MODELING HEALTH CARE SYSTEMS: JUNE 1979 WORKSHOP PROCEEDINGS

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Editors

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FOREWORD

The aim of the Health Care Systems Task at IIASA is to build a family of models for national health care systems and to apply them, in collaboration with national research centers, as an aid to health service planners. This approach envisages a number of linked submodels dealing with population, disease prevalence, resource needs, resource supply, resource allocation, and external systems. Different submodels and combinations of submodels will be appropriate for applications in different health services.

These Collaborative Papers contain the papers submitted by the participants of the June 1979 IIASA workshop on modeling Health Care Systems (HCS) and a brief summary of the principal items of discussion that took place during the meetings. The participants represented 13 countries, the Headquarters of the World Health Organization (WHO), and its Regional Office for Europe. The aims of the workshop included reviewing the HCS modeling that has been done at the participating organizations and discussing the possibility of extending the HCS Task at IIASA to include health-economic models. In order to promote a more rapid publication of the workshop proceedings, the papers have not been edited and are direct reproductions of the manuscripts provided by the participants.

Recent publications in the IIASA Health Care Task are listed at the end of these proceedings.

Andrei Rogers
Chairman
Human Settlements
and Services Area

ABSTRACT

These Collaborative Papers contain the papers submitted by the participants of the June 1979 IIASA workshop on modeling Health Care Systems (HCS) and a brief summary of the principal items of discussion that took place. The participants represented 13 countries, the Headquarters of the World Health Organization (WHO), and its Regional Office for Europe. The aims of the workshop included reviewing the HCS modeling that has been done at the participating organizations and discussing the possibility of extending the HCS Task at IIASA to include health-economic models.

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INTRODUCTION

On June 6-8, 1979 the International Institute for Applied Systems Analysis held its third workshop on modeling Health Care Systems (HCS). The aims of the workshop were:

1. to consider the next step in the HCS Task, the possible extension of the task to include health-economic models,
2. to update knowledge of the state-of-the-art in this field of work in IIASA, WHO, and national centers,
3. to discuss directions and plans for model application in national and international centers.

The workshop was divided into six sessions (two of which were held simultaneously) with each session devoted to one or more of the three aims.

Of the 34 participants, 28 were from research groups representing 13 countries, 2 were from WHO, and 4 were from IIASA. Over half the participants presented papers. These have been reproduced in their original form in Section 2 of these proceedings. Section 1 gives a list of the papers presented at each session and the discussion that followed. A complete list of the participants and the organizations they represent is given in the Appendix.

I. PAPERS AND DISCUSSIONS OF EACH SESSION

Session 1.

State-of-the-art in the Development of the HCS Model at IIASA

Chairman: A. Rogers (IIASA)

<u>Papers</u>

1. Introduction to the Health Care Task*, E. Shigan (IIASA)
2. Health Care Systems Modeling: The Approach Adopted at IIASA, P. Aspden (IIASA)
3. IIASA Health Care Systems Sub-Models: Short Overview and Latest Results, P. Kitsul (IIASA)
4. Application of IIASA Health Care Systems Models in NMO Countries, D.J. Hughes (UK)
5. Problems and Experiences in Adapting IIASA Health Care System Models to the Specific Conditions of the GDR, K. Fuchs-Kittowski, J. Otto, H. Friedmann, T. Hager, C. Dahme, E. Muehlenberg (GDR).
6. A Test Application of the DRAMI Model to Quebec Data, J.M. Rousseau (Canada)

Discussion

Mr. Härö congratulated the HCS Task on its achievement over the last two years. He added that he thought the models developed incorporated the "realities of management". Professor Kaihara also congratulated the HCS Task on its achievement. He considered that applications of models fell into two stages, (1) using the model to analyze data, and (2) making model predictions for planners. He asked which stage the Canadian application had reached. D. Hughes replied (Prof. Rousseau not being present at the time) that the Canadian application was in the first stage. However, he pointed out that a major application of DRAM in the Department of Health in England is in the second stage. This study is concerned with estimating, in terms of the numbers of patients treated, the likely effects of different resource constraints.

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*No written formal paper for this presentation

Professor Reinhardt asked Dr. Hughes what was meant by the calibration of DRAM. Dr. Hughes replied that calibration meant determining parameters for DRAM. This can be achieved either by inferring their values from previous resource allocations or by using routine statistics (or special surveys) to estimate them directly.

Professor Shigan commented that the HCS Task hopes to carry out regional case studies in the Silistra Region, Bulgaria, and the South West Region in England.

Session 2.

