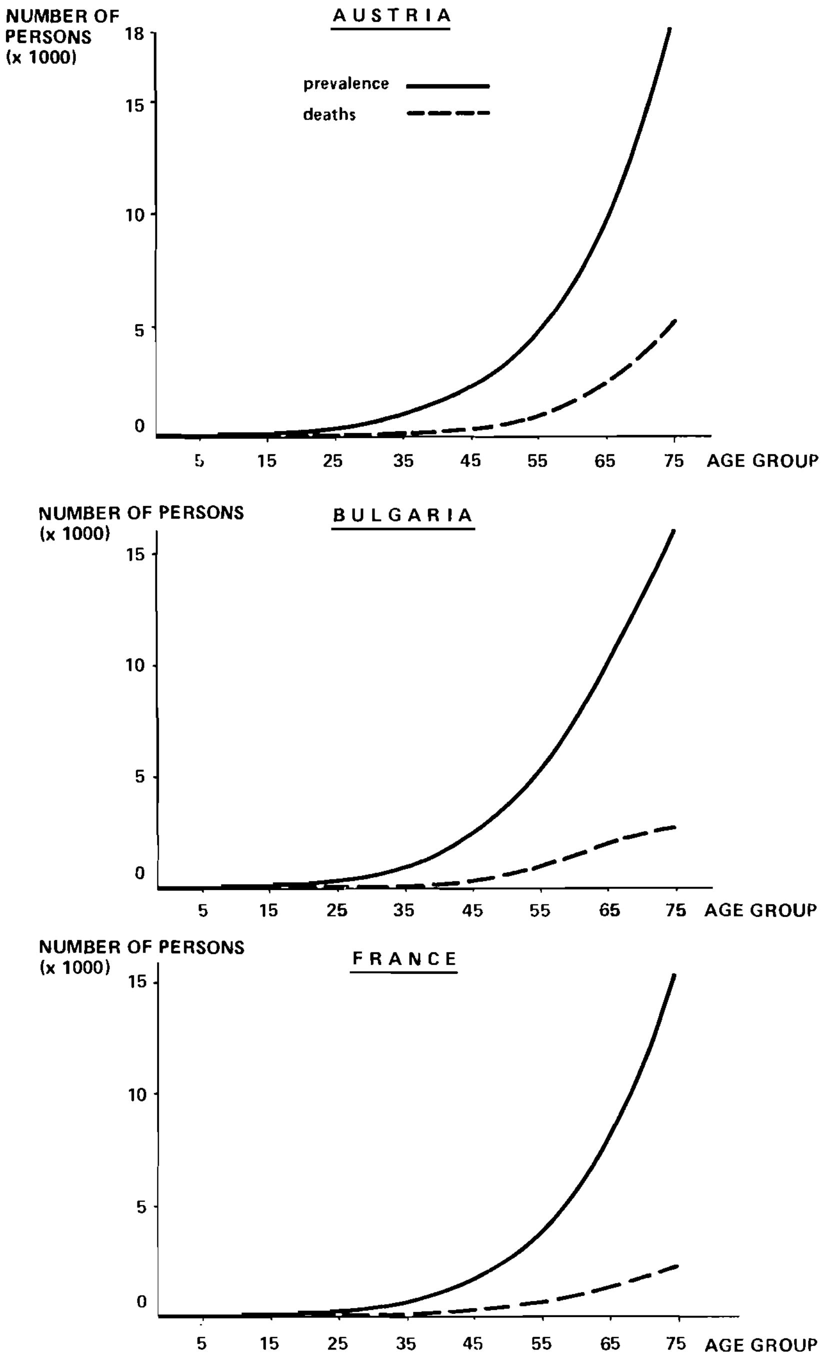

Figure 2. Prevalence of and deaths from a malignant neoplasm in Austria, Bulgaria, and France.

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[2] *World Health Statistics Annual, 1971 - Volume 1*, WHO, Geneva, 1971.

[3] Emmanuel', N.M., and L.S. Evseenko, *Kolichestvennye osnovy Klinicheskoi onkologii*, Meditsina, Moscow, 1970.

DISCUSSION

Professor Atsumi described the background to Dr. Klementiev's paper. In the plan for IIASA's work on health care modeling it was envisaged that models would be built on three aspects of the system: demand, resource supply, and resource allocation. The demand model, in turn, is divided into three parts: population, morbidity, and demand/supply. Having already developed a very good population model, the IIASA team turned its attention to developing a morbidity model. The first step was to model degenerative diseases including cardiovascular diseases, malignant neoplasms, and senile deaths.

A model of degenerative disease built was tested on WHO statistics, and applied to various countries: Philippines, Mexico, Japan, England, and Sweden. Future trends of degenerative diseases were estimated (see reference [1] above). The model could have fruitful applications both for projecting future trends and for international comparisons. Professor Atsumi and his colleagues would like to apply the model in other countries and would welcome comments from them.

Professor Shigan stressed that the relevance of the model was for national decisionmaking rather than for individual physicians. Thus it was permissible to group together a number of different diseases, on the basis of certain common properties, e.g. consumption of resources, type of screening process, type of examination.

HEALTH CARE SYSTEM MODELING: IIASA EXPERIENCE

Macromodels of Inpatient and Outpatient Health Care Systems in the Federal Republic of Germany

C. Dietrich

Application of mathematical methods to health services in the FRG started only in 1968, when the Federal Ministry of Defense ordered an investigation into the efficiency of its military medical service. In the last few years, two or three university institutes focused their interests on OR-problems in hospitals (OR stands here for all kinds of mathematical methods). In 1975, there were 19 OR-studies applied to health services. This compared with about 140 studies in Great Britain in 1972, and shows the lag in experience and application of this field in our country. Therefore you should not be surprised to hear that we have little experience with macromodels applied to health services either.

The classification of the macromodels follows that N.T.J. Bailey chose in his lecture "Systems modeling in health planning" given at the IIASA Conference "Systems aspects of health planning" in 1974 (published by North-Holland, Amsterdam in 1975 as *Systems Aspects of Health Planning*, eds. N.T.J. Bailey and M. Thompson). In the following, I give a short review of several studies on specific models that have been sponsored by a number of different Ministries at both the Federal and Regional level; these Ministries have accepted the resulting proposals.

A SIMULATION MODEL OF HEALTH INSURANCE (SPONSORED BY THE FEDERAL MINISTRY OF LABOR AND SOCIAL WELFARE)

P. Rosenberg

The main goal of this study was to demonstrate the effects of different system input parameters on revenues and expenditures of health insurance.

Rosenberg began his study by setting up a reference system consisting of 75 input variables and 80 output variables. The input variables were related to policy holders, producers of performances, associations, insurance, political, and socio-economical aspects. Some input variables were very appropriate for a quantitative approach, like "density of general practitioners". Many others were not yet operational like "actual standard of medical knowledge," or "hospital management." The output variables described the consumption rates, the fee scales, and the expenditure of the health insurance according to medical activities.

Considering all possible interrelations between the input and output variables, Rosenberg came to a total of 1709 hypothetical relations. Having analyzed the data, Rosenberg could only set up an estimator for 61 of these 1709 relations and therefore concluded that it would be premature and misleading to build a system model. There was too big an obscurity about the interrelations between input and output variables. Instead of a system model Rosenberg finally set up a "statistical program" for health insurance as a first step to a dynamic simulation model.

AN OR-APPROACH TO FIND LOCATION AND CATCHMENT AREAS OF HEALTH CARE STATIONS

M. Heinhold

Heinhold looked for realistic solutions to the following problems:

- Patient distribution between physicians at different locations

- Determination of the optimal number and sites of specialists and general practioners in outpatient treatment

- Determination of the optimal number and sites of hospitals and numbers of beds per hospital.

To solve these, Heinhold used OR-methods of nonlinear programming. For outpatient treatment, which is in the hand of settled doctors, he took as the objective function "The maximum number of sites of each kind of speciality" starting from a known average income.

Further restrictions were:

- the income of each physician

- patients attend the nearest doctor measured in time units.

For inpatient treatment, he used a stratification model of three types of hospital, which are hierarchically structured. As the objective function he took here "The total distance between a certain hospital and the domiciles of patients who need a hospital of this category must be minimized."

Heinhold also reported on a third aspect of his work, which is the practical results of the application of the models in a test region in South Bavaria: very good agreement with the real situations had been shown.

GROWTH AND BALANCE IN HEALTH SERVICES: COST EXPLOSION IN HEALTH INSURANCE AND ITS CONTROL

P. Herder-Dorneich

In his study, Herder-Dorneich looked for a logical systems policy in health care delivery. Unlike Rosenberg, he regarded the actual data situation in the FRG in the field of health care good enough to begin model building.

First, he constructed a reference line for appropriate cost and price development. This guideline for controlled development in health care delivery lies above the development of the gross national product. Here he used the Fourastie'-theorem of growth of the services sector.

Then he divided the health service into the three subsystems:

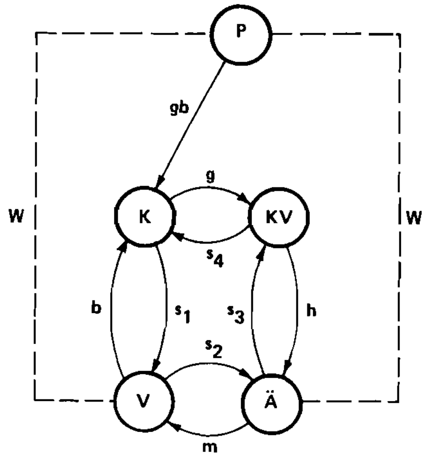
- ambulatory medical treatment
- stationary medical treatment
- drug provision

to compare their cost development with his guideline for controlled development. He found that the costs in the subsystems stationary treatment and drug provision increased faster than his guideline would admit. Here, he argued, was a control problem, i.e. a lack of control. While, if the cost development of a subsystem goes below the guideline, then there was a financing problem. Herder-Dorneich used systems dynamics to establish the lack of control or lack of financing.

Figure 1 shows a model of ambulatory medical care delivery. There is an external circuit of activities and an internal control circuit (of medical certificates) that connect both the parties (groups) concerned, e.g. physicians, insurances, patients, politicians, medical associations.

Herder-Dorneich considered this model to be a good example of a closed control system. He pointed out that the existence of a closed circuit is the reason why the costs of ambulatory medical treatment in the FRG develop similarly to his guideline.

The cost increase in the two other subsystems differed strongly from his guideline. From his model, Herder-Dorneich concluded that control is lacking in the subsystems stationary treatment and drug provision. In order to reduce the cost increase in these two systems to near that of the guideline of controlled development, it is necessary to close the control circuit at the middle level of associations.



V,	INSURED PERSONS	g,	REMUNERATION
Ä,	PHYSICIANS	h,	HONORARIUM
K,	SICK FUNDS	m,	MEDICAL ACTIVITIES
KV,	MEDICAL ASSOCIATIONS	s_1, s_2, s_3, s_4	CIRCUIT OF MEDICAL CERTIFICATES
P,	POLITICIANS	W,	ELECTIONS
b,	PREMIUM	gb,	SCALE OF FEES

Figure 1. System of ambulatory medical treatment.

OPTIMUM HOSPITAL SIZE

D. Fischer

In his study, Fischer investigated the problem of what the optimum size of a hospital within a hospital system is. He developed three models:

- A parametric cost model that allows a relative assessment of costs dependent on functions and size of the hospital and the patient mix as well.

- An LP model for an optimum allocation of resources within a hospital of certain size and function with respect to existing restrictions.

- An LP model to identify the optimum size of a hospital as a part of a hierarchical system of hospitals covering the whole country.

With these three models, Fischer came to the following conclusions:

- If there exists a hierarchical structure with respect to hospital specialization, then it is wrong to enquire about optimum size of a hospital in isolation from the rest of the system.

- The analysis of resource requirements and costs as functions of hospital size shows that in most areas cost per bed and cost per patient tend to increase with hospital size. Economies of scale existing especially in the supply area were by far outweighed by cost increases in others, especially by investment and personnel cost. The total treatment cost per case tended to increase with hospital size.

- In a hierarchically structured hospital system, there exists an optimum size of hospitals for each provision level.

- A hierarchy of hospitals with more than three levels conflicts with an integrated system of hospitals covering the whole area.

- In a hospital system with a certain bed capacity, there always exists an objective function, which causes a certain patient mix. The objective function "To maximize the patient number" is the same as the objective function "To maximize the efficiency of the system" or "To minimize the cost per case".

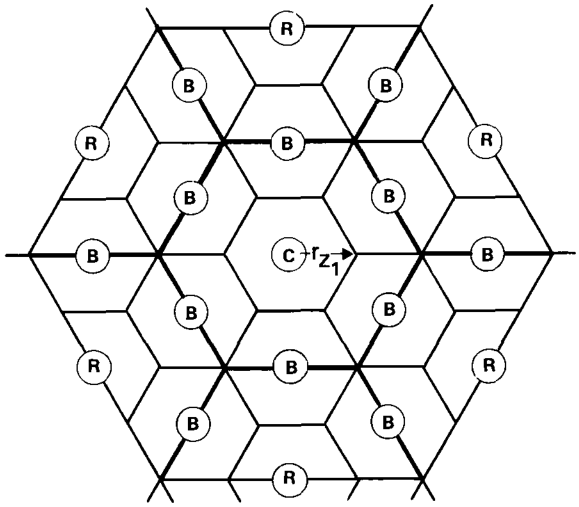
A hexagonal pattern (Figure 2) was selected which allowed the elaboration of an integrated hospital system structure for a homogeneously populated area (e.g. a big city) providing full area coverage. The system consisted of one central care, three regional care and twelve basic care level hospitals providing lower level care at the same time.

SIMULATING MEDICAL TREATMENT AND TRANSPORT OF COMBAT CASUALTIES

C. Dietrich and G. Weiser

During wars or catastrophes, the purpose of a military medical service is to ensure maximum survival of casualties.

A complex discrete event simulation model has been developed in order to provide a computational tool for the comparative analysis and evaluation of medical treatment and evacuation systems. The model describes a transportation system consisting of seven interacting transport loops and a medical treatment chain formed by four medical treatment levels. It follows the movement of each patient through the entire treatment chain, from the time the patient enters until the patient leaves the medical system by returning to duty, by dying, or by being evacuated from the critical zone.



$$P_{j,Z_1} = 2.6 q r^2_{Z_1} p_{j,Z_1}$$

$$P_{j,Z_2} = 2.6 q r^2_{Z_1} [p_{j,Z_1} + 4p_{j,Z_2}]$$

$$P_{j,Z_3} = 2.6 q r^2_{Z_1} [p_{j,Z_1} + 4p_{j,Z_2} + 16p_{j,Z_3}]$$

where $p_{j,Z}$ is the number of patients per 1000 inhabitants belonging to diagnostic category j, requiring care level Z, and

q, the inhabitants per square kilometer.

Figure 2. Catchment areas of an integrated hospital system structure.

Each patient entering the system is classified according to the nature and severity of his injuries by assigning him to one of 19 injury classes. These classes are described by two curves forecasting the life expectancy and survival probability, and by treatment times. At all levels patients are treated and evacuated on a priority basis.

What kind of results were obtained? The primary output of a simulation run was individual data about each patient, surgical team, vehicle and so on. A statistical program evaluated the great quantity of primary output data and elaborated lists of waiting times, waiting lines, workloads, survivability, through-run times, and average values of these and similar quantities. It is then up to the decisionmaker to evaluate different system models by using the information.

STUDY ON THE UTILIZATION OF MEDICAL PERSONNEL

F. Oberhofer

The problem was to find the reasons for the growing shortage of medical doctors in the West German armed forces and to discover possible means with which to stop it. The factors that influence both the demand for and the supply of doctors were investigated, e.g. a person's interest in the medical profession, the social status enjoyed by soldiers, the interest in joining the military forces as a medical officer, the influence of the size of the salary offered, etc. All these factors were combined in a realistic model showing the comparative weight of the factors and their various interactions.

One result of the analysis was that the armed forces medical service could be more attractive to members of the medical profession if military hospitals were open to both military and civilian patients, or if medical facilities in the form of so-called "health centers" were to be established. Such a system would, for example, provide a better professional incentive to doctors by allowing them to treat a sociologically more differentiated group of patients.

Another possible solution was seen in an increased division of labor within the medical service to free doctors from administrative tasks and other nonprofessional duties. It was proposed that female doctors could be admitted to the forces, and that the simpler and less professional medical and surgical functions could be assigned to medical technicians who would have to receive a highly specialized training.