Development of HCS Models: General Aspects

Chairman: N. Bailey (WHO)

<u>Papers</u>

1. Modeling the Effects of National Health Insurance in the USA, G. Wilensky (USA)
2. On the Analysis of Regional Health Service Utilization, P. Ruotsalainen, P. Nokso-Koivisto (Finland)
3. The Role of Sensitivity Analysis in Health Care Systems Modeling, N. Bailey (WHO, Geneva)
4. A Stochastic Approach to Health Service Models*, B. Schneider (FRG)
5. Towards Systems Analyses of Health Services in the Federal Republic of Germany, D. Schwefel, W. Van Eimeren (FRG)
6. A Program for the Elaboration of a Public Health Model for Silistra District in Bulgaria** E. Apostolov, A. Zenov, S. Bacev, E. Petkova (Bulgaria)

Discussion

Much of the discussion in this session was concerned with the collection of HCS data, particularly in connection with various interest groups like doctors, health insurance companies, etc. Dr. Wilensky reported that in her experience it was difficult to collect good quality data. Further it was inappropriate to generalize to the whole population results of analyses of data

*No formal paper submitted
**Paper not presented formally as authors unable to attend workshop.

from such a self-selecting group as people in a given health insurance company. Rather it was necessary to produce a sample of the population and then collect the appropriate data from doctors and insurance companies. This approach had been adopted in the U.S. with success. She commented further that the U.S. experience was contrary to the pessimism about data collection that she had understood from the presentation by Professor van Eimeren.

In reply, Professor Van Eimeren said he had been somewhat misunderstood. In his view, health data from routine sources in the FRG were suspect as they were likely to be biased in favor of the interest group providing them. To avoid this, one must carry out sample surveys, but here again there were problems in the FRG. Health information was an important part of the bargaining between the various interest groups, and these groups were reluctant to share information. He added that any model of the FRG Health System must explicitly include the various interest groups (e.g. insurance companies, doctors, etc.).

Dr. Lagergren said that the analyst begins with data collected for administrative purposes. This data quickly becomes insufficient and he finds it difficult to persuade the decision maker to collect more data, because somehow it is assumed that no extra data are required to make decisions.

Professor Shigan said he would speak in more detail about information requirements for modeling purposes. He thought it was time to review the type of health information collected, in view of the lack of information concerning such external subsystems as education. He also thought there was a need for strategic information systems for long-term planning purposes.

Session 3a.

Economic Aspects of HCS Modeling
(Sessions 3a and 3b were held simultaneously)

Chairman: U. Reinhardt (USA)

Papers

1. Output Measures and the Interaction of Public Expenditure Programmes, C.E.R. Tristem (UK)
2. Resource Allocation Problems in HCS, M. Bojanczyk (Poland)
3. Suggestions for IIASA's Role in Modeling the Economic Mechanisms in Health Care Provision F. Rutten (The Netherlands)
4. The Spatial Organization of Urban Hospitals, L.D. Mayhew (UK)
5. Thoughts on Systems Analysis of the Health Care System, P. Fleissner (IIASA)

Discussion

The view was expressed that the current Health Care Systems models were of a "mechanistic" nature and contained only simple behavioral ideas. It was considered that the HCS Task should develop models of a richer behavioral character which would encompass the market orientated HCS. These models would incorporate the fact that there are, in market orientated systems, many actors and interest groups, each with differing objectives. Economic variables would be an important part of these models which would attempt to explain behavior and indicate the variables through which the system can be modified. An example of such a model developed at Leyden University was described briefly by Dr. Rutten. Here an attempt was made to explain the level of outpatient and inpatient care in the Netherlands by means of regional variations in supply of resources, population density, etc.

There was also a discussion on whether it was possible to develop universal behavioral models for the HCS. It was recognized that the health systems of many countries had many areas of commonality. However, it was considered that universal models could not be built because the definitions of basic variables would differ between countries and because of the differences in data availability. One possibility appeared to be to develop a behavioral model of some aspect of one country's health system and try to parameterize it in an other country. The extent to which the model represented behavior in the second country would be important.

In discussing the objective functions one should use for resource allocation in HCS, Dr. Kitsul pointed out that the Soviet Health System was not as centralized as was perhaps thought. With regard to health planning the Soviet Republics had considerable autonomy and only a few subsystems (e.g. manpower) were centrally planned. Dr. Hughes also pointed out that in the UK the Regional Health Authorities had considerable autonomy. Furthermore, in planning health services, the UK Government had to consult a considerable number of interest groups.

Session 3b.

Problems of Health Estimation in Developing HCS Models

Chairman: J. Radkovsky (CSSR)

Papers

1. The Modeling of the Sampling Procedure for the Hungarian Hospital Morbidity Studies, L. Greff, A. Kramli, J. Soltesz (Hungary)
2. A Survey of Health Care Models to Evaluate Screening Programs in Japan, S. Kaihara, N. Kawamura (Japan)
3. Epidemetric Model of Tuberculosis J. Radkovsky (CSSR)
4. Interactions Among Health Care Subsystems and the Need for an Extended Information Supply, E. Shigan (IIASA)
5. Model for Short-Term Prognosis of the Need of Growth of Medical Personnel (Physicians, Stomatologists and Pharmaceutists) and Students' Admission to Higher Medical Educational Institutions*, A. Zenov, S. Bacev, E. Petkova (Bulgaria)

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*Paper not presented formally as authors unable to attend workshop.

Discussion

(See Chairman's Report given in Session 4)

Session 4.

Decision Maker's Requirement for Models and their Application

Chairman: C.E.R. Tristem (UK)

1. Summary of Reports and Discussions from Sessions 3a and 3b

   Chairman: U. Reinhardt (Session 3a)

   Chairman: J. Radkovsky (Session 3b)

   (No formal papers, see below)

<u>Paper</u> 2. Strategic Health Planning in Changing Economic Environment, A.S. Härö (Finland)

Report of Session 3a.

Professor Reinhardt said two important issues arose during Session 3a's discussion. Firstly, in discussing objective functions for resource allocation, it was pointed out that health services in countries such as the USSR and the UK were not as centrally planned as was imagined. Secondly, it was suggested that the HCS Task should consider extending its work from "mechanistic" modeling (described as simple behavioral models) to models that would incorporate richer behavioral assumptions. The methodology for producing such models has been relatively highly developed in the U.S. How should IIASA move into this area? One suggestion was to develop a core model and then apply it in several countries. This idea was discarded because of differences in culture, variable definition, and data availability among countries. Professor Reinhardt ended by saying the alternative seemed to be to look at problems common to many countries, such as drug prescribing and long-term care.

Discussion

During the subsequent discussion it was made clear that in market orientated health care systems, it was possible to influence the system by price mechanisms and government policy levers. The importance of developing behavioral economic models lay in improving our understanding of how the system works so that price mechanisms and policy levers could be used effectively. Professor Reinhardt reported that the American delegation felt very positive about collaboration with IIASA because it is an international institute and there is much to be gained from an exchange of ideas.

In conclusion, it was suggested that the HCS Task at IIASA should hold further bilateral discussions with scientists in market orientated health systems (e.g. U.S., FRG, and the Netherlands) to see if a mutually beneficial program of research could be set up. The aim could be to produce some proposals by the next workshop.

Report of Session 3b.

Professor Radkovsky said the session was mainly concerned with the development of health estimation models for devising improved strategies of health care. The overall conclusion was that more information was required to improve the quality of these models. He then summarized each paper. The first paper described an approach to patient-oriented information systems developed in Hungary. Professor Kaihara from Japan described models for evaluating screening programs for gastric cancer and cardiovascular disease. Professor Radkovsky then presented a paper giving details of an epidemiological model for the TB program. He indicated how this model could be improved with greater knowledge of the disease. Professor Shigan then gave a presentation concerned with the problems of modeling the interactions between different subsystems of the HCS and other systems.

Discussion

Professor Shigan said it was difficult to study the HCS because the collection of much routine data was not standardized over space and time.

Professor Radkovsky suggested that the correlation between polution (air, water, noise, etc) and health could be a possible research topic for IIASA.

Session 5.

Concluding Session

Chairman: E. Shigan (IIASA)

Papers

1. Collaboration between IIASA HCS Modeling Task and National Centers, E. Shigan (IIASA) (No formal paper, see below)
2. Collaboration in Health Care Systems Modeling between IIASA and WHO, N. Bailey (WHO Geneva)
3. Development of Research in WHO-Europe*, H. Zöllner (WHO, Copenhagen)

Discussion

Professor Shigan began his presentation by saying that the HCS Task will continue to develop the existing models and the existing collaboration with research centers. After hearing the presentations given at the workshop he thought that there were possibilities of further collaboration with institutes in the FRG, Poland, and Finland for DRAM, and Austria, Hungary, Japan, and Czechoslovakia for the health estimation model.

Professor Shigan then said he hoped the Task would develop new health care models. With regard to health economic modeling he thought there were some problems because of basic differences between the member countries of IIASA. Nevertheless, he hoped that some research could be set up in collaboration with the U.S. and the Netherlands, particularly the former because of its great experience in this type of research. Furthermore, it may be possible to hold a special seminar on health economic modeling.

He continued by saying that IIASA hoped to start in the HSS Area a new task on manpower modeling. Some of the initial work will be on medical manpower modeling. This is a problem common to all countries, East and West. Some countries have a shortage of physicians, others have an imbalance between

*No formal paper submitted.

physicians and nurses. He hoped that Professor Reinhardt would be able to help with this work.

Professor Shigan ended his presentation by saying that the HCS team was small at IIASA and that the success of the HCS Task depended greatly on successful collaboration with other research institutes.

After Dr. Zöllner's paper, Professor Shigan closed the workshop by thanking the delegates for their participation and by expressing the hope that they would continue their contact with the HCS Task at IIASA.

Conclusion

The aims of the workshop as expressed in the introduction to these proceedings were achieved. The main achievements were two fold. Firstly, the participants agreed that consideration should be given to expanding the HCS Task to include health-economic (behavioral) modeling, and that IIASA should explore the possibilities with interested parties. Secondly, following participation at the workshop, the U.S. delegation expressed a favorable response towards collaborative research with IIASA. Participants at the workshop were also brought up-to-date with the work of the HCS Task by formal presentations and by the Status Report written by Shigan, et al. Lastly, the workshop helped to strengthen existing links and develop new ones with national centers.