MILITARY HOSPITAL STUDY

E. Donner, D. Burkhardt, W. Thierschmann, and F. Oberhofer

This study considered how existing hospitals and those to be built by 1980 could be put to best use.

At present, there are 15 military hospitals with about 3600 beds. So, the military forces are the most important owner of hospitals in West Germany. In October 1970, the IABG was awarded a contract by the Ministry of Defense to analyze eight new concepts for military hospitals and to determine what action should be taken to improve the effectiveness of the whole hospital system. The work was performed in two steps, the first being to design eight different mathematical models to represent the alternative hospital concepts. Among these models were the so-called teaching hospitals integrated into universities and combined military-civilian hospitals.

The second step was a comparative evaluation of the eight models by benefit, cost and overall effectiveness. To find input data for the benefit analysis, a poll was taken of the 25 top-ranking medical officers of the West German armed forces. A total of 16,000 binary judgments were collected on how these alternative hospital concepts compare in meeting 57 selected requirements for an optimum hospital system. The input data for the cost analysis were calculated from the actual cost of more than 40 typical military and comparable civilian hospitals.

A computer program was developed for processing the input data, using ALGOL language. This enabled an evaluation of the alternative concepts by the various criteria described. Then the parameters and criteria of the models were compared with those of existing hospitals. Several models of an ideal hospital were derived from the comparison and used as a basis for reform proposals.

MODEL OF REGIONAL PATIENT CARE SYSTEM

W. Klimke

Using systems dynamics, Klimke investigated the interrelations between stationary and ambulatory medical and nursery care with respect to length of stay, bed capacity, and cost per day. He applied his model to a region in Baden-Württemberg that has a hierarchically structured hospital system with four levels of care. No details are yet available.

Present Status of the Health Care System and its Modeling in Japan

K. Atsumi, S. Kaihara, and I. Fujimasa

INTRODUCTION

After World War II, a national health insurance system was introduced in Japan and almost every citizen has been covered by this system since. Nevertheless, most of the medical care is still in the hands of private physicians and the delivery of medical care in Japan has become more and more complicated.

Total medical expenditure has been increasing year by year. The gap between demand and supply in medical services is also increasing. Therefore, in 1972 the Japanese Government planned a national project to promote the medical information system and in 1973, the Japan Medical Information System Development Center (MISDC) was organized under the guidance of the Ministry of Health and Welfare and the Ministry of International Trade and Industry.

THE MAIN PROJECTS OF MISDC

Five main projects were started by MISDC with its staff of 50, and assistance from 30 external consultants.

- A survey and evaluation of health care information systems.
- A survey and experiments on the reorganization and planning of health care delivery in a district.
- The arrangement of a coding system and thesaurus of medical terms.
- Experiments on an information service system for physicians.
- The development of new technologies in health care delivery.

Of these, the second is the most important and the five districts (Kanagawa, Niigata, Wakayama, Tottori, and Nagasaki prefectures) were selected as model districts for surveys and experiments on emergency care system, telemedicine care system in remote areas without doctors, and reorganization of the health care delivery system.

Another important task is to propose appropriate decision-making, for which a new committee was organized. The responsibility of the committee is to construct a guideline to promote the health care information system and to investigate the methodologies of evaluation for the projects. In 1974, the investigation group on simulation model of health care delivery was started in this committee.

SOME TRENDS IN HEALTH STATISTICS IN JAPAN

Population

In 1970, the population of Japan was 103,720,060. A remarkable point is the recent change in the age structure of the population towards proportionally more old people.

Birth Rate

This has decreased since 1950 and reached 17.2 in 1977.

Deaths

The annual death rate continued to decrease since 1920 and has remained between 6.6 and 7.4 for the past ten years.

Leading Causes of Death

The deaths from degenerative diseases such as apoplexia, malignant neoplasms, and heart diseases have been recently increasing.

Medical Care

Hospitals and Clinics

The total number of hospitals and clinics in 1972 was 8143--439 national, 1067 municipal, 178 semipublic, 274 social insurance and 6185 private.

Medical Care Personnel

In 1972, the number of physicians per 100,000 was 117, dentists 37, pharmacists 79, public health 14, midwives 28, and clinical nurses 315. The number of physicians in Japan is almost the same as in European countries, but in Japan they are concentrated in cities and there is a lack of specialists in public health.

A SIMULATION MODEL OF HEALTH CARE

In order to analyze and forecast medical demand, construction of a simulation model of medical demand was started in 1972. Since medical care is related to various social factors, the model took these into consideration. The total population was divided into four groups--healthy, unaware sick, sick without medical care, and patients. The causes of illness, the progress of civilization, education, and the accessibility to physicians were analyzed and some future trends estimated.

Another important task of the simulation model was to estimate the effect of the automated multiphasic health testing system (AMHTS) on the social structure, and the interesting result obtained was that the national average quality of medical care will be decreased by the introduction of AMHTS, unless hospitals and clinics are increased to accomodate the extra patients and clients detected by AMHTS.

EVALUATION OF THE MEDICAL INFORMATION SYSTEM

The Evaluation Committee divided the medical information system (MIS) and hospital information system (HIS) as follows.

MIS for Patient Services

- MIS for outpatient clinic services
- HIS for outpatient services in hospitals
- HIS for inpatient services
- HIS for clinical investigation
- Patient monitoring and clinical measurement system
- Clinical decisionmaking system
- HIS for pharmacy
- AMHTS and regional clinical laboratory center
- MIS for receipt accounting

Medical Data Base

- Patient record system
- Regional medical consultation data base

- Community health register
- National medical information services
- Statistical data base

MIS for Management of Health Care Delivery

- HIS for hospital management
- HIS for regional health care delivery
- Emergency health care delivery system
- Administration system of national or regional health care delivery

These applications were analyzed from two viewpoints: the technical methods of MIS--transportation system, data processing, and communication system--and the interface and software--language, software, and hardware.

These applications were classified into the four phases of the planning and implementation of MIS--fundamental survey, experiment, development, and implementation, and then identified and evaluated under the following criteria by the Delphi method (15 specialists):

Essential Criteria

- Comprehensiveness and integration in health care
- Quality of care
- Effective allocation of resources
- Serviceability in health care
- Reasonable allocation of clinical demand
- Social acceptability
- Impact on medical education

Practical Criteria

- Reasonable cost for development and education
- Technical efficiency for development
- Industrial efficiency for development

- Allocation efficiency for administration and policy

- Covering of supply-demand gap

- Impacts upon other systems and technologies

A new concept of the promotion score was proposed, i.e. that the score of practical criteria be divided by that of the essential criterion. The evaluation revealed that the HIS for outpatient, pharmacy and receipt accounting, statistical data base, and administrative system for regional health care delivery should be promoted in the near future. In consequence, the shared HIS--where satellite hospitals share the use of a large computer installed in the medical center--is beginning to be implemented in local areas this year and is supported by the Japanese Government.

DISCUSSION

In response to questions, Professor Atsumi explained that MISDC is a part-governmental agency; one third of its funds come from government and two thirds from private enterprise. It has a staff of 50 persons plus the use of about 200 consulting specialists such as Professor Atsumi himself, who belongs to the University of Tokyo. The purpose of MISDC is to promote systems analysis in the Japanese health services. It includes one division that is developing simulation models. This team is collaborating with the IIASA biomedical team so that models developed by one team can be tested and used by the other.

Health Care System Modeling in the United Kingdom

A.G. McDonald

My intention is to discuss the development of the modeling work we have been doing in the last few years to indicate some of the applications that have been made and to relate our work to that of one or two of the earlier speakers. I shall indicate what is common ground and also where the difference lies. Our modeling work has been reported in various publications and at the December 1975 IIASA Biomedical Conference.

On the technical side, there has been some development of that aspect of the work in which our Russian colleagues here were interested at the Moscow conference, namely the choice of elasticities. The main technical development has been given a lot of attention: in the nonlinear model, there are some parameters that we call elasticities--similar to the economist's elasticities--and the question in 1975 was how to set their level. We have done some sensitivity analysis and a good deal of mathematical work, which will be reported later this year, on developing the methodology to determine the parametric values to put into the model.

In addition, the model will be extended by putting in more patient care groups--we are developing the child care section for inclusion into the model--and by the extension of other client groups, but the basic model has not changed in any fundamental way. It is the applications being made that are more interesting. In Shigan's paper (see Figure 3) the modeling schema is described and connected upwards to a decisionmaker and sideways to a manager. These relationships I think have to be; in fact it is this particular branch--the function of the decisionmaker and the management system--that deserves a great deal of attention. It is where we are working. My group are not trying to stand away from the health service, model it, and then say what it ought to be like. We are involved with decisionmakers and with management, and therefore, referring to Shigan's Figure 3 again, I would say we have another loop going around--model, decisionmaker/manager, and back through the model. I would argue that the decisionmaker block in the diagram breaks down into many dimensions as in the model of the system. Both are multidimensional boxes. And so is management.

In the United Kingdom, the health service is not the line management responsibility of the central government. The central government sets the budget level, distributes the money to regions (or in IIASA terminology, districts), and the districts have the responsibility for line management. But in order to get their appropriations, they have to submit plans which are analyzed centrally to see if they conform with the policy directives of government. And so we have a cycle.

Our models are used in the Department, i.e. in Central Government, in contributing towards policy decisions. The output of our work plus contributions from other fields influences policy statements which go before Parliament.

There was a recent example about two years ago when Government published the White Paper "Better Services for the Mentally Ill". Our work contributed to that. The particular contribution here was to demonstrate the feasibility in terms of cash flow and timing of being able to shift from institutional care of the mentally ill to care based much more in the community. What is feasible in a 15 year time span? What would it cost? How would the cash flow look? That kind of question. The reference to our work appears in a paragraph in that White Paper. That is one example of how we interface, i.e. in forming national policy.

We also contribute towards the appropriations process. Central Government determines how much money it can spend on the health budget for the next planning period. That money has to be divided between "districts" (IIASA terminology)--there are 14 in England; Wales and Scotland are separate. The 14 districts get their money according to a set of rules, as described in a publication called "The Report of the Resource Allocation Working Party, Sharing Resources for Health in England".

For the first time this year there is a new way of cutting up the national "cake", which is based on some of our modeling work. It is a financial model. What it is doing really is attempting to redistribute the money in a rational way rather than go on in the traditional way of what was done last year plus a bit or minus a bit. The reason being that it was decided by politicians that there was not a fair distribution of health services over the country as a whole. Too great a proportion of the health care was being delivered in London, around teaching hospitals, giving a relatively high standard of care, and too little in some of the industrial and rural areas. And this was a deliberate attempt to shift the balance.

I think one of the problems that modelers have to face and recognize is that we are dealing with very stable systems. The health care systems in the developed countries are really quite stable. They do not break down when stressed; they are stable in the scientific sense. And it follows, that they are rather difficult to change. There is only room to change them by a few percent on the margin. So while the outcome of this new method of setting the financial distribution to the outside observer would not look very different, it is causing a great deal of discussion. There is argument, particularly among the medical profession because there is some movement away from the traditional centers that have always had the larger share of the resources. So it is important.

Allocation of finance is a central function. [There are other central functions, for example, the size of medical training schools. The number of students that are going to go through the system is controlled centrally, so that some of the manpower planning for the medical profession is a central function in our country and this of course links to management as well.] Once the amount of monies has been determined centrally it goes to districts. They have to generate their own strategic plans over a 10 year or so cycle and submit these back to the department. These then contribute to the next annual cycle of budget setting. And in that loop round, there is a central analytical team that examines the plans and relates them to the national strategic guidelines and priorities. This team consists of operational research scientists (drawn from my group), economists and the statisticians. This three-pronged team examines the plans as they come in and sees that they are consistant with national policies; for example, it may be thought necessary to develop more care of the mentally ill, or more care of the physically handicapped, or that children between the age of 12 and 18 should have more resources. The task would be to see if plans coming up were in agreement with that kind of very broad statement. The macromodel, our main resource allocation model referred to by Dr. Fleissner, works at the national level and assists in the setting of national priorities.

The district plans are the top of the line management of the system, and are themselves amalgamations of area plans. (There are 90 areas underneath the districts.) That is really the place where the health care delivery strategic plans are set. We are using the same resource allocation model, the macromodel, with certain modifications to the detail, in two areas of the country. One in Devon, a county in southwest England, and one in Warwickshire, a county in central England, near Birmingham. And the problems as perceived by the area authorities in those two areas are somewhat different. Thus we are using the model in two localities for two rather different purposes. And this is why I stress that decisiontaking is not a single entity, that you can just put a ring around. It has many dimensions. The problem in Devon, which tends to be a retirement area, arises because it is overloaded with elderly, it does not have a lot of industry, it is an agricultural county, with a favorable climate on the coast where retired people tend to migrate. So it is not a typical microcosm of the country as a whole. It is a bit special. It means that they have a higher proportion of care to deliver as opposed to cure. It is not with acute hospital provision that there is a problem, it is just caring for an elderly population, complicated by also having a rural population which is distant from acute medical centers. The problem as they see it is their interface between the medical system and the social service system. In the new organization of health services in the UK there exists a joint planning function in which both health and social service authorities take part. There is the possibility for some money that has been voted for health care to be switched to local authority social services for support of needy sections of population. It might be domestic accomodation for mentally ill who are not so ill they have got to be in hospitals, but at the same time they need some shelter. Equally some of the elderly--maybe they do not need full institutional care, but can be maintained in the community if they have some support, and that is a local authority function, not a health services function.

Our same macromodel is being used to service the joint care planning team in Devon so that they can harmonize their plans. This issue is quite different from the decision about the balance between institutional care and community care--for one thing it is at a more micro level.

In Warwickshire, the problem is rather different. The emphasis there is more on the medical side. They are concerned with the acute and general practitioner service and yet it is the same model being used.

So those are two specific ways in which the model is currently being used. The current planning cycle has just started and the plans are just coming in, from local health authorities to central government. They are meant to conform with a government publication called a Consultative Document. It is not an instrument of Parliament telling people what they have got to do. It is merely a document which expresses the political wish of a government and puts it forward for discussion.

The macromodel was used to show that the document was consistent both logically and resource-wise, and not producing directives which were in conflict with one another.

We are also involved--but not by using the macromodel approach--assisting with other decisions which face people at area level. There are some similarities with earlier presentations. It is interesting that with different systems, with different countries, one seems to come back to the same problems. We are now working on one problem which Dr. Dietrich spoke of as being a problem in West Germany. I did not know he had that problem and I was quite surprised about what he said. We have the same problem. It is to do with the defense hospital. We are looking at an area plan in the south of England which includes Southampton and Portsmouth and it stretches up beyond Winchester to Basingstoke.

The population is concentrated in the Portsmouth-Southampton area. In the "district" are other agricultural counties but no other major centers of population. The problem that is facing the planners has two ingredients. One is the development of a new teaching hospital, in an area that has not had a teaching hospital before and this has to be planned in. We are having to do this in a different economy from the Japanese economy that Professor Atsumi described. He had a large growth of GNP--we have little or no growth. We have to consider a teaching hospital with all the facilities that implies without growth, or very little, of revenue resources. It is very difficult. However this is complicated by a naval hospital. The problem is that described by Dr. Dietrich. The navy wants to capture young clinicians, they want to keep their hospital, but to make it really viable from the point of view of training and providing experience and being attractive to medical people entering the navy. This means the inclusion of e.g. obstetrics, gynecology, and pediatrics to make it a whole hospital open to the public.

The planner for that area has got this nasty complex problem. His first task is to grow a medical school but also if he goes along with the naval plan, he will have to provide some funds for part of their hospital. So he has a very tricky planning problem with no extra resources. These are the sorts of decisions that have to be faced once we open up that decision box in Professor Shigan's schema. I do not think they are unique to the UK; that is why I have picked this particular example. Modelers have got to understand the structure of the decision process and what possible decisions are: because of the stability of the system it is not possible to pick the whole thing up and change it completely. There has to be a growth process and what we have to do is try to plan flexibility and a widening field of options rather than going down a path which narrows choice and fixes the whole system for a long time.

Another element coming into our work, which was mentioned by Dr. Fleissner, is the area of evaluation. If I go back to the dichotomy of care and cure which I mentioned earlier, a lot of our work is spent on the care end of the system because that is where a lot of resources go. It is an area where social pressures are forcing the system to devote more and more of its resources--looking after the elderly, the mentally ill, the mentally handicapped, the physically disabled.