II. PAPERS PRESENTED

HEALTH CARE SYSTEMS MODELING:
THE APPROACH ADOPTED AT IIASA

Philip Aspden

INTRODUCTION

This paper briefly describes the approach and objectives adopted at IIASA towards Health Care Systems Modeling. The paper begins by outlining the distinctive features of the Health Care System. The Health Care System is complex and it is difficult, if not impossible, to develop a comprehensive model of the whole system. Consequently, it is only practical to model subsystems and this is what we have attempted to do at IIASA.

The reasons for choosing the particular submodels developed are then discussed. The paper ends with a description of some of the technical characteristics of the submodels. The paper follows closely Section 2 of the Status Report (Shigan et al).

HEALTH CARE SYSTEMS

The distinctive features of Health Care Systems (HCS) are considered to be:

- The HCS is a social system. Its behaviour reflects the participation of individuals such as patients, doctors, health managers, and their interrelations with external systems.

- The HCS is often organized *hierarchically*. Not only are the systems in particular regions often managed separately but there is usually some specialization according to the severity of disease.

- The HCS is *dynamic*. The number of doctors available today depends upon the training policy of five to six years ago, and society's health today may depend upon the activity of the HCS during the last half century.

- The main result of HCS activity-- the health status of population--can only be estimated by a set of interrelated quantitative and qualitative indices.

- Much of the HCS cannot be subjected to experiment.

- Existing medical data bases are adapted mainly to classical medical statistical aims but not to forecasting or estimating the consequences of different policies in HCS management.

In summary, from the point of view of mathematical modeling the HCS is a complex *hierarchical*, *dynamic*, large-scale system with a number of quantitative and qualitative criteria and with incomplete and indirect observations. Currently, problems in controlling and administrating such systems are mostly solved by decision makers using their personal experience. It is the aim of the HCS modeling activity to assist the decision maker with his problems. The HCS is therefore complex and it is difficult, if not impossible, to develop a comprehensive model of the whole system. Consequently it is only practical to model subsystems. Before discussing the subsystems, modeled at IIASA, I will describe briefly our general approach to model building.

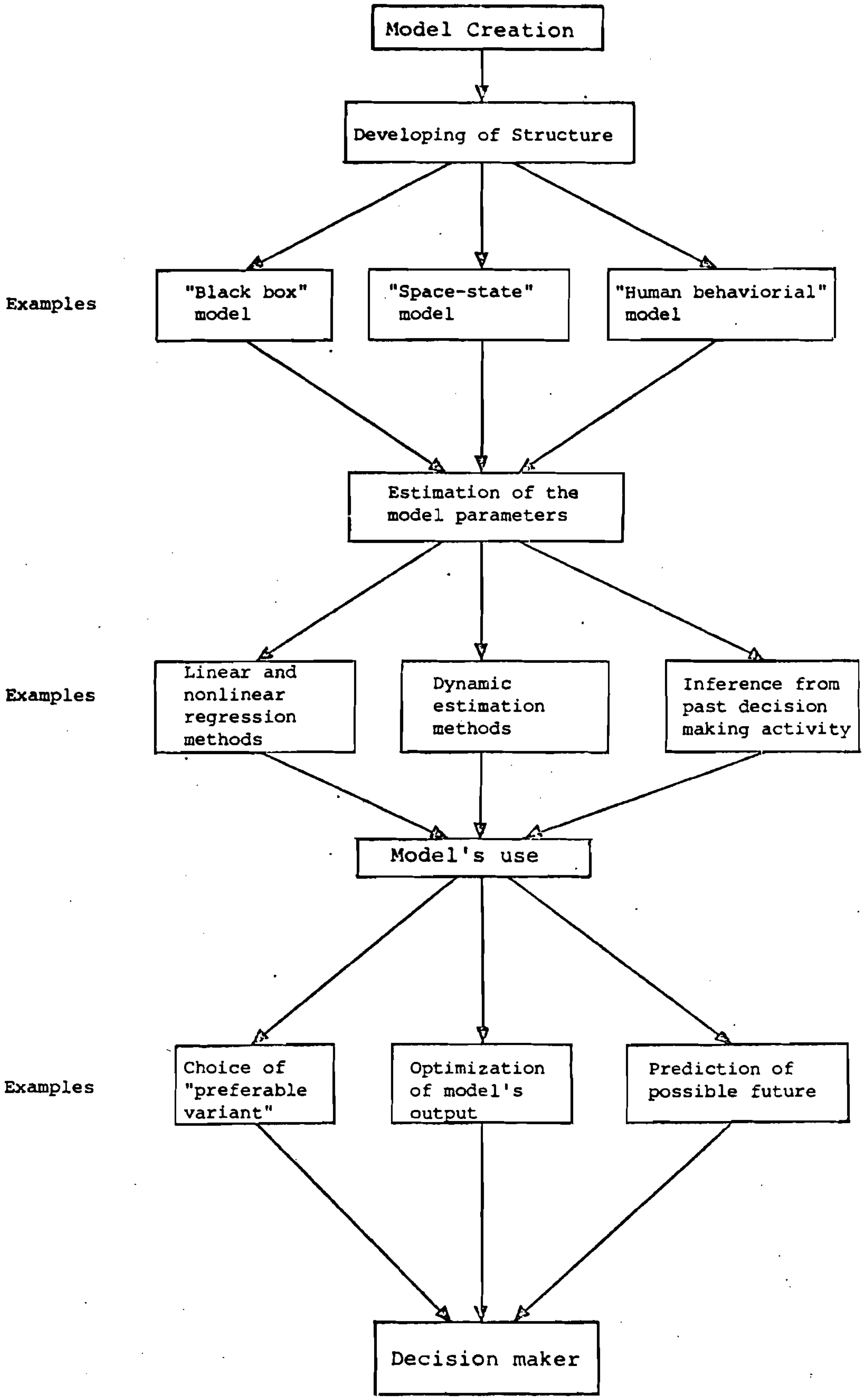
APPROACH TO MODEL BUILDING

Figure 1 gives our general approach to model building. As Yashin and Shigan (1978) indicate, modeling consists of three parts: developing the structure of the model; estimation of the parameters of the model; using the model. For each of these activities, there are various different approaches. Examples of these are given in Figure 1. In general our modeling activity is orientated to the right of the scheme given in Figure 1.

Figure 2 summarizes the HCS submodels developed at IIASA. In totality, these submodels represent the processes by which people fall ill and by which health resources are provided and used for their treatment. There are five groups of submodels. Population projections are used by morbidity models to predict true health needs. Such estimation of needs can be used either to estimate resource requirements at a certain normative level, or they can be partially satisfied according to a resource allocation model which has some inputs from a resource supply model. The areas of choice for the decision maker include his policies, standards, and performance indicators. The HCS relates to other systems. For instance, the economic system relates to the supply of resources and the environmental system relates to the incedence of morbidity. These relationships have not been modeled, but may be areas for future research.

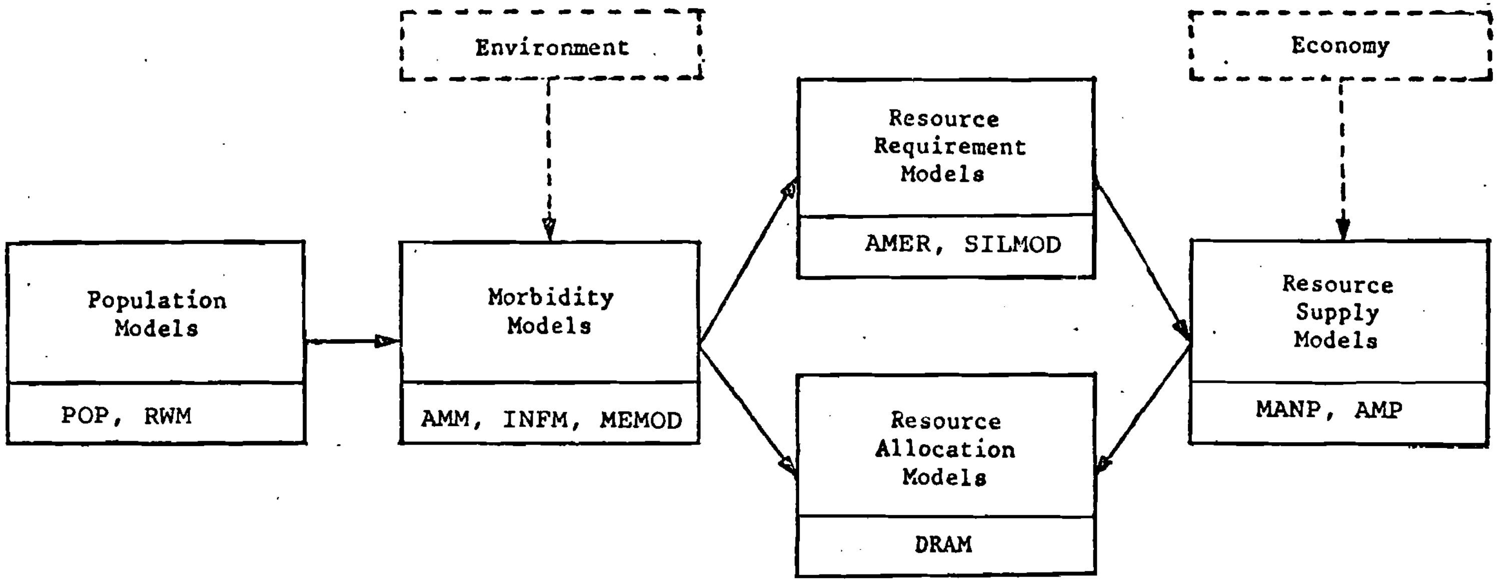
Given that we cannot model the whole of the HCS, it is reasonable to ask why we have chosen those parts to model that we have. The first reason is that these are the parts of the HCS which generate many of the important medium-term problems with horizons of 5 to 15 years. Many countries are now finding it necessary to draw up medium-term policy plans for health care that are linked with other plans for welfare and social services. Secondly, it is these parts of the HCS which we think are easiest to parameterize. The mechanisms by which doctors are trained are easier to identify and depic than those by which the environment influences health. Thirdly, these are the areas of the HCS for which data are most readily available. Every country has statistics of mortality, and resource supply and use which are broadly comparable.