We are not trying to cure them--we cannot. But we have to devote more and more resources to their care. On the acute side, the cure side--we are beginning to become involved in the area of evaluation. We have developed a generalized method for doing this which involves producing a mathematical model of patient progress for the disease under study. So far we have applied this approach, with some success to two specific cancers: acute myeloid leukemia, and Hodgkin's disease. Some of the work on acute myeloid leukemia was reported at a Paris NATO conference, and that work is continuing. We have reached the stage where our model actually fits past trials at St. Bartholomew's Hospital, the Royal Marsden Hospital in South London, and St. Mary's Hospital Manchester. In addition we are in the process of analyzing some acute myeloid leukemia data from the Sloane-Kettering Clinic in New York.

Somebody was asking earlier if our work was published. We are a little different from many of you here in that we are not a research organization, we are part of a Government Department. Our main function is to service the decisionmakers on the problems that arise within the Department and Dr. Levien stressed that IIASA was not like that and he had very good reasons why it should not be like that. I think there are some good reasons why it should be like that, if I may say so.

To use an American colloquialism, at least we get some of the action. I am very conscious that in being part of a Department we could become inbred and not exposed to our scientific peers. That is why we try to present our work at conferences, we try to join in with IIASA, with other national and international groups. We do have some of our work done in universities, to ensure that we are constantly exposed to academic criticism. But basically the endpoint of our study is not necessarily a research report as is usually the case. It could be a contribution to a Government policy paper, e.g. a paragraph in the report of "Resource Allocation Working Party" that I mentioned earlier.

Finally, we have also done work on hospital size. Again I can see parallels in our experience with the outline that was given by Dr. Dietrich. I agree that the problem is transferable. You can either look at it as a problem of hospital size or you can look at it as one of catchment areas. If there is a natural catchment area, then the problem is where to locate the acute beds for that area--do you put them in one place or two? And that immediately implies a problem of hospital size. The problems can overlap and this seems to be part of the message of the West German presentation. It was certainly our experience: we started on the size problem and we ended up almost at the presentation stage by recognizing that we were not really talking about a hospital size, we were talking about a natural catchment area and how to deliver medical care in that area. This view of the problem is more readily understood by line management since that is more nearly the problem as they see it.

DISCUSSION

In reference to questions from Professor Atsumi, Professor McDonald explained his view of the stability of HCS in developed countries. He suggested that since the margin for change in any one year is small, a sustained pressure over a number of years is needed to elicit a significant change. Professor Shigan said that the UK health service had relatively good statistics and that it was particularly appropriate that Dr. Gibbs, a member of Professor McDonald's group, would soon be joining the IIASA biomedical team. In the discussion on staffing, Professor McDonald said that half of the work program of his group was carried out by outside groups in universities, institutes and consultancy organizations working under contract; one advantage of this arrangement was the professional contacts between the internal and outside staff.

Systems Analysis in Public Health Services in the Soviet Union

Y. Komarov

Let me tell you a little about the application of systems analysis in public health services in the Soviet Union. During the last decade, regular work there has been done to build a health information system all over the country. The work is in three main directions. The first is to establish a network of computer medical centers at national, republic, district, and establishment levels. Medical personnel are being trained in computer processing of information and in systems analysis. Standard designs and norms are being developed as well as standard procedures and methods of collecting and analyzing data. Package programs are being written. The second direction consists of developing several subsystems of the health system for automatic planning and management. The third direction is to develop a dynamic simulation model of public health.

At the national and republic level, we first of all built non-specific or auxiliary subsystems, for example, an information subsystem for recording medical personnel, the subsystem of planning drug provision, etc. Then we built specific subsystems such as the medical statistics subsystem, the epidemiological subsystem, the standard reference information subsystem, the treatment and prophylaxis subsystem, and so on. At the regional level, there are a considerable number of these subsystems. A number of cities have also continued work on integrated systems of emergency hospitalization and intensive care, etc. At the establishment level, a number of information systems are being developed, such as information systems of scientific research institutes, for example, then for a large multiprofile hospital and polyclinic, and so on.

The building of medical information systems in the USSR has already gone beyond the stage of discussing whether they are needed in general. One more important consideration is that the information system is a base for public health modeling. For this purpose, we build the decision model of health care and we plan to work in the area of system modeling at the different levels. For example, by using linear programming at the republic level, we built a model for the location of health institutions. Some of these models are included in the catalog of models in IIASA. We also work on creating different common integrated criteria for public health with some success.

In our country, with the leadership of the Deputy Minister of Health, D. Venedictov, and with IIASA specialists we proposed a methodology of public health modeling at the national level.

DISCUSSION

Professor Shigan explained that in the Soviet Union the development of data processing systems is coordinated by a board which has distributed the work between different republics. For instance Latvia is responsible for the solution of drug problems. Some of the projects are very near to implementation.

Professor Fuchs-Kittowski asked about the interaction between the three aspects of the work in the Soviet Union--data processing, the information system for planning and management, and the health care model--and suggested that the work on the model might help to create a conceptual basis for the other two. Dr. Komarov confirmed that all three aspects were connected and being developed according to an overall plan. Professor Atsumi said that a similarly comprehensive systems approach was being applied in an area in Japan of about one million population with submodels being developed in smaller units within the area.

Professor Shigan stressed the technical problems that had been encountered in Sweden, UK, USA, and other countries on the subject of medical record linkage. Dr. Härö said that WHO was arranging for a technical discussion in October. This would be oriented first to considering the information requirements of the decisionmaker and then to considering the technological implications.

The Need for an Equilibrium Model in Health Care System Planning

J.-M. Rousseau

INTRODUCTION

In this short presentation, I will discuss one type of equilibrium model that could be useful for HCS planning. I will also discuss our current research in this area, the reason why such model should be built, and the shortcomings of more classical approaches to national health care modeling. But first I shall introduce you to our national HCS.

QUEBEC NATIONAL HEALTH CARE SYSTEM

Each province in Canada has its own independent system of health care and each province could be considered as a nation in the IIASA vocabulary. In Quebec, the HCS is divided in two. All physicians are paid by a governmental body called RAMQ (Régie d'assurance maladie du Québec). This body is financed half by the Federal Government and half by a special income tax. Most physicians are paid directly a fixed price for each medical service they render from a negotiated list of more than 2600 medical procedures. In IIASA vocabulary, we could call the system a National Health Insurance System. The hospitalization costs (other than medical services) are paid directly by the Ministry of Social Affairs from general taxation (about half of this cost is also covered by the Federal Government).

Each resident of the province has a health card (like a credit card) that gives him free access to the system. The drugs outside the hospital, ambulance, dental services for children over twelve years of age are not yet covered (except for patients receiving social benefits). Plans are being drafted to include these services in the near future.

A STANDARD ECONOMIC APPROACH (DEMAND-RESOURCES MATCHING)

In project Medics, we developed and tested a standard economic model for HCS planning. This model is illustrated in Figure 1. On one side, we modeled the population dynamics by a demographic model working at a district level. Provisions were made to include eventually socio-economic factors. Modeling then the morbidity of the population by incidence or prevalence rate, we could obtain for each given period a flow of patients per disease category. This flow could be transformed in demanded resources by the calculations of standard care units of each resources for each class of patients. On the other hand, resources could be forecast for the physicians by standard methods (medical school attendance and migration), and other resources could be fixed by policy setting. By considering utilization rate, we could obtain levels of available resources. We then have a problem of allocating available resources to demanded resources and this problem could be solved heuristically [Milsum, et al., 1971], by linear programming [Belanger, et al., 1974] or by goal programming [Bellerose and Rousseau, 1974]. This is not however the weak point of the approach.

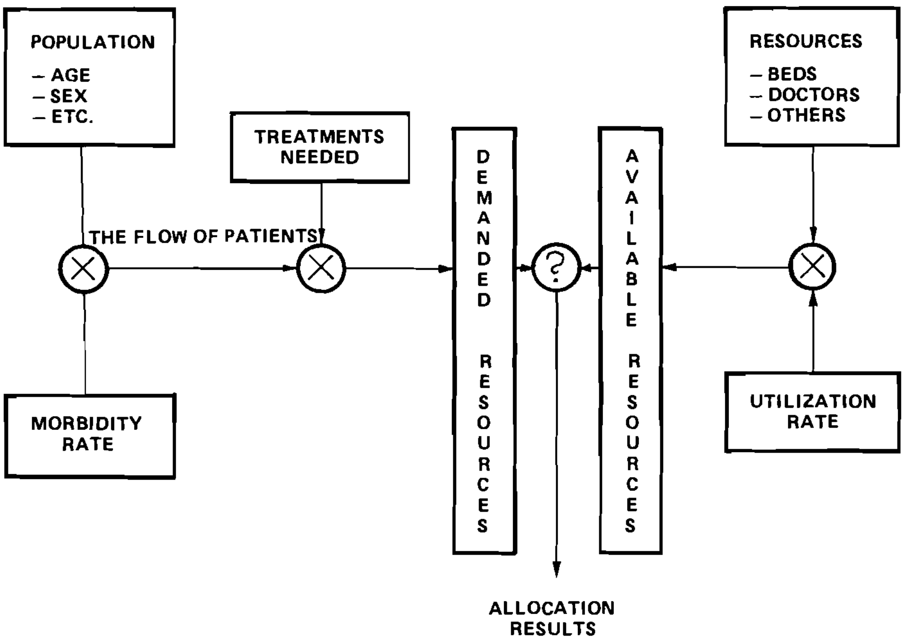
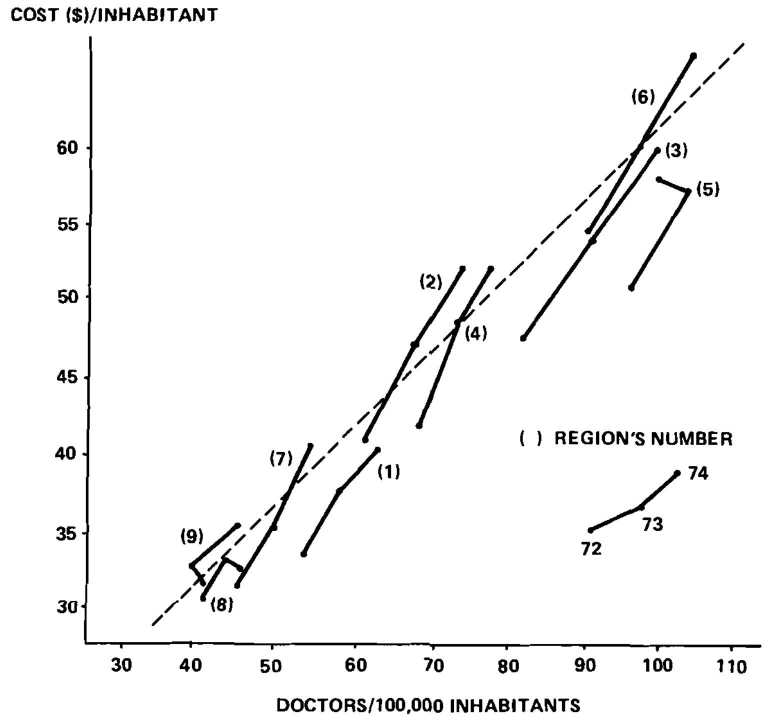


Figure 1. The Medics Model.

THE WEAK POINTS OF THE STANDARD APPROACH

Several weak points could be identified. The main hypothesis underlying this approach is, we think, basically wrong. One must realize that to accept it we need to believe that demanded (or needed) resources could be calculated directly from population characteristics (age, sex, diagnostic, etc.). Several indices tend to reveal that, on the contrary, the demanded resources or consumption of resources are directly related to the available resources and that in practice and in a global perspective demand could never be saturated, or if we can envisage a saturation, it is not at a level a society can afford. We can find the first clue of this in Figure 2 where we have related for our nine districts the average cost of medical services per person to the density of physicians. We can also observe the same fact from another point of view; one can see that the average revenue of physicians does not vary greatly from one district to another even if the density of physicians varies from one to three (Table 1).



Source: RAMQ annual statistics.

Figure 2. Relationship between medical cost per inhabitant and the number of full time doctors per 100,000 inhabitants in the nine districts for the years 1972, 1973 and 1974.

If demand were independent of resources one could expect the physicians to work more in areas where there are less physicians and then as a consequence earn more*. On the contrary, one can now say that physicians are working to a certain capacity (nearly their maximum) wherever they practice and whatever the population and the density of physicians. In fact, a recent study by the RAMQ

*We must remember that physicians are paid directly for each medical service they render.

(1977) reveals that more than 92% of the cost of treatment (including hospitalization) is generated (or controlled) by the physicians themselves. Their control on the system is great; the patients have great confidence in them and are generally happy to receive more services. One can find the same phenomenon in the utilization of hospital beds, a point noted by several authors [Feldstein, 1968; Van der Gaaq, et al., 1975]. Table 1 gives some indication that this is also true in Quebec. In particular, one can note that in the district Côte Nord (9), the number of beds per thousand inhabitants is high. Moreover, because of the relative rarity of specialists and surgeons, a high percentage (24) of the population is hospitalized outside the region thus creating a relatively high level of available beds, which results in a very high level of hospitalization. (Because of long travel distance in this district, hospitalization is a convenient way for doctors to keep patients on hand for closer supervision.)

AN EQUILIBRIUM MODEL

We believe that any person who has studied the data of a health system closely has come to the conclusion that the consumption of health resources is the result of an equilibrium between resources available and the unlimited desire of the population to consume them. Such a model is already used by the British Health Department [McDonald, et al., 1974].

The basic hypothesis of their model is that if available resources increase the result will be both an increase in the number of consumers and an increase in consumption by consumers. This fact was also verified by a study in the Medics project where it was concluded that about 50% of the increase in consumption was due to the increase of services per disease case*. We also tested recently one type of equilibrium model for health services. We have tried with success to simulate the medical practice with a quadratic programming model. We will now briefly describe this model.

A QUADRATIC PROGRAMMING MODEL FOR THE SIMULATION OF THE MEDICAL PRACTICE

The problem is essentially to allocate a certain known quantity (A_i) of medical services by category to different categories of physicians (specialists) each with a given capacity (M_s) of work. Both the evaluation of the quantity of services to allocate and the capacity of work of the physician are done in dollars (the dollar evaluation of a medical service has been set up by the RAMQ related to the time required to perform the service). Also, we have noted from Table 1 that physicians on average receive the same amount of money from the system wherever they practice. Mathematically, the problem is as follows:

*A case in our vocabulary is one person with at least one episode of a given disease during a given year.

Table 1.

Some Data for the Quebec Health System by Administrative District

Region	No. of full-time physicians per 100,000 inhabitants	Mean income of physicians ($)	Relative rate of medical care consumption (1)	% of specialized care (2)	Beds per 1000 inhabitants (3)	Hospitalization rate per 1000 inhabitants	% of hospitalization outside of district	Hospitalization rate with surgery per 1000 inhabitants
1. Bas St. Laurent Gaspésie	79.3	57,020	0.76	37	5.26	178.4	18	80.7
2. Saquenay Lac St. Jean	90.7	62,537	0.92	49	5.75	160.7	6	78.3
3. Québec	150.4	55,311	1.00	51	6.32	148.4	5	75.2
4. Trois-Rivières	93.5	59,053	0.84	48	4.64	149.7	16	78.3
5. Canton de l'Est	167.4	53,578	1.01	50	7.14	179.5	5	91.0
6. Montréal	158.7	54,527	1.07	58	4.91	118.5	2	65.9
7. Outaouais	82.2	58,357	0.86	43	3.91	115.0	37	56.2
8. Nord-Ouest	52.9	58,027	0.67	35	5.71	181.3	25	77.7
9. Côte Nord and 10. Nouveau Québec	55.7	56,088	0.74	30	6.07	236.3	24	82.1

Note 1: Ratio between observed consumption in region and Québec mean consumption.
Note 2: Care given by a speciality other than a general practitioner or general surgery.
Note 3: Beds for acute care.

$$\text{Min } f(X)$$

$$\text{s.t.} \quad \sum_s \delta_{is} X_{is} \geq A_i \qquad \forall\ i \ ,$$

$$\sum_i \delta_{is} X_{is} \leq M_s \qquad \forall\ s \ ,$$

$$\text{where } \delta_{is} = \begin{cases} 1 & \text{if speciality s can perform medical service i,} \\ 0 & \text{otherwise.} \end{cases}$$

We also suppose $\sum_i A_i = \sum_s M_s$.

The δ_{is} are introduced to take into account the fact that a given medical service can be performed by some categories of specialists but not by others; this is determined from the observed data of the medical practice. To have a well defined problem it remains to define the objective function. In project Medics, a linear function was used and the results were very far from reality. There is in fact a great flexibility and a great number of feasible solutions to this problem. Two hypotheses had to be made to define the objective function:

Assumption 1. There exists an ideal scheme of practice that would be attained if enough resources were available.

Assumption 2. The observed practice is as close as possible to the ideal scheme, given the resource constraints.

From these hypotheses we get an objective function of the following form:

$$\text{Min} \sum_{i,s} k_{is}(X_{is} - \bar{X}_{is})^2 \ ,$$

where $\bar{X}_{is}$ is a constant corresponding to the ideal scheme of practice for procedure i and speciality s in a given district.

We do not want to give the same weight k_{is} to all allocations X_{is}; in fact, one can observe from the data that some medical services are always performed in about the same proportion by the same specialists while there is much more variation for other medical services. We thus calculated from the data of our nine districts medical practice means m_{is} (a mean fraction of service i performed by resource s) and standard deviations δ_{is}. We then used as objective function:

$$\text{Min} \sum_{i,s} \left(\frac{X_{is} - \bar{X}_{is}}{\sigma_{is}} \right)^2 ,$$

where $\bar{X}_{is}$ and $\bar{\sigma}_{is}$ are obtained from m_{is}, σ_{is}, and the volume of medical services A_i in a particular application of the model ($\bar{X}_{is} = m_{is}A_i$, $\bar{\sigma}_{is} = \sigma_{is}A_i$).

In fact, this separable objective function will look like that in Figure 3a when σ_{is} is small and in Figure 3b when σ_{is} is large, leaving the allocation more flexibility to get away from the ideal scheme when such flexibility of allocation has been observed. This problem could be solved very easily with our available convex flow algorithm [Tilquin, 1974]. The results are in fact pretty good. In Figure 4 we have plotted the point (X,Y) where X is the allocation generated by the model and Y the allocation observed in a given region. In Figure 5, for the same region we have plotted in the same way the application of the mean scheme of practice ($\bar{X}_{is}$) in the region against the allocation observed. We observed that our model performed better than the single application of the mean practice in a given region.

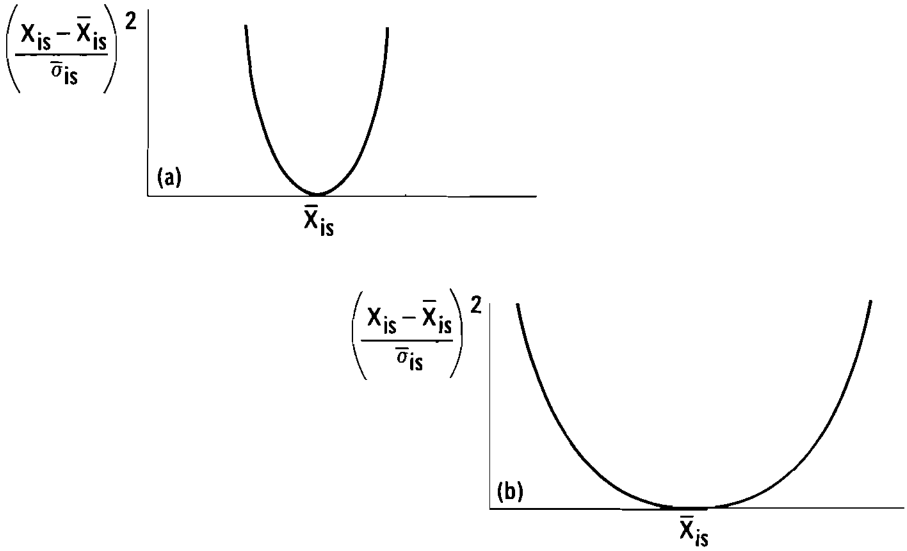


Figure 3. The cost function if σ_{is} is (a) small or (b) large.

Our model may not perform ideally but it is the best available for this problem. This model is influenced by two forces. First in the objective function we tend to allocate the services as the ideal (or mean) practice would suggest. Second, the availability of resources tend to make the allocation more like the one observed. In Table 2, we see that this latter influence is predominant; in all districts the model gives results that are nearer to reality than to the mean practiced ($\bar{X}_{is}$). In Table 2 also we see that the model is consistently a better predictor of reality in comparison with the mean practice. These results were obtained by Nobert in his thesis (1976) and related works.

EXTENSION OF THE MODEL

Of course the data needed for this kind of model are not available in every country. The approach however could be used in a more general context. For example, one could formulate the same model with categories of health resources on one side and categories of health consumers on the other. Of course, the

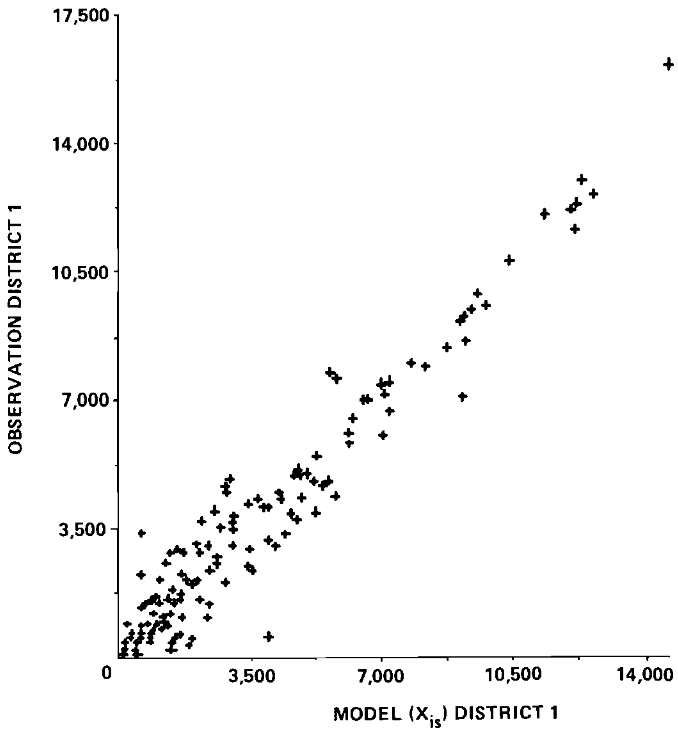


Figure 4. Model vs. Observation in District 1.

level of resources available and demanded must be measured in the same units, but several models could be constructed for different kinds of health resources (hospital beds, medical resources, etc.). This approach is obviously less detailed than the British model [McDonald, et al., 1974]. There is, for example, no indication of the number of patients treated and no choice between alternative treatments. To achieve this, if needed, one could solve a series of small linear programs with the given allocation of resources per category.

The other difference is that, in this type of model, no guarantee is made for the complementarity of resources. The model does not guarantee that if both resources a and b are needed together in a given proportion to achieve the treatment of a patient that these resources will be allocated in the exact proportion to the patient. Experimentation with this model could reveal if this is a real shortcoming at the general level of planning. However, we will soon study the implications on the solution method used of integrating these additional constraints into the model.

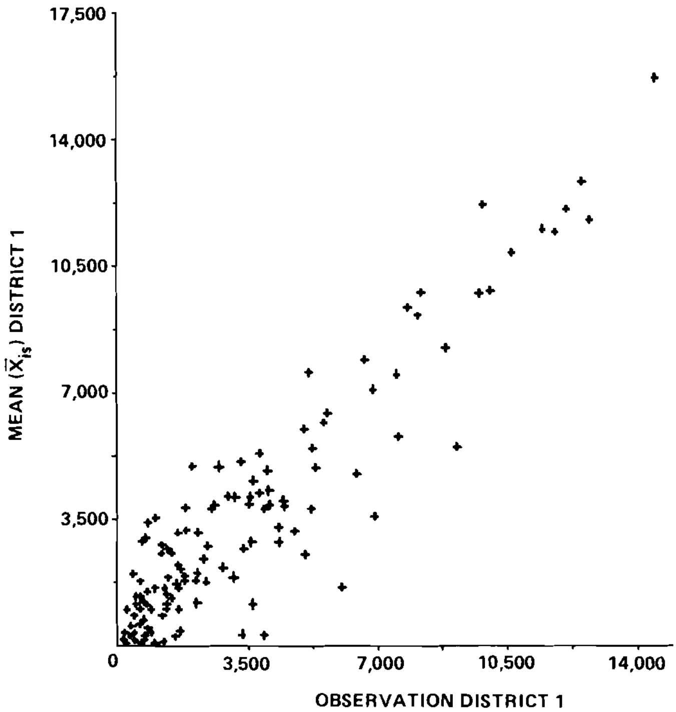


Figure 5. Mean vs. Observation in District 1.

Table 2.

The results of the model allocation compared with the observed allocation and the mean practice

District	Mean value of X_{is}	Mean and (standard deviation) of		Euclidean distances between		
		$\lvert X_{is}$ - observed$\rvert$	$\lvert \bar{X}_{is}$ - observed$\rvert$	X_{is} and observed	X_{is} and $\bar{X}_{is}$	$\bar{X}_{is}$ and observed
1. Bas St. Laurent Gaspésie	174	29.84 (51.95)	52.65 (97.14)	790	1333	1457
2. Saquenay Lac St. Jean	191	31.71 (58.98)	38.99 (49.85)	883	950	835
3. Québec	747	94.9 (140.45)	179.35 (370.19)	2236	5193	5426
4. Trois-Rivières	316	37.16 (52.21)	64.54 (132.94)	845	1846	1949
5. Canton de l'Est	201	25.21 (28.92)	50.23 (76.71)	506	1198	1204
6. Montréal	2515	412.65 (754.19)	717.76 (1452.12)	11340	24445	21366
7. Outaouais	138	18.5 (34.74)	30.72 (53.3)	519	834	811
8. Nord-Ouest	84	14.14 (20.32)	30.86 (67.68)	326	995	981
9. Côte Nord and 10. Nouveau Québec	66	9.65 (14.22)	24.89 (49.34)	227	695	728

We are also planning to test if with this kind of approach we could simulate not only the medical practice but also the level of consumption of medical procedures in a given district. This kind of model could be very helpful for planning the effects of adding medical resources to a given district and helping plan a better regional distribution of specialists. This model is generally described in Figure 6 and could mathematically be expressed as:

$$\text{Min} \sum_{s,i} \left(\frac{X_{si} - \bar{X}_{si}}{\sigma_{si}} \right)^2 + k \sum_i \left(\frac{Y_i - \bar{Y}_i}{\bar{u}_i} \right)^2 ,$$

$$\text{s.t.} \qquad \sum_i X_{si} = M_s \qquad \forall \ s ,$$

$$\sum_s X_{si} = Y_i \qquad \forall \ i ,$$

$$X_{si}, Y_i \geq 0 .$$

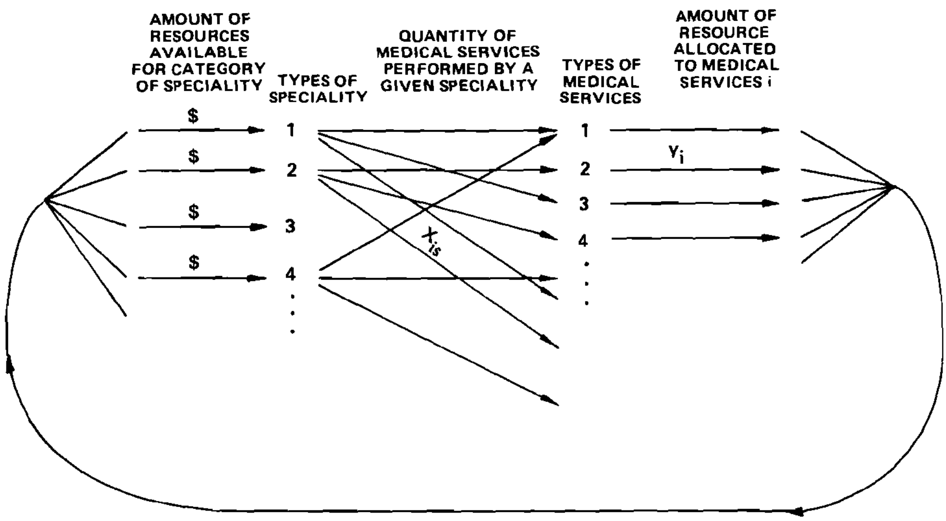


Figure 6. An equilibrium model for the medical services and the medical practice.

CONCLUSION

We think there is a whole area of research to explore in HCS modeling, that of equilibrium or entropy modeling. We are in a field where the control variables for the planning agency are very limited and the models developed must be of the type "user optimization" rather than "system optimization" in the sense that the models should predict how the different people (physician, patient ...) in the system would react given certain constraints rather than try to model how they should react for the well-being of the whole system. I think that this field of research is very promising for HCS modeling.

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DISCUSSION

Dr. Komarov asked whether the results of the models had been discussed with decisionmakers. Dr. Rousseau said that decisionmakers had been closely involved in the Medics project. Although the first model is not of great use to them the second one probably will be, if it works successfully, because it demonstrates some of the consequences of different initial allocations of doctors, which would assist decisionmakers plan the regional allocations.

Professor Wasserman described a somewhat similar exercise in the USA--the profession activities study (PAS). This involves defining standards for comparing hospital performance, e.g. in terms of the length of stay for appendectomy. Dr. Rousseau mentioned some of the problems he had encountered with this type of exercise. For example a hospital that was below a standard on length of stay might in reality be as "bad" as a hospital above the standard since it might be below the standard because of the lack of appropriate equipment. Another problem arises with a patient who is transferred from one hospital to another--this could appear as, say, a two day stay in a small hospital for coronary patient and it would be impossible to link this statistic with the subsequent three month stay in a specialist hospital.

Dr. Kuznetsov asked whether the variables used in the model were normally distributed; Dr. Rousseau replied that this aspect had not yet been studied.

Community Screening Systems for Providing Data for a Health Care Model

K. Fuchs-Kittowski, H. Friedmann, and P. Gutermuth

GENERAL COMMENTS ON GDR COOPERATION

The modeling of a health service system, as envisaged in the IIASA research plan "Modeling Health Care Systems", is of great international interest. The project should be supported by as many countries as possible, as assessing the state of health of the population and the allocation of resources to health is a problem equally important for all countries, irrespective of the nature of their health system.

The results obtained by Venedictov, Klementiev, Atsumi, Kaihara, Fujimasa, Fleissner, Kiselev, and others have been of great scientific interest and should be generally used. In particular, the latest publication by Atsumi, Kaihara, and others, on Japanese experience, represents decisive progress. So far, the budget allocated to health care modeling does not correspond to its international importance. At the conference in November, activities must be clearly charted for the next few years to prove the need for at least doubling the budget, and increasing the number of personnel involved in modeling work. Larger international groups, from Austria, the UK, the US, Japan, and Bulgaria, should be involved; the GDR can make a contribution, too.

In principle, it should be possible to define the basic structures and functions of health service systems, and to establish a model that at least provides a universal image by referring specifically to the biological and universal processes, such as morbidity, birth, death and recovery from diseases. Every health system is strongly influenced by existing social conditions and national peculiarities. However, since the basic human need for health is universal, there are far-reaching common aspects. Thus "modeling health care systems" does not tackle any narrowly limited task, but a genuinely universal problem.

This implies a great variety of methods of systems analysis and multiple correlations with other research projects of IIASA. The establishment of such a model of planning health care makes it possible at the national level to categorize a number of ongoing activities sensibly, e.g. in the development of screening systems and medical information systems, and to reach a higher effectiveness. Testing and adaptation of models will result in a broad methodological discussion in the field of applied systems analysis, and a deepened substantive discussion in the various related disciplines.

For this reason, outstanding scientists and above all scientists who hold key positions, especially at WHO, should be invited to the conference to be held in November. At the conference the contributions that will be made by the National Member Organizations (NMOs) should be discussed and so key scientists from the NMOs should participate.

In the event of participation by the GDR the following considerations are presented:

- Establishment and analysis of territorially organized subsystems of medical diagnostics for supporting the decisionmaking process by the state: analysis of territorially organized systems of laboratory diagnostics for registering and evaluating expenditures and services; description, evaluation, and development of screening systems (preventive examinations) as subsystems for the health care of the population.

- Establishment of medical information systems (data banks) for later utilization as input information for the model intended to improve the health care: a study of the use of data banks in medicine; preparation of criteria for the deployment of data banks in medicine; preparation of an organizational and technical program for the development of institution- and morbidity-related data banks by using available data registers; comparative analysis of computer-assisted medical information systems.

- Preparation of long-term plans for the development of medical science and public health by comparative analyses of different systems of health care and medical science.

Figure 1 shows the gradual transition between health and disease. The quality change takes place through overlapping stages. Screenings serve to identify abnormalities at early stages of a diesease, and should make it possible to introduce preventive or therapeutic measures before actual manifestation of the disease. In this way, irreversible damage or early sickness might be prevented.