Figure 1. Different stages of modeling.



Source: Shigan, et al. (1979), p. 10.

Figure 2. Family of HCS submodels constructed at IIASA.



Submodel

Sub-system not yet modeled

Link between submodels

Specification of Submodels elaborated at IIASA

POP	Population Model
RWM	Rogers-Willekens Model for Demographic Analysis
AMM	Aggregate Morbidity Model
INFM	Infection Morbidity Model
MEMOD	Morbidity Estimation Models
AMER	Aggregate Model for Estimating Resource Requirements
SILMOD	Sick-Leave Model
DRAM	Disaggregated Resource Allocation Model
MANP	Manpower Supply Model
AMP	Manpower Migration Model

Source: Shigan, et al. (1979), p. 11.

A second reasonable question is: Who will use these models? We have designed them for use by scientists at IIASA and in different countries with whom we are collaborating. On the other hand we hope that the models will be useful for decision makers at the higher levels of the HCS. It is impossible for a small IIASA HCS modeling team to establish active links with decision makers across the world. In consequence, the preferred form of collaboration is for scientists in collaborating countries to use the models themselves and to develop their own links with decision makers, supported by the HCS modeling team. Two such institutions* have exchanged scientific personnel and research in this way. Similar institutions in other countries are also involved.

A third natural question to ask is: What technical characteristics do our models possess? First of all, our models are compact and easily programable. We believe that large models are hard to comprehend and difficult to parameterize. Secondly, we have tried to design models for use with existing data. Such models are more useful than models which cannot be used without special survey. Thirdly and, perhaps most importantly, we have used a mixed modeling strategy in which different mathematical approaches are developed. For instance, our morbidity model forecasts the number of people in various morbidity states, but incorporates no direct element of human behaviour and no optimization technique. The resource allocation model is also a forecasting model, but in order to simulate some element of human behaviour it assumes that the human agents in the system act as if they were maximizing a utility function.

CONCLUSION

In conclusion, we are creating models which first, will represent mathematically the main components of the HCS, and second, can be used independently by decision makers at different levels of the health care system.

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*Operational Research Services, Department of Health and Social Security, London and the Institute of Control Sciences, The Academy of Sciences, Moscow.

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IIASA HEALTH CARE SYSTEMS SUB-MODELS: SHORT OVERVIEW AND LATEST RESULTS

Pavel I. Kitsul

I. INTRODUCTION

The aim of the IIASA Health Care Systems Modeling Task is to develop a large-scale national health care systems model and apply it in collaboration with national research centers as an aid to the health service planner. The main methodological problems of the creation of such a model were solved within the framework of the IIASA-WHO conference (Moscow-Laxenburg, 1975) [1], where the now well-known conceptual scheme of health care systems was proposed (Figure 1).

This conference defined the main directions of the IIASA Health Care Systems Modeling Task, which consists in the creation of the suite of interrelated submodels oriented, on the one hand to the mathematical re-establishment of the main blocks of the conceptual scheme and, on the other hand, to the possibility of independent usage in the decision-making practice on the different levels of health care system management.

During the first steps, the main attention of our work was given to the resource demands, allocation, and supply modeling. The current state of IIASA health care systems modeling activity is expressed in Figure 2 [2]. It represents one part of the larger system shown in Figure 1: namely, the processes by which

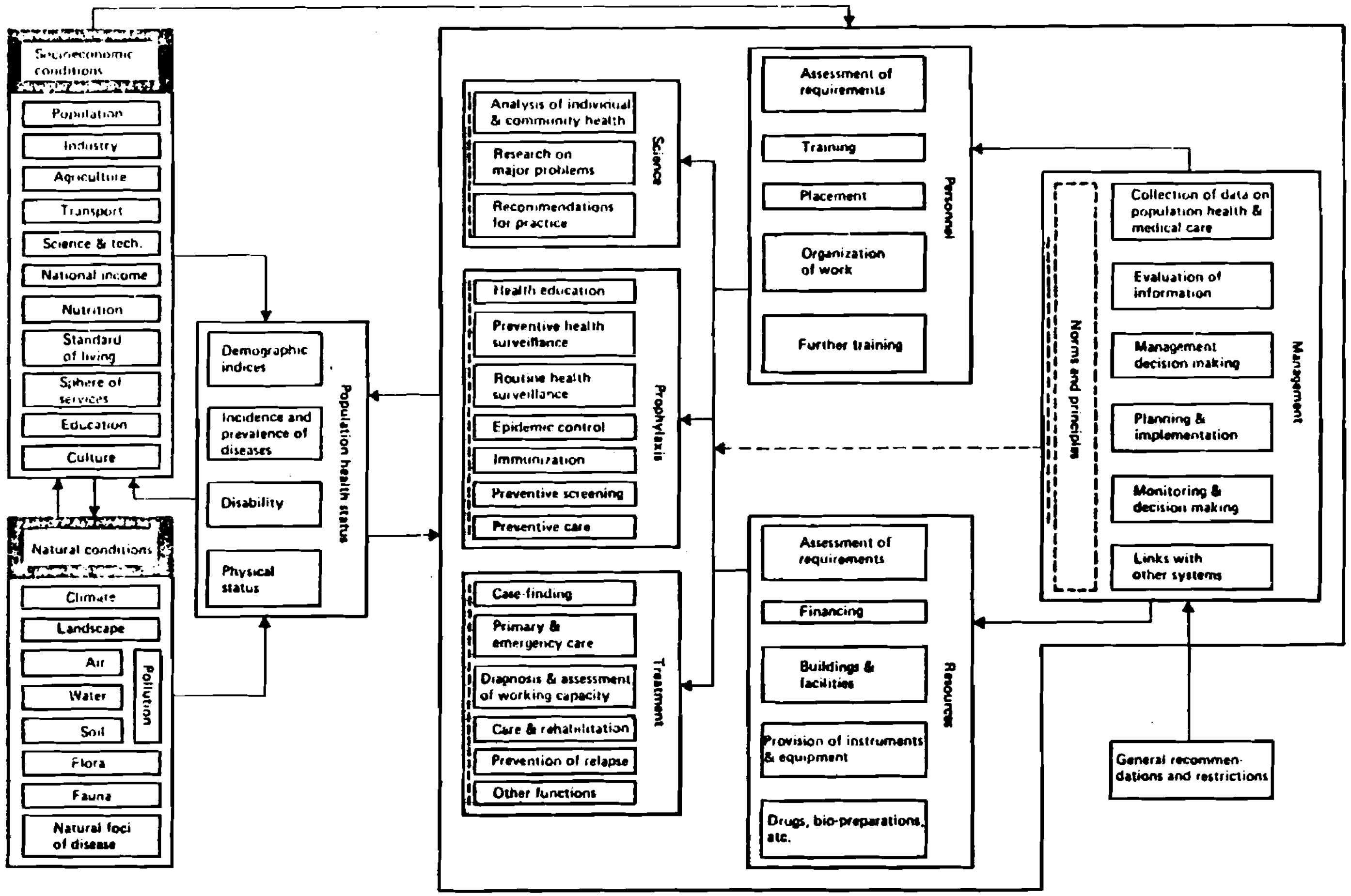


FIGURE 1 Functional chart of a public health system. Source: Venedictov (1976), p. 109.