Figure 2 shows the close association between screening procedures and the development of a general model for planning medical care. The analysis of the interrelation between screening and medical and "dispensary" treatment helps one to decide upon the distribution of resources between these two areas.

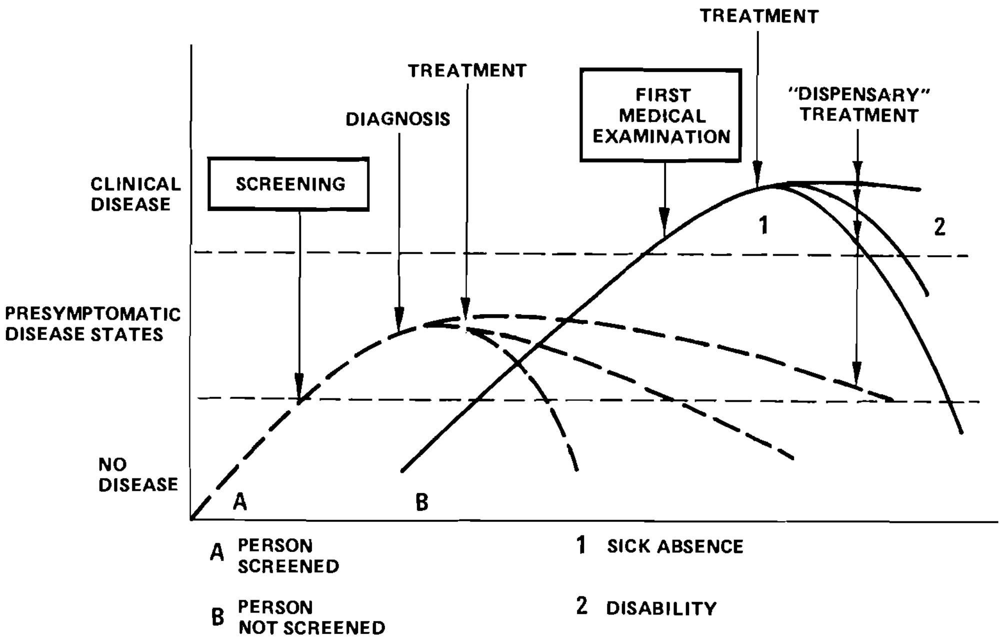

Figure 1. The transition between health and disease.

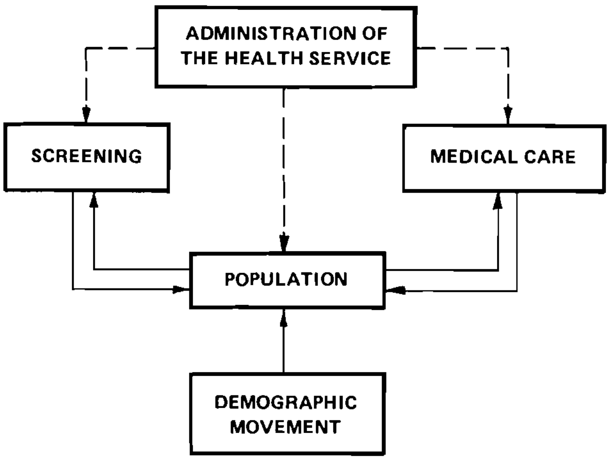

Figure 2. The association between screening and modeling medical care.

In Figure 3, screening is shown to be only one aspect of the total complex "prevention." Symptom-carriers (unaware sick persons, who consider themselves healthy, although they actually have some illness) will be detected by screening with the aid of defined parameters or combinations of parameters. These carriers would then be diagnosed, treated, and possibly followed by "dispensary" treatment. The effectiveness of multiphasic screening has not yet been established.

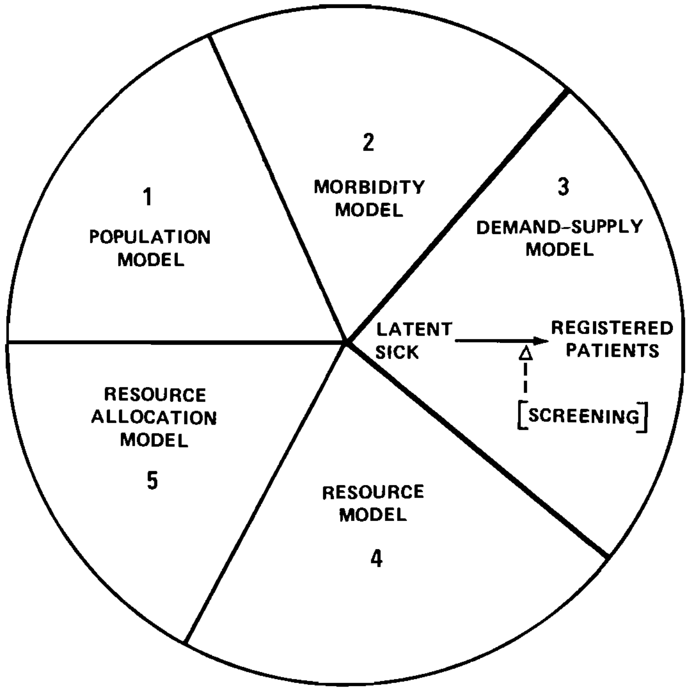

Figure 3. Universal health care model.

The following questions need to be answered.

- What is the relation between the known morbidity rate of an individual disease to the prevalence rate of the early stages of the disease in the population?

- Does the relation that exists between the early stage of a disease and its morbidity rate justify the introduction of screening?

- How far can the general health status of the population be improved by screening?

- What prerequisites must be met in order to make differential diagnosis based on the findings from mass health examinations (facilities and personnel for making diagnoses and treatment, availability of hospital beds, etc.)?
- What is the relation of cost to benefit of mass examinations?
- Which criteria are appropriate to define the health status of the population? Which combinations of characteristics and parameters are needed to reduce misclassification?

Figure 4 shows that the specific problems of early recognition of disease are in general agreement with the "universal health care model." Our work has a special relation to submodel 3 (the demand/supply model) which is interrelated with submodel 2 (morbidity model) and submodel 4 (resource model).

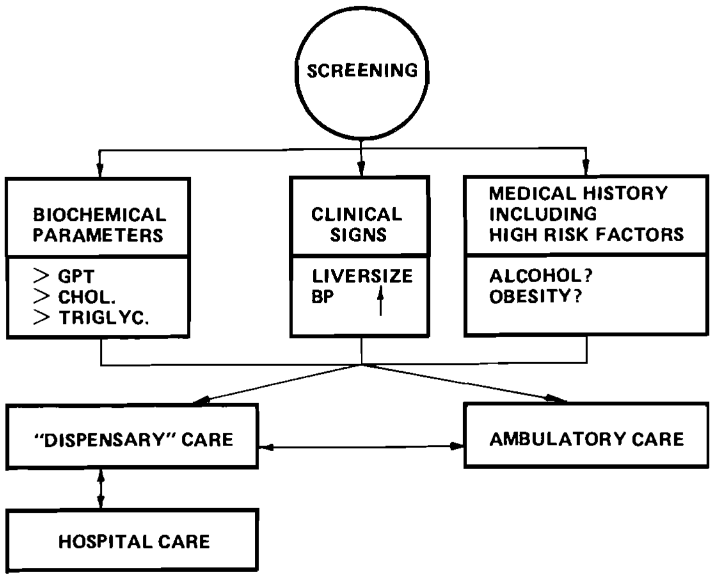

Figure 4. The early recognition of disease.

The general plan of the Ministry of Health of the GDR includes screening as an integral part of community health care. Much experience has been accumulated in the organization of mass screening programs, e.g. chest x-rays, the search for unrecognized early stages of diabetes mellitus, the testing of all newborns for certain inborn errors of metabolism (PKU, galactosemia), etc. In fact, our data on screening for diabetes mellitus and of newborns could be used for testing the "universal health care model" in the GDR. Data are also available from a multiphasic screening study in which more than 30 biochemical and clinical examinations were made in 1970 and repeated in 1973 and 1976 on a representative sample of the population. In these examinations, prevalence rates were determined for degenerative illnesses such as CHD, anemia, liver disease, etc. We would like to test the submodels of the "universal health care model" with our data after adapting them to our requirements.

THE DATA BASE OF THE HEALTH CARE MODEL

Testing and adaptation of a model of health care in the GDR requires the establishment of an adequate informational basis. It is necessary to qualify the models step by step. The provision of relevant health data required for the testing, adaptation, and application of models will meet with great difficulties. The problem of determining the morbidity structure cannot be solved either in the short term for material, technical, and personnel reasons. In addition to this, data on the incidence of the various diseases are required in case a more detailed modeling of the health service is later required--including the distribution of the stages of the disease. Data registers have so far been available in the GDR in several uncoordinated fields, both with regard to content and structure. This does not satisfy the requirements of automated information processing or mathematical modeling. It is essential to us that the preparations for decisionmaking be based on suitable mathematical models and there are certain preconditions: the use of models must not result in additional unnecessary medical examinations or data collections. So their use in the GDR will be possible only in close connection with the actual medical care--within the framework of territorially arranged health services and computer-assisted information systems already established (see Figure 5).

The extension of medical service and screening systems as part of the overall health care system and the further development of automated medical information processing systems have the primary aim of increasing the quality of medical care, rationalizing the activities of doctors, and improving the management and planning of public health. However, in the course of establishing a data base and developing territorial medical data banks, it will be possible to use models. In fact, the experience gained with routine electronic data-processing projects in the GDR health service favors establishment of a close link between the use of models and the medical service system and related medical data banks. The main reasons are:

- Minimizing the expense (doctors, medium-echelon medical personnel, data processing operatives, etc.) of data collection and of storing and processing is possible only within an integrated framework.

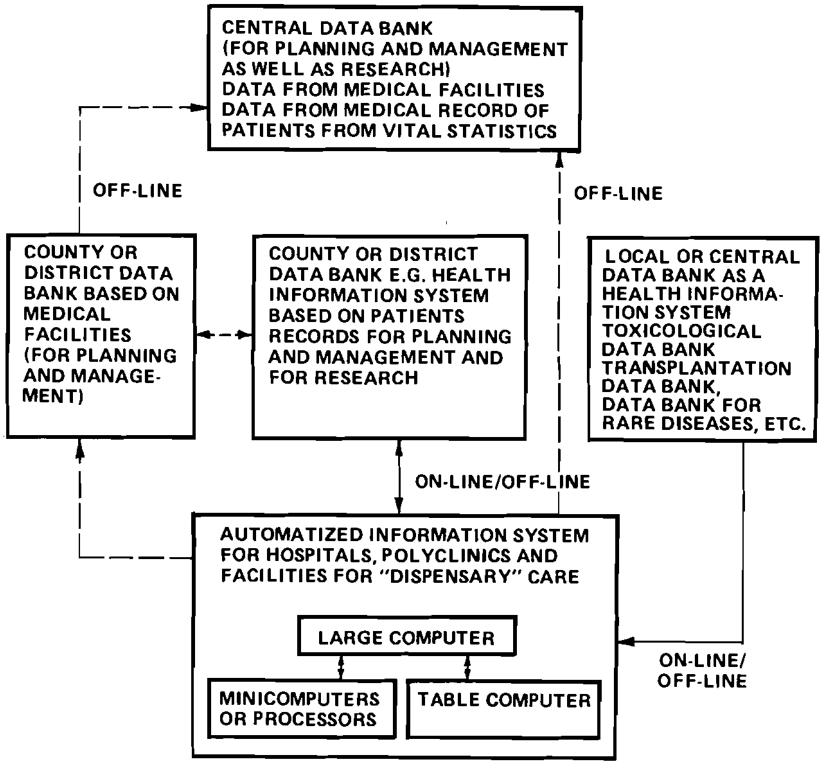

Figure 5. Health service organization in the GDR.

- The quality of model computations is essentially dependent on input data quality, and data that are simultaneously used in actual medical services and thereby checked are therefore better. Special inquiries without semantic checking result in a high error quota.

- The readiness to participate in the inquiries and data collections required by both the population and medical personnel comes from recognizing an immediate benefit.

- For humanitarian and economic reasons, the citizens cannot be imposed upon with unnecessary physical and temporal burdens. Obviously, citizens who had been diagnosed to have a disease within a screening program have to receive effective and immediate treatment in one of the health service systems;

- For a number of parameters, e.g. morbidity structure of the population, the relevant data can only be obtained from long established computer-adequate data archives;

- It is advisable to check the model with the use of data and their logical relations stored in banks;

- Already existing medical data banks make it possible to ensure a more objective selection of test persons for substantive implementation of models.

The approach in the GDR will be to utilize and expand existing medical service systems and their related automated information processing systems and thus to take advantage of the practice-oriented, effective, and low-priced results from the use of the model. By proceeding step by step with overlaps between individual phases or with analyses made simultaneously, and by using existing DP-projects and medical data banks, the aim will be the establishment of an institution-oriented and territorially and centrally organized system of medical data banks. Only by the building-up of coupled and hierarchically structured data banks can the enormous quantities of data obtained in medical care be used effectively for the medical service or for the managment and planning of public health.

We hope that other NMOs will declare their readiness to test the various models and adapt them to their conditions. A broad methodological and substantive discussion could then be expected and experience obtained given to the working group at IIASA. We would be happy to prepare papers for the forthcoming conference on medical information systems, territorial screening systems, and a data base for testing and adaptation of a health care model. Our task will be:

- To specify the research plan--its aims and deadlines;

- To specify the financial and personnel requirements in IIASA and the NMOs involved;

- To state the individual tasks of the NMOs in a more precise manner.

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DISCUSSION

Professor Shigan said that the GDR paid special attention to improving routine statistics. Such good routine statistics were needed both in the GDR and elsewhere to provide a satisfactory basis for modeling and, in particular, to allow for a systems approach to screening. A number of participants spoke about the desirability of applying systems analysis to screening and the important role that the IIASA team could play. Dr. Härö said that such an approach was all the more needed because although many evaluation studies on screening had been carried out they had usually failed to define the system boundaries clearly, to say what had been included or excluded, and to clarify whether the study had dealt with a complete population or sick patients only.

In response to a question by Professor Fuchs-Kittowski, Dr. Rousseau described the data collection process used in Canada by the insurance corporation. Items of service are collated and stored on computer files, one per doctor. The patient's name is recorded so that the procedures carried out on individual patients can be checked. In the Medics project this data is being reprocessed so as to be stored on patient-based files. This system is being developed in Quebec; a similar one, though lacking diagnostic information, is being developed in Ontario. There is no such integrated system in Ottawa, although two separate hospital systems exist.

SUGGESTIONS FOR FUTURE MODELING WORK AT NATIONAL CENTERS

Dynamic Linear Programming Models in Health Care Systems

A. Propoi

The development of mathematical models for health services is of growing interest for systems analysis and operation research specialists. There are a large variety of methods and approaches now used in SA/OR, but of all these techniques, optimization methods and especially linear programming (LP) seem to be the most widely recognized and exploited [1]. The interesting analysis of methods used in applied optimization [2] shows that linear programming algorithms clearly predominate in literature and seem to serve a broad spectrum of needs (thus, among papers examined in [2], more than 60% use LP or related techniques).

The reason for this is that linear programming allows us to take into account in some optimal way a large number of variables and constraints on them.

In optimizing health service activities, it is reported that LP applications aid scheduling of hospital admissions, nurse staff assignment, menu planning, desirable mix of patients to be treated by hospitals, location of hospitals, total hospital production model, etc. [3,4].

The basic range of these applications is of a one-stage, static nature; that is, in this case the problem of the best allocation of limited resources is considered at some fixed stage in the development of a system.

However, when the system to be optimized is developed and this development is to be planned, a one-stage solution is inadequate in relation to reality. In this case, the decision should be made several steps in advance and the problem of optimization becomes a dynamic, multistage one. For example, the decision to increase the enrollment of students to some speciality will cause an increase in the number of these specialists only after some definite period of time; the building of some large hospital in a region can be implemented only after a period of time and the increase in the quality of health care in this region can be noticeable only after another period of time.

Thus, the majority of optimization problems become nowadays multistage, dynamic problems. Dynamic linear programming (DLP) may be considered as a new stage of LP development and is aimed at the elaboration of methods for optimal planning in different large-scale systems [5,6].

In some cases, the direct application of deterministic optimization techniques of single health care activities may seem to be embarrassing because of the stochastic nature of some of these activities, associated with the illness or recovery processes. However, the consideration of health care systems on a large-scale basis allows us to operate with mean values and thus bypasses these difficulties.

The purpose of this paper is to discuss the possibilities of the DLP approach to planning problems in different health service systems. The typical problems here are connected with planning manpower, prevention and control of diseases, or the long-range allocation of resources for total care.