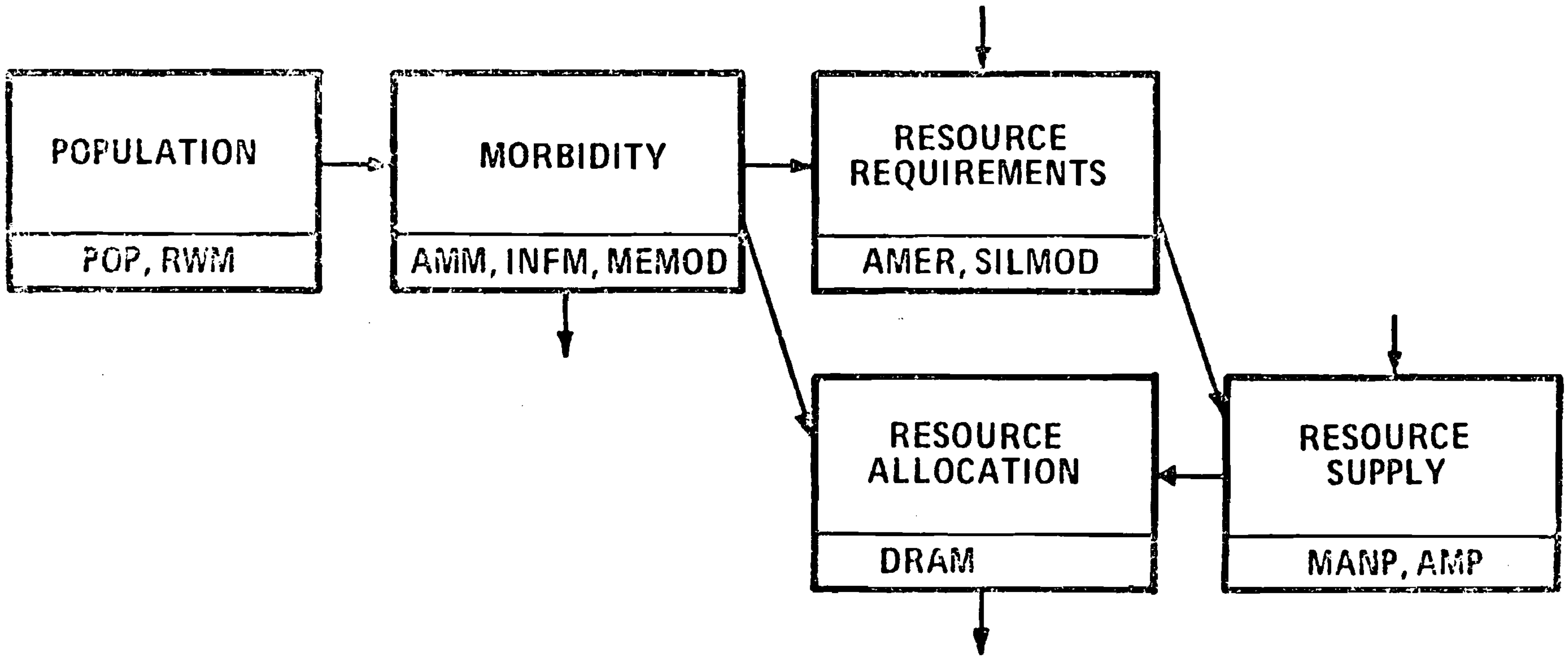


Figure 2. Family of HCS sub-models

people fall ill and by which health resources are provided and used for their treatment. This model also summarizes the system of submodels constructed in the framework of the IIASA HCS Modeling Task activity up to now. There are five groups of submodels. *Population* projections are used by *morbidity* models to predict true health needs. Such an estimation of needs can be used either to estimate *resource requirements* at a certain normative level, or they can be partially satisfied according to a *resource allocation* model which has some inputs from a *resource supply model*. The areas of choice for the decision maker include his policies, standards, and performance indicators. Beyond the HCS boundary are the external systems of environment and economy, and we believe that the direction of our future activity in these fields will be defined at the outcome of the present workshop and the forthcoming IIASA-AMIEC Conference in the fall of this year, which are devoted to the problems of health economics and environment.

In accordance with the aim of this workshop, the purpose of the present report is to bring to your attention the short input-output description of IIASA HCS submodels and to present within this description our progress since the last HCS Task Conference.

II. THE SHORT INPUT-OUTPUT DESCRIPTION OF IIASA SUBMODELS

1. Models for Demographic Projection

It is obvious that the dynamics of mortality rates and, hence, morbidity rates themselves are correlated with the dynamics of the demographic age pyramid, and that this correlation is different for different countries. In developed countries the age-specific registered morbidity rate is changing very slowly over time by comparison with the dynamics of age structure. Evidently, therefore, models for morbidity prediction must be age-specific and indeed all of our submodels need information about population.

In some applications it is possible to use population projections provided by national agencies with specific responsibility for such work. For other applications we have a population model developed with the Human Settlements and Service Area of IIASA. This model, developed by Willekens and Rogers [4] uses spatial demographic data and can be used, not only on the regional (multiregional) or national level, but also for precise projections of population, because it uses more detailed information about fertility and mortality rates in the different regions and includes multiregional migrations.

2. Morbidity Models

The problem of estimating trends in health indices is one of the serious problems in all countries, and much attention has been given to it by WHO.

Different alternatives exist for estimating morbidity rates using the information available in different countries [5]. Such models can be divided by their degree of detail into the following types:

-- *aggregative morbidity models*, which estimate and forecast "crude" general morbidity rates without specifying specific diseases or groups of diseases,

-- *group morbidity models*, which model groups of diseases, i.e., the classes in the International Classification of Diseases (ICD), or the groups used in several IIASA publications (degenerative diseases, infections, accidents, etc.),

-- *specific morbidity models*, which consider specific diseases (e.g., cancer, cholera, tuberculosis, etc.),

-- *stage of disease models*, which look not only at a specific disease, but also at the different stages of its development and at risk-group estimation and classification.

Together with a number of national centers, and also using the statistics of the WHO, we have designed and constructed three groups of computer models:

-- for estimation of aggregative morbidity rates,

-- for estimation of morbidity rates for infectious diseases,

-- for estimation of morbidity rates for terminal degenerative diseases.

Aggregative Morbidity Models

As mentioned above, data about morbidity and its trends can, with a certain amount of difficulty, be taken from real comprehensive studies, conducted periodically in some developed countries. But since there are only slight variances among aggregate morbidity rates, aggregate mortality rates, and the ratios between them (risk ratios) over time, it is possible to estimate roughly aggregate morbidity data using mortality data from official vital statistics and the risk ratios from such studies. The model uses as input the age-specific mortality rate, a forecast of the population age structure and the age-specific risk ratio. The central assumption of the model is that risk ratios are constant in time. As output the model forecasts age-specific morbidity. This model was used as an auxiliary morbidity submodel in the AMER model. A similar model for prevalence estimation on the basis of age-specific hospitalization, episode and attendance rates was developed last year [6].

A Morbidity Model of Infectious Diseases

This model was designed by Fujimasa et al. [7]. The aim of the model is the estimation of age-specific prevalence and death rates per total population for two groups of infectious diseases: epidemic diseases (ICD A1-A44), and diseases of the respiratory system (ICD A89-A-96). On the basis of some standard rates which one can easily obtain from domestic health statistics, it is possible to estimate the prevalence rate, disease specific death rates per capita, and mean length of stay in the sick state, under the assumptions that mean length of stay in the sick state is less than one year and prevalence is constant over time. In accordance with the model's first assumption, the ageing of sick individuals during the duration of the disease is not taken into account. On the other hand, the second assumption implies that prevalence does not oscillate