Manpower planning is one of the most important problems in health care systems; manpower problems predominate in the health care industry and present, perhaps, the greatest challenges [7].

The absolute or relative increases in the quantity of health manpower will not determine the quality of the health care system and sophisticated planning of different categories of health care specialists is needed.

There are a large variety of manpower planning problems on different levels. For illustration we shall consider here a model of a system for the improvement of professional skill. These systems play an important role in health manpower systems for the reason that for each health care specialist it is necessary to take into account the permanent progress in the development of health care means.

Let all health manpower be broken down into n different groups (grades) and let

$x(t) = \{x_i(t)\}$	be the number of health care specialists of group i at step (year) t,
$u^k(t) = \{u_i^k(t)\}$	be the number of health care specialists of group $i(i = 1,\ldots,n)$ who enter at step t the courses for improving qualification of type $k(k = 1,\ldots,r)$,
$A(t) = \{a_{ij}(t)\}$	be the transition matrix for specialists who do not enter any courses at step t, and
$B^k(t) = \{b_{ij}^k(t)\}$	be the transition matrix for specialists who enter courses at step t; τ_k is the training time for courses of type $k(k = 1,\ldots,r)$.

Then the state equations describing the dynamics of the distribution of health care specialists over different groups will be:

$$x(t+1) = A(t)[x(t) - \sum_k u^k(t)] + \sum_k B^k(t-\tau)u^k(t-\tau^k) \quad ,$$

$$x(0) = x^0 \quad . \tag{1}$$

Here $x(t)$ is the <u>state</u> variable and $u^k(t)$ is the <u>control</u> variable.

We have physical constraints

$$x(t) \geq 0 \quad , \qquad u^k(t) \geq 0 \quad , \qquad x(t) - \sum_k u^k(t) \geq 0 \tag{2}$$

and resource constraints

$$\sum_k D^k(t)u^k(t) \leq f(t) \quad , \tag{3}$$

where $f(t)$ is the vector of given resources (teachers, buildings, equipment, etc.).

The typical problem here is to minimize the total deviation of a real manpower plan $\{x(t)\}$ from the desired distribution $\{\bar{x}(t)\}$:

$$I = \sum_{t=0}^{T-1} \alpha_i(t)|x_i(t) - \bar{x}_i(t)| \quad , \tag{4}$$

subject to (1)-(3).

This model can be incorporated into the whole health manpower planning system or can be treated separately.

Another important group of DLP models is connected with planning problems for the *prevention or control of different diseases or total health care.*

The problem of HCS planning may be reduced to finding a plan of allocation funds, manpower, and other capacities over time among different disease treatment activities in such a way that the optimal output in terms of reduced mortality, morbidity and other losses [8,9,10,11] is obtained. As an example we shall consider a simple model of planning different activities in a program of the treatment of some disease (e.g. heart disease, cancer, tuberculosis, etc.).

Let the population of a region (country) be broken down into n groups both by age and by the state of the disease, and let $z_i(t)$ be the number of people for group i at step (year) t.

It is supposed that r ways of treatment of the disease are at the disposal of HCS. The number of people in group i, who recieve treatment of type k at year t will be denoted by $u_i(t)$. The transition matrix for those people who did not receive any treatment at year t is denoted A(t) and the transition matrix for those who receive treatment k at year t is denoted by $B^k(t)$ (this matrix defines the efficacy of the treatment of type $k(k = 1,\dots,r)$ in respect to different population groups).

The equations that describe the change in the state of the system over time will be

$$z(t+1) = A(t)[z(t) - \sum_k u^k(t)] + \sum_k B^k(t)u^k(t) \quad . \tag{5}$$

State equation (5), which describes the process of improving the state of population health, has just the same form as the state equation (1), which describes the process of improving the professional skill of manpower.

The constraints are also similar:

$$z(t) \geq 0 \quad , \qquad u^k(t) \geq 0, \qquad z(t) - \sum_k u^k(t) \geq 0 \quad ,$$

$$\sum_k D^k(t)u^k(t) \leq f(t) \quad .$$

Thus, a unified solution method can be developed for this and other DLP problems.

The models described can have different modifications and variants and they may serve as a basis for the development of more sophisticated models in the planning of resource allocation in HCS either for treatment of separate diseases or for the HCS at whole.

Realistic models certainly require cooperative efforts of both the health care specialists and systems analysts, and the DLP approach might be an effective tool for the elaboration and implementation of optimal policies in HCS.

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DISCUSSION

Professor Shigan reminded participants that Dr. Propoi comes from a group working in collaboration with Dr. Kantorovich, the Nobel Prize winner, and with Dr. Dantzig from the USA. The IIASA team would be seriously considering the use of LP techniques because they had been successfully applied in several countries.

Dr. Rousseau said that he had experienced some success with LP techniques in his Medics project but that one of the problems he encountered derived from the well-known property of an LP solution, namely that it is an extreme case at an apex of the feasible space. Dr. Propoi recognized this problem and said that it would normally be necessary to run an LP several times, for a range of parameter values.

The International Integrated Health Care System (IIHCS) Model--A Preliminary Report

K. Atsumi

INTRODUCTION

Throughout the world--in developed as well as in developing countries--demands and requirements for health care have been increasing from year to year and are continuing to increase. On the other hand, health care resources are limited even in developed countries and in the future they will be strictly limited in all countries. It is difficult now, and it will be more difficult in the future, to resolve the imbalance between demand and supply in each country. Also, the gap in health care quality between developed and developing countries will increase to a critical level.

Regional or global health allocation will be needed in the near future. System oriented and interdisciplinary research and development will be needed because the problems confronting us are sophisticated and multidimensional.

GOAL AND OBJECTIVES OF THE IIHCS

The goal of the IIHCS is to supply decisionmakers at national and international levels with information on the allocation of health care resources in the (multinational) regions and in the world, and to propose appropriate strategies for their measures.

The objectives of the IIHCS are:

- To estimate and forecast the quantitative range of the minimum and maximum demands and requirements in health care in each country, in each region, and in the world.

- To estimate and forecast the range of the minimum and maximum capacities of resources and their supplies in each country, in each region, and in the world.

- To analyze socio-economic indicators of health demands and supplies and their relationship.

- To analyze the essential components and their functions in the HCS.

- To construct a regional model of health care.
- To analyze the available and practical measures for the allocation of health resources.
- To propose management strategies for health resource allocation in the regions and in the world.

PRINCIPLES FOR RESEARCH AND DEVELOPMENT OF THE IIHCS MODEL

- For everyone, at every time and every place, to reach equality in accepting their appropriate health care services.
- To divide the world into several regions similar with respect to social and political structures and health situations (Western Europe, Eastern Europe, Africa, North America, South America, Oceania, East Asia, etc.).
- To recognize the regional characteristics of health care in each region and to appreciate their independence as much as possible.
- To allocate limited health resources effectively and efficiently at the regional level.
- To develop more details of models and submodels after step-by-step modification.
- To modify the structure of the models according to actual data and their operation.
- The concept of health means human welfare--physical, mental and social--in the world.

Health care includes not only comprehensive medical care--preventive care, curative care, rehabilitation, and health maintenance--but also environmental problems--water, food, air, energy, housing, transportation, etc. However, in this research, the modeling of comprehensive medical care will be mainly discussed, of which relevant factors are information, manpower, material, instruments, facilities, and socio-economics.

FRAMEWORK

The IIHCS modeling is integrated and comprehensive and comprises several submodels, namely, population, morbidity, demand-supply, resource, and resource allocation. These are interconnected with the other relevant models, namely, environmental, food, water supply, ecology, urban and rural, value, and policy analysis models. Therefore, in the development of the IIHCS, not only international cooperation but also cooperation with the other tasks in IIASA are necessary.

HEALTH RESOURCES IN SUBMODULES OF THE IIHCS

Comprehensive HCS are divided into several submodules--environmental care, communicable disease care, preventive care, rural health care, sanitary education, emergency care, curative medical care, health maintenance, comprehensive care, etc. For operation, these submodules need health resources--manpower, facilities, instruments, materials, etc. And these resources may depend on population size and their socio-economic factors and may be calculated as a package unit. Therefore, with the population and socio-economic indicators in the regions as input, the health resources required in each submodule may be calculated.

ESTIMATION OF DEMAND AND SUPPLY IN REGIONAL HEALTH CARE

The first step of the R & D in the IIHCS modeling is to estimate the demand and supply in each region in two ways. One is to collect the data on the demand and supply in each country and to sum them for the region. This takes time and manpower. The other approach is the systems-oriented approach of classifying the region with the appropriate socio-economic indicators and estimating present and future demand and supply for a whole region. If the latter approach is possible, the comparison of different regional data would be performed easily, saving time and manpower.

The submodules of the IIHCS are related to the socio-economic indicators. The hierarchical and quantitative relationship of submodules in comprehensive health care modeling in the region may be calculated from the socio-economic indicators and the demand and supply of health care in the region estimated.

The most important problem in this research is to decide upon the socio-economic indicators and to clarify the relationship between the indicators and health care. The following three indicators--GNP, GNW (gross national welfare), and GNS (gross national statisfaction)--are considered as the socio-economic indicators.

GNP

GNW

- Health care indicators (medical care cost/GNP, health manpower, facilities, morbidities, etc.)

- Sanitary indicators (water supply, drainage, pollution measures, etc.)

- Education indicators (number of universities, university/student ratio, literacy ratio, etc.)
- Environmental indicators (green park ratio, highway ratio, etc.)
- Welfare indicators (housing, social security, employment, etc.)

GNS

- Suicide rate, divorce rate, strike rate, recreation time rate, etc.

DISCUSSION

The question of the user of a global integrated model was discussed. Professor Atsumi considered that WHO would probably be a user and, by studying the HCS of different countries with a universal methodology, would be in a position to advise these countries on what mix of facilities they should provide.

Objectives of the Research Group on Health Services (GERSS--Paris)

M. Goldberg

For our research group, health systems are a branch of human ecology concerned mainly with the study of the health of human populations in relation to their social, cultural, economic, and physical environment considered as determinants of health. As stated in WHO's definition, health cannot be reduced to the mere absence of disease. Therefore in our approach, health is considered not only in its negative aspects, but also in its positive ones.

The word "system" has a significantly different meaning depending on the discipline that uses it. For us, it means a global approach to the problem of the various disciplines concerned with the health of populations: epidemiology, psychology, sociology, economics, mathematics, informatics, and statistics. As the central aspect of our work is the health of populations, we can say that our approach is mostly epidemiological as opposed to economic for instance. Therefore, our research is not focused on the health care delivery systems, but, rather encompasses the entire set of determinants of health. A determinant of health may be defined in a systems analysis context as a generalization of the epidemiologists' concept of risk factors. It covers all elements correlated with health in a negative or positive way without excluding those for which no strict causal relationships can be ascertained or those that cannot be physically defined, such as socio-economic conditions, life habits, iatrogenesis, climatic conditions, and so forth.

In order to organize its activities within these general objectives, our group has chosen a few major research areas for the next two years:

- Comparative analysis of the health systems of various countries. We already have established relationships with Algeria, Austria, and the Canadian province of Quebec, and we are seeking to develop new contacts with other public health research departments especially within the WHO European region.

- Measurement of the health of populations. A great amount of conceptual, methodological, and practical work needs to be carried out in this field, since there is no general agreement concerning the various concepts of health or the best way of measuring it. We are currently investigating various dimensions of illness--health-mortality, morbidity, disability, and handicap--as well as of positive health, including the use of more or less global population health indexes.

- Study of the relationships between a series of health determinants--with an emphasis on socio-economic ones--and the health of a population.

- Investigation of relationships between the health determinants themselves. Systems analysis will be used to set up networks of relationships among the health determinants.

These last two items are undertaken with special emphasis placed on nonmedical prevention.

- Investigation of relationships between socio-economic parameters and health determinants.

- Critical analysis of the epidemiological literature. The hypothesis is that the choice of the phenomena to be investigated by the epidemiologists is biased and linked to certain socio-economic factors. The result is that many important phenomena are not studied enough. We decided to focus this aspect of our work on the analysis of the "unsaid" in the epidemiologic literature.

- Construction of a global epidemiological dynamic model of the health system of our country. We consider this model a necessary tool for validating and synthesizing the results of our work in the other areas and as a predictive tool. Concerning the latter point, we plan to use it mainly for simulation of the global impact of preventive programs and actions on the health of the population.

In order to avoid working in only a methodologically oriented structure, we decided to study two major health problems, namely tuberculosis and alcoholism within the general framework of the tasks listed above.

METHODS OF WORK

GERS was set up in September 1976 after two years of regular meetings and preparation. The group is part of the Research Unit on Methodology in Medical Informatics and Statistics and of the Department of Medical Informatics in the Pitié-Salpêtrière Medical School, both headed by Professor R. Gremy.

Material priorities with respect to the objectives are defined by the group's members. So are the sciences and methods used; domains of knowledge are quite numerous: epidemiology, economics, statistics, informatics, mathematics, sociology, psychology, and biology being the most important within the framework of our objectives. Therefore, it is of utmost importance to ensure a multidisciplinary structure of the group. The GERSS is now composed of eight individuals working part-time:

Name	Background
Cannone, François	Medical Doctorate
Chaperon, Jacques	Medical Doctorate, Epidemiologist
Fuhrer, Rebecca	Psychologist, Medical Informatics PhD
Goldberg, Marcel	Medical Doctorate, Computer Science Doctorate
Goldberg, Paquerette	Mathematics Doctorate
Le Beux, Pierre	Engineer, Medical Informatics PhD
Leclerc, Annette	Statistics Doctorate
Seidner, Chantal	Documentalist

In addition we plan to have as soon as possible researchers with a background in economics and social sciences. Close contacts have been taken with other research units working in the different fields connected to our projects and in some cases collaboration has been initiated on specific topics. Owing to its recent creation, the GERSS does not have as yet institutional autonomy. Plans are being made to set up in the near future an autonomous institution, possibly in association with other groups.

DISCUSSION

Answering a question from Dr. Härö, Dr. Goldberg explained that he intended that his analysis of the relationship between mortality and socio-economic factors would be of the longitudinal type, based on time-series data at the district level in France.

Professor McDonald asked Dr. Goldberg whether he intended to construct measures of health based on available surrogate indices such as mortality, morbidity, disability, and handicap--which seemed to be a pragmatic approach--or whether he was proposing to develop a new concept and measure of health. Dr. Goldberg said that he intended to follow the former approach; he planned to redefine concepts such as disability and handicap in a more pragmatic way so as to be able to use existing data available in a number of countries. Professor McDonald stressed the importance of constructing measures that were specific to certain stated criteria in specific groups of people. He gave examples from the work of his group--a social independence vector that is being used in planning the care of the elderly disabled, and a vector containing elements pertaining to care, cure, and roof that is being applied to the provision of services for the mentally ill--and contrasted this with the far more difficult task of constructing a global measure. Dr. Goldberg agreed; he said that his group were trying to define sets of indicators for specific groups of people.

Professor Atsumi asked about the standardization of data. Dr. Goldberg replied that this would be considered after the definition of indices for specific groups. Dr. Komarov asked about the selection of criteria for defining indices and stressed the problem of interpreting health care objectives. Dr. Goldberg said that he intended to devise some way of selecting from the available data in many countries and to see whether some items matched with others so that the data gaps in some countries such as France could be filled. He would then try to translate them in terms such as disability in such a way as to reveal the impact of health services on morbidity and mortality. Professor Shigan remarked that this approach was consistent with work being carried out elsewhere and with the historical process of continual refinement of measures. One hundred years ago, only mortality indices were used, today morbidity measures are increasingly being used and in future it is to be expected that other additional measures will be required, particularly those relating to socio-economic factors.

SUGGESTIONS FOR FUTURE MODELING WORK TO BE DONE BY THE IIASA BIOMEDICAL TEAM

The IIASA Scientific Area "Human Settlements and Services" and the Biomedical Team*

F. Willekens

One of the four research areas at IIASA is Human Settlements and Services, led by Professor Andrei Rogers. The principal research questions posed in this Area concern people: how many are there; where do they live; what are their demands for resources, goods and services? What is the impact of these people on resources and on the environment?

The study of people or population has been organized in three overlapping categories, defined in terms of the time-perspective of the decisionmaker (Figure 1).

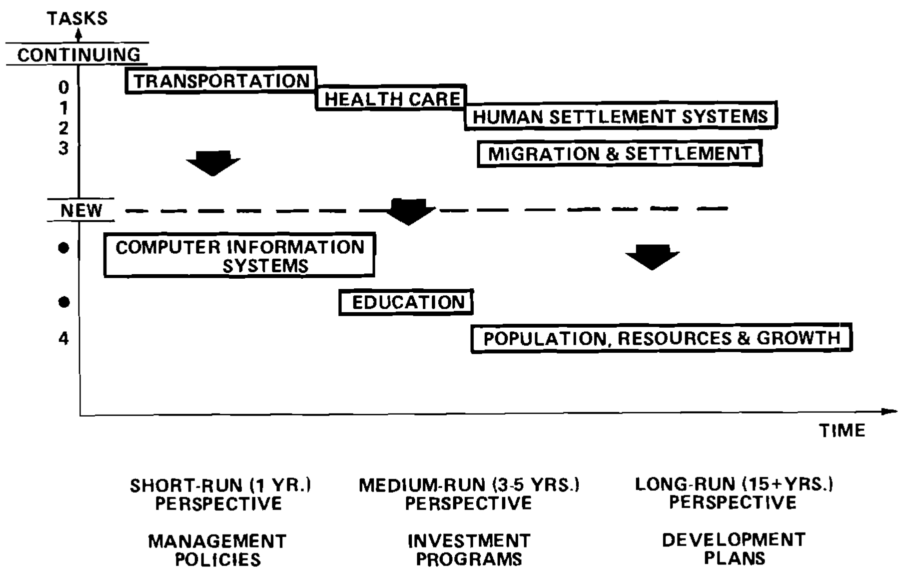


Figure 1. Research activities.

*This overview is based on HSS-Area descriptions by A. Rogers.

- Short-run perspective. In the short run, the structure of the system cannot be changed. The only thing that can be done through policies is marginal improvements in terms of better management to make the system more efficient. An illustration of this management-related research is automatic traffic control to improve the efficiency of urban transportation systems. Another illustration is the use of computers in local government. This topic will be dealt with in 1978.

- Medium-run perspective. In the medium run, the basic structure of the system cannot be changed. However, investments can be made in certain parts of the system. Programs are the principle vehicles of implementation. In health care, for example, the expansion of hospitals is a problem of investment. Similarly, educational planning is largely within a medium time horizon.

- Long-run perspective. In the long run, structural change can take place. Structural change is defined here as change in the pattern of human settlement systems, or, in other words, a change in the distribution of people among cities and hinterlands and among regions. The study of the features of these long-run changes, of their causes and consequences involves the consideration of the development process and of development plans.

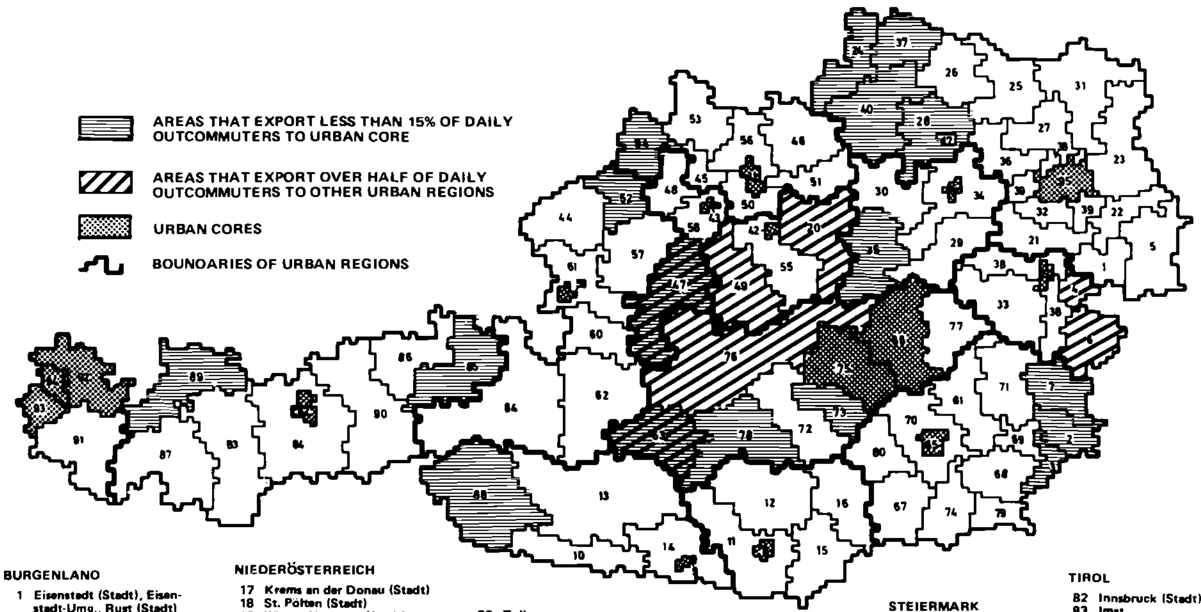
The research in the Human Settlements and Services Area is organized into four tasks: Health Care Systems; Human Settlements; Migration and Settlement; and Population, Resources, and Growth. Tasks are the basic research units at IIASA. Where the areas are permanent, and may be compared with university departments, the tasks have a very well defined time horizon of approximately two to three years, and deal with very well defined research topics and have about three to five scientists. The first task is the *Health Care Systems Task*. Its purpose is to develop a computerized mathematical model that will enable the policymakers to evaluate the consequences of alternative courses of action with regard to investments in particular HCS and to compare alternative national HCS. It is the people working in this task who are responsible for the preparation and organization of this workshop. Dr. Shigan and his collaborators will provide you with a detailed description of the research strategy and findings of the health care task.

The second task is the *Human Settlements Task*. It studies the spatial structure of human settlements and its dynamics. In this task, "human settlements" is defined as a system of cities. The objective of this task is to understand the spatial and temporal development processes of systems of cities better. A major question addressed is: how can we define geographical sources of innovation and economic growth, and what are the features of the diffusion of innovation and economic growth? The research strategy is first to determine functional units in human settlement systems. Functional units consist of a source of growth or innovation (a larger city, say) and its hinterland. The delineation of functional regions follows a paradigm proposed by Brian Berry in a study on the US, by Norman Glickman on Japan, and by Peter Hall on the UK. Currently, this task is working on the mapping of functional regions in IIASA's member nations, the work being carried out in collaboration with the Department of Geography at the University of Reading, UK. Figure 2 presents an illustration of such a delineation of functional regions.

The third task is the *Migration and Settlements Task*. It studies the growth and the distribution of people in a multiregional system: its pattern, causes, and consequences. The focus is on methodology: the formulation of descriptive models of spatial population growth, of explanatory models of its major component (migration), and finally, of policy models of population distribution policies. The task is organized into four subtasks (Figure 3):

- The study of spatial population *dynamics*;
- The definition and elaboration of a research area called *demometrics* and its application to migration analysis and spatial population forecasting;
- The analysis and design of migration and settlement *policy*;
- A *comparative study* of national migration and settlement patterns and policies.

The first subtask, dynamics, studies the spatial population growth in purely demographic terms. It investigates how the forces of fertility, mortality, and migration shape future populations. Age is the single most important determinant of the relative importance of the growth components. This together with the observation that age curves of fertility, mortality, and migration are remarkably similar for different countries and different time periods, led us to select age-specific rates as the basic parameters of the models developed in this subtask. Topics studies include the long-run spatial impact of current fertility, mortality, and migration behavior; the short- and long-run spatial impact of changes in this behavior--in particular, the impact of alternative drops of fertility to replacement level. In addition, we have addressed the problem of aggregation and decomposition in demographic modeling.



BURGENLAND
1 Eisenstadt (Stadt), Eisenstadt-Umg., Rust (Stadt)
2 Güssing
3 Jennersdorf
4 Mattersburg
5 Neusiedl am See
6 Oberpullendorf
7 Oberwart

KÄRNTEN
8 Klagenfurt (Stadt)
9 Villach (Stadt)
10 Hermagor
11 Klagenfurt (Land)
12 St. Veit an der Glan
13 Spittal an der Drau
14 Villach (Land)
15 Völkermarkt
16 Wolfsberg

NIEDERÖSTERREICH
17 Krems an der Donau (Stadt)
18 St. Pölten (Stadt)
19 Wiener Neustadt (Stadt)
20 Amstetten und Waidhofen an der Ybbs (Stadt)
21 Baden
22 Bruck an der Leitha
23 Gänserndorf
24 Gmünd
25 Hollabrunn
26 Horn
27 Korneuburg
28 Krems an der Donau (Land)
29 Lilienfeld
30 Melk
31 Mistelbach an der Zaya
32 Mödling
33 Neunkirchen
34 St. Pölten (Land)
35 Scheibbs
36 Tulln
37 Waidhofen an der Thaya
38 Wiener Neustadt (Land)
39 Wien-Umgebung
40 Zwettl

OBERÖSTERREICH
41 Linz (Stadt)
42 Steyr (Stadt)
43 Wels (Stadt)
44 Braunau am Inn
45 Eferding
46 Freistadt
47 Gmunden
48 Grieskirchen
49 Kirchdorf an der Krems
50 Linz (Land)
51 Perg
52 Ried im Innkreis
53 Rohrbach
54 Schärding
55 Steyr (Land)
56 Urfahr-Umgebung
57 Vöcklabruck
58 Wels (Land)

SALZBURG
59 Salzburg (Stadt)
60 Hallein
61 Salzburg-Umgebung
62 St. Johann im Pongau
63 Tamsweg
64 Zell am See

STEIERMARK
65 Graz (Stadt)
66 Bruck an der Mur
67 Deutschlandsberg
68 Feldbach
69 Fürstenfeld
70 Graz-Umgebung
71 Hartberg
72 Judenburg
73 Knittelfeld
74 Leibnitz
75 Leoben
76 Liezen
77 Mürzzuschlag
78 Murau
79 Radkersburg
80 Voitsberg
81 Weiz

TIROL
82 Innsbruck (Stadt)
83 Imst
84 Innsbruck (Land)
85 Kitzbühel
86 Kufstein
87 Landeck
88 Lienz
89 Reutte
90 Schwaz

VORARLBERG
91 Bludenz
92 Bregenz
93 Feldkirch
94 Dornbirn

WIEN
95 Wien

Figure 2. Functional urban regions in Austria.

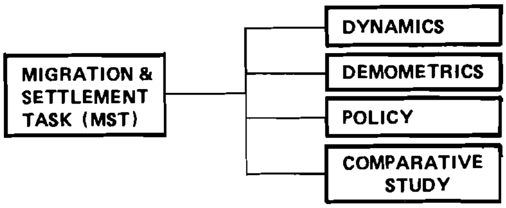


Figure 3. Migration and settlement study.

The second subtask, demometrics, deals with the econometric modeling of migration: identification and estimation of migration functions. The synthesis and extension of migration theory also belongs to this subtask. We are convinced that good econometric modeling requires a good underlying theory. Hence, model and theory-building are intimately related.

The third subtask of this migration and settlement task is related to policies. First, it studied the individual and social consequences of migration. For it is the deviation between individual welfare and social welfare that is the rationale for government intervention. Second, it looks at the methodology, or mathematical modeling of policies. The paradigm used is that of Tinbergen developed for the study of quantitative economic policies. Extensions of this paradigm to dynamic policies have been investigated. They draw heavily on mathematical systems theory and the theory of optimal control.

The fourth subtask is a comparative study. It was set up to promote collaboration between IIASA and national institutions. In each of the 17 member nations of IIASA we have now scientists working with us on the comparative study of internal migration patterns and migration policies. As part of this comparative study, a data bank is being set up, and standard computer programs have been written to analyze the data. The computer programs perform the following tasks:

- Computation of multiregional life tables.
- Projection of multiregional population systems (multiregional cohort-survival model).
- Analysis of characteristics of stable populations (i.e. long-run impacts of current demographic behavior).
- Estimation of age-specific population data when available data are inadequate or incomplete.
- Simulation of multiregional population growth under alternative scenarios.

The fourth and newest task in the Human Settlements and Services Area is called Population, Resources, and Growth. This task started at the beginning of this year and resulted from the following observations:

- Unprecedentedly high rates of population growth in the world;
- Massive rural to urban migration, particularly in developing countries;
- The inability of fertility policy to reduce the excessive urbanization and hence the associated problems of urban unemployment and housing and the provision of public goods and services; in short, the problem of underdevelopment.

The purpose of this research activity is to examine the principal interrelationships between population, resources, and development. It is in the study of these interrelationships that IIASA's structure is most fully utilized, since the cooperation between the several Research Areas of IIASA is a prerequisite for the success of this study.

DISCUSSION

Professor Wasserman asked whether time series analysis had been employed to study the time lags between changes in GNP and birth rate and whether the effects of employment on fertility had been looked at. Dr. Willekens said that the former effects had been studied and that the general result was that following a rise in GNP there is first a drop in death rate and then, later on a drop in birth rate. The effects of unemployment on fertility tended to be of too short a time scale to be relevant to these studies; on the other hand the effect on migration was relevant.

The Development of the National Health Care System Model at IIASA

E.N. Shigan

In working on our HCS model, we have been considering it as a complex of several consecutive submodels. For the construction of these submodels, short lists of parameters have been used. For example, for the "population" submodel, two parameters--age and sex--were used; prevalence was the only parameter used for the "health" submodel.

Thus, as a first step we plan to extend the list of parameters for each submodel. For example, in the "population" submodel, we will include such data as "urban/rural population", "density", etc. These parameters are very important, especially from the point of view of resource supply.

The "prevalence" submodel was created on the basis of cancer and cardiovascular disease data. Therefore our second step will be to test this submodel with different disease data. For this purpose, statistical material from the research investigations in different countries (Bulgaria, Finland, Japan, the USSR, etc.) will be used.

The resource problem holds a very important position in the IIASA model. First of all, there are different principles for estimating resource demand (physicians, paramedical personnel, beds, etc.). They all have positive and negative aspects, common and specific parts. Therefore, in the course of our elaboration of this submodel, many different approaches must be summarized.

The "resources" submodel is the third task of our common work. This submodel is very closely connected with the external systems. For this reason, during the elaboration of the "resources" submodel we must take into consideration some points concerning the different situations existing in developed and developing countries. We must also remember that the problem of resource supply depends not only on the "developed-developing" situation, but also on the different public health principles--"state", "socialistic", "insurance", "private", "mixed" (Figure 1). Therefore fourthly we plan to generalize the different approaches or, if this proves impossible, to elaborate computerized models for each of them. This will require us to study the impact of socio-economic factors on the HCS and Dr. Fleissner will outline later in this report suggestions on the research that we might perform in this area.

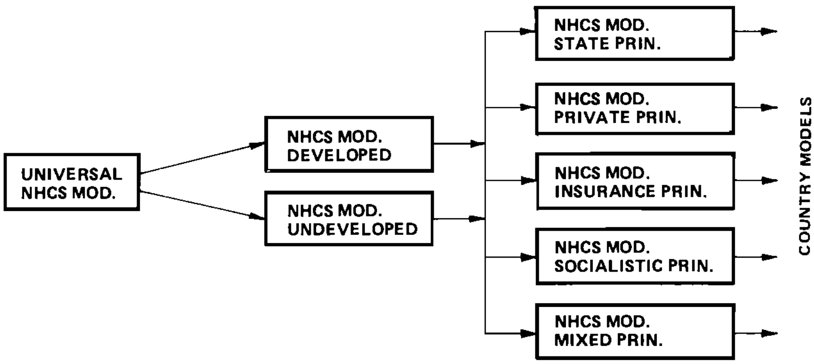


Figure 1. Development of the NHCS Model.

Since official national data are insufficient for the modeling process, special attention will be paid to different district experiments in some countries. Such experiments are currently being conducted in Gabrovo (Bulgaria), Devon (United Kingdom), Ontario and Quebec (Canada). Thus, as our fifth step, we plan to work together with national teams to generalize the results of such experiments and to select commonly acceptable parts (Figure 2).

Taking into account the great importance of the infectious disease model, we have already begun to gather data on the different experience in this field. However, it is clear that IIASA's small biomedical group will be able to carry out this large-scale investigation only by working in very close contact with national teams, WHO, and other international organizations.

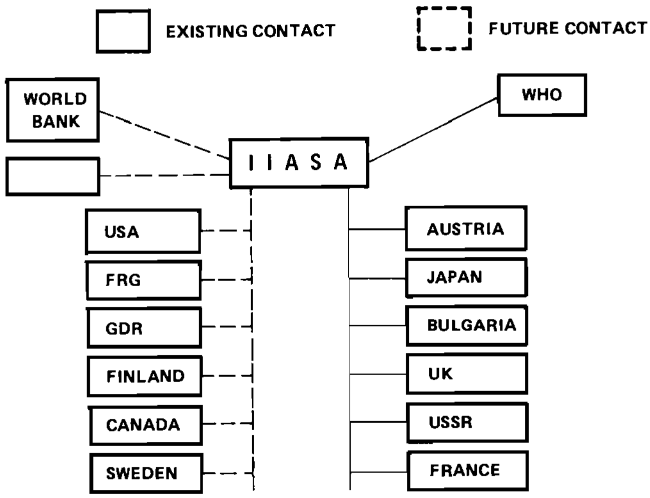


Figure 2. Development of IIASA biomedical group contacts with other national and international organizations.

Collaboration Between IIASA and National Centers--a Discussion

Professor McDonald asked whether the IIASA team would be interested in receiving details of national or district plans from some of the national centers and analyzing and comparing them. Professor Shigan said that he would be very interested in this and that he was already taking steps to compare plans for Gabrovo, Devon, Quebec, and certain parts of the Soviet Union. Dr. Dietrich said that such plans do not exist, in a comprehensive form, in the FRG and in some other countries.

The discussion then turned to the possible roles of the IIASA team in preparing collaborative publications with national centers and in acting as a central clearing house for the exchange of information between national centers. Dr. Fleissner reminded participants that IIASA had made a start on this task with the review analysis (of national HCS models (see later). Professor Shigan said that IIASA could take on a limited role in the exchange of information but that it could not afford to devote a large proportion of the small amount of the project's resources to it. Dr. Härö pointed out that WHO had once attempted to take on an open-ended commitment in the exchange of information but had been forced to abandon the task because the list of participating centers had become too long. Professor Atsumi, for Japan, Dr. Dietrich, for FRG, and Dr. Goldberg, for the Technical Committee for Medical Application of IFIP (TC4), described other agencies who were actively exchanging information.

Professor Shigan then described some aspects of the current research plan for the IIASA biomedical project. Because the budget permitted only a small core group at IIASA it was essential for this group to work in close collaboration with national centers. This collaboration would take a number of different forms. Firstly, members of national teams would come to join the IIASA team for short periods of up to 3 months. IIASA would try to invite people with special expertise in certain relevant fields, such as resource allocation, socio-economic influences, regional planning, etc. Secondly, some people would be invited under WHO fellowships, e.g. some members of the Gabrovo project team. Thirdly national teams were being invited to adjust their own research programs in ways which would assist the IIASA program.

Coordination of Scientific Studies Undertaken by IIASA and USSR National Teams

Y. Liachenkov

We are currently discussing the subject of collaboration in the field of national health care system modeling. The first goal of the future conference to be sponsored by WHO and IIASA is to bring together different groups of scientists working on NHCS modeling. The coordination and collaboration of our work is very important for the following reasons:

- Systems analysis is currently being developed in several countries.
- In order to achieve good results in every country, it is necessary to change the information methodology for coordinating our efforts.
- The solution of the global problem will be impossible without the participation of all countries.

I would like to suggest a long-term program (3-5 years) as a framework for HCS modeling at IIASA from the USSR, and express my opinion concerning the possibilities for carrying out this long-term program. There are many classical methods for the coordination of any problem. In this situation, it is interesting to use the matrix structure of IIASA to demonstrate the interactions between the main trends of HCS at IIASA and the national scientific works of the USSR (see Figure 1).

Horizontally, we may arrange the main trends of HCS at IIASA:

- Model of the planning process.
- Model of the present health situation of the population.
- Model of population demands on different medical services.
- Model of the planning process for the development of medical science.
- Planning and distributing resources.
- Model of the relations of HCS rates (morbidity, prevalence, etc.) with the environment.

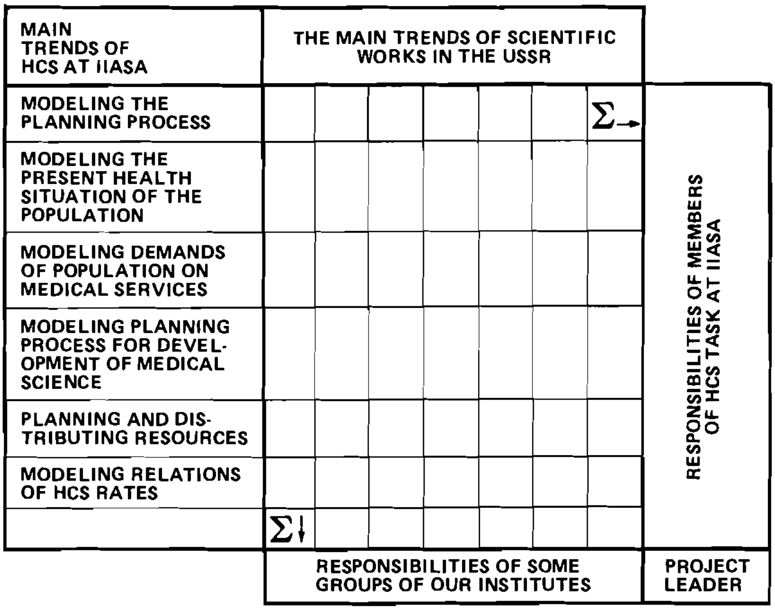


Figure 1. Matrix interactions between the main trends of HCS at IIASA and the national scientific work of the USSR.

Vertically, we may arrange the main trends of USSR modeling of HCS. In such a way, it is possible to determine the responsibility at the national level. In the USSR, the responsibility for modeling the health care system is conducted by the Scientific Council of Systems Analysis in Biology and Medicine under the supervision of Professor Venedictov. At the international level, the responsibility of modeling the main trends of the health care system at IIASA may be conducted, of course, by the biomedical leader together with his team (see Figure 2).

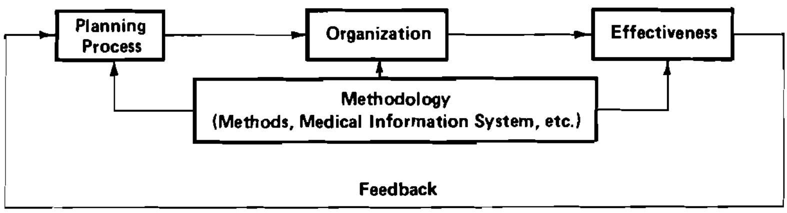


Figure 2. Block scheme of the scientific planning process.

With the help of this matrix, it is possible to plan a long-term program for the biomedical group for five years from the USSR. After that, it will be necessary to organize all our efforts and activities and, then assess the effectiveness of our collaboration. Feedback from this effectiveness influences the planning process and all three (planning process, organization, and effectiveness) depend on the various methodologies, medical information systems, etc.

I would like to propose similar matrix interrelations between the main trends of HCS at IIASA and the national scientific works of various countries (see Figure 3). Horizontally, as in the first case, we may arrange the main trends of HCS at IIASA. Vertically, we may arrange the national scientific works of various countries. The object is an improvement in the methodology of international cooperation of HCS modeling at IIASA. The tasks are the determination of national efforts in the project and the carrying out of the framework of HCS at IIASA to evaluate the development of this project for 1977-1981.

MAIN TRENDS OF HCS AT IIASA / COUNTRIES	JAPAN	FRG	USSR	FINLAND	ENGLAND	OTHERS	
MODELING THE PLANNING PROCESSES							$\sum \rightarrow$ RESPONSIBILITIES AT THE INTERNATIONAL LEVEL (IIASA)
MODELING THE PRESENT HEALTH SITUATION OF THE POPULATION							
MODELING DEMANDS OF POPULATION ON MEDICAL SERVICES							
MODEL PLANNING PROCESS FOR DEVEL-OPMENT OF MEDICAL SCIENCE							
PLANNING AND DIS-TRIBUTING RESOURCES							
MODELING RELATIONS OF HCS RATES							
	$\sum \downarrow$ RESPONSIBILITIES AT THE NATIONAL LEVEL						PROJECT LEADER

Figure 3. Matrix interactions between the main trends of HCS at IIASA and the national scientific works of some countries.

Future Research Programs--a Discussion

(E.N. Shigan)

INTRODUCTION

The task "Modeling the health care system" is a very broad, continuous project that can be developed in several directions.

- We are currently working on the model at the national level. Therefore, it is possible to proceed to medical establishment, district, regional, and global modeling.
- The model we are building at IIASA is a general health care model that covers all kinds of HCS. Sector health care modeling (modeling of tuberculosis, cardiovascular diseases, services, etc.) is a possible research program for the future.
- In the development of the HCS model, a short list of the most important parameters was included. Thus, one possible direction for developing the model could be describing each block of the model in greater detail.
- The development depends on the type of information, the list of parameters required, and the medical information system for each hierarchical level of the system.
- Another possibility for future research would be to work together with other Areas and Programs on subjects of common interest (e.g. alcoholism, problems of the aged, etc.).

OTHER SUGGESTIONS FOR FUTURE RESEARCH PROGRAMS

Before giving your opinions, please consider the following basic principles:

- We should work on problems of international interest. Problems specific to one country can be studied by the national center.

- Although the core of systems analysis methodology is the mathematical model, not all medical problems can be solved by means of mathematics.

- The interdisciplinary approach should play an important role in future research programs.

- The research program must be oriented to defined users.

- In future research programs that can be fulfilled together with other Areas and Programs, the medical aspect must play a leading role.

DISCUSSION

The discussion centered on whether the IIASA project should be directed at individual health care sectors, e.g. the treatment of cancer or of cardiovascular disease, or the more general problems relating to the health care system as a whole. Professor Shigan stated a preference for the latter. There was general agreement on this point although some speakers stressed the importance of including within the general scheme certain specific topics: prevention, screening, environmental effects, information systems, and the care of the elderly.

Suggestions for Future Work on the Influence of Socio-Economic Factors on Health Care

P. Fleissner

In this brief exposé a long-term research program on the influence of socio-economic factors on the health care system is suggested.

Up to now IIASA's health care models did not take into account the socio-economic situation of a country. The models dealth with sex, age, and diagnosis only, not reflecting different health status, health care usage and health care policies for different social strata. IIASA should proceed more deeply along the socio-economic lines of investigation to find out the quantitative influence of the social and economic background of certain groups of population. By comparing the socio-economic factors pertaining to population groups with the health care supply offered to them one can begin to evaluate the scope and possible results of reforms within the HCS. There is some evidence, especially for the incidence of chronic illnesses, mortality, and life-expectancy, that these indicators are much more determined by socio-economic factors than by health care institutions.

Table 1 suggests four stages through which a research program in this field could proceed.

Table 1.

1. Socio-economic factors: Definitions and methodological framework.

2. Influence on Health Status and Mortality
   - Mortality (infant, by age, by cause)
   - Morbidity--hospital statistics, sick leave, screening

3. Influence on the Usage of Medical Care
   - Usage rate (MD, dentist, hospital, screening)
   - Costs

4. Influence on the Availability of Resources

   (Mark Field's categories: article on US/USSR comparisons)

DISCUSSION

Three participants described studies that have produced data potentially useful for the type of analysis that Dr. Fleissner had described. Dr. Härö described the WHO/ICS-MCU study, Dr. Rousseau described his own Medics system, and Dr. Goldberg described some studies in France. Each speaker suggested how Dr. Fleissner might be able to gain access to the data.

Dr. Härö warned of the dangers of starting a system study with a large data collection exercise, as had been the case with the WHO/ICS-MCU study. It was always better to start with a model and to consider conceptually what the key elements of the system might be and then to concentrate the data collection activity on these elements. Professor Shigan concurred and said that this was the approach being adopted at IIASA.

The discussion then turned to the differences in the HCS of different countries and whether different models would be appropriate in, say, private insurance based systems and centrally planned systems. Professor Shigan said that the IIASA approach was, at the first stage at least, to search for the universal features in different systems. Dr. Rousseau speculated that the underlying differences between private and socialized systems might not be as great as they appeared on the surface and that more important differences might arise between situations of saturated and non-saturated health service consumption.

Draft Agenda

"Modeling Health Care Systems" Conference

sponsored by

IIASA, WHO, and National Centers

November 1977

GOALS

1. To bring together different groups and scientists working in the field of national health care system modeling.
2. To familiarize these scientists with other studies being conducted in national health care system modeling.
3. To demonstrate the state-of-the-art in national health care system modeling in IIASA, WHO, and different countries.
4. To discuss questions of management.

1. Introduction
   - Definition
   - History
   - Systems analysis in national health care

2. Decisionmaking Process at the National Level
   - Identification of the problems
   - National statistics ("routine")
   - Meaning of research information
   - Medical information systems

- Models and their meanings
- Training of decisionmakers

3. <u>Modeling of National Health Care Systems</u>

   - Forecasting population dynamics
   - Modeling of health
     (mortality, morbidity, invalidity, integration of health components)
   - Resource allocation

4. <u>Interrelation of the National Health Care System Model with Others</u>

   - Socio-economic system
     (topology of the health care systems; developed and developing countries)
   - Environmental system
   - Science
   - Interrelation of the general and sector health care system models
   - Interrelation of the global, regional, and district health care systems

5. <u>Questions of Management</u>

Draft Agenda for the November 1977 Conference on Modeling Health Care Systems--Discussion

The draft agenda was discussed. Dr. Härö stressed the importance of defining more fully the meaning of some of the items on the agenda. Professor Shigan suggested that the WHO glossary provided appropriate definitions.

Dr. Rousseau asked about item 2, "The Decisionmaking Process at the National Level". Professor Shigan explained that he intended that speakers from different countries should describe how this process operates in their own coutnries and should attempt to structure their talks around the headings in the draft agenda and the schema proposed in this paper (see Figure 3).

It was agreed that participants would consider the draft agenda further after returning to their national centers and send Professor Shigan their suggestions at a later date.

Closing Remarks

E.N. Shigan

During these four sessions we have heard some papers from our small biomedical team here and some very interesting papers from different countries. Before deciding about the list of participants to invite, we studied the literature and consulted many people. Half of the participants are here at IIASA for the first time and I think it is very good that *you have made contact with us; we shall maintain this contact.* During the discussion of specific and general problems you have found that there is much in common in different countries. And we stress attention to common problems. *Everybody understands that each country has enough problems of its own.* We decided also to work on national health care system modeling, including all component levels--district, medical establishment, etc. It was very important for our biomedical project that we made arrangements about working on the aggregated model of NHCS.

In conclusion let me say thank you for your participation, thank you for having taken time to visit IIASA, and I hope to see all of you at the November conference.

APPENDIX

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RELATED IIASA PUBLICATIONS

Health System Modeling and the Information System for the Coordination of Research in Oncology. D.D. Venedictov, editor. (cp77-004) $20.80/AS375.

Proceedings of the Joint IIASA/WHO Workshop on Screening for Cervical Cancer. J.H. Bigelow, coordinator. (cp75-005) $4.50/AS80.

Proceedings of IIASA Planning Conference on Medical Systems, August 6-8, 1973. Bio-Medical-Project. (cp73-005) $2.00/AS40. (Formerly PC-73-5; MICROFICHE ONLY)

Systems Analysis for the Evaluation of Bio-Medical Research. M. Thompson. (rr75-007) $2.00/AS40. (MICROFICHE ONLY)

On the Logic of Standard Setting in Health and Related Fields. G. Majone. (rr75-008) $2.00/AS40. (MICROFICHE ONLY)

An Approach to Building a Universal Health Care Model: Morbidity Model of Degenerative Diseases. S. Kaihara, I. Fujimasa, K. Atsumi, A.A. Klementiev. (rm77-006) $2.00/AS40. (MICROFICHE ONLY)

Alternative Analysis of Different Methods for Estimating Prevalence Rate. E.N. Shigan. (rm77-040) $1.50/AS30.

On the Estimation of Morbidity. A.A. Klementiev. (rm77-043) $1.50/AS30.

Comparing Health Care Systems by Socio-economic Accounting. P. Fleissner. (rm76-019) $3.50/AS60.

A Computer Method for Projecting a Population Sex-Age Structure. A.A. Klementiev. (rm76-036) $1.50/AS30.

Mathematical Approach to Developing a Simulation Model of a Health Care System. A.A. Klementiev. (rm76-065) $1.50/AS30.

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The Anokhin Theory of the Functional System: Its Principal Propositions, Operational Architectonic and Possible Application in Biology and Medicine. V.G. Zilov. (rm75-021) $1.00/AS20.

Systems Analysis of Some Bio-Medical Problems Related to Medical Treatment Management. A.M. Petrovsky. (rm75-023) $1.00/AS20.

A Systems Approach to Health Care. A. Kiselev. (rm75-031) $1.50/AS30.

Factors Affecting Participation in Cervical Cancer Screening Programs. J.H. Bigelow, H.L. Brown. (rm75-062) $1.00/AS20.

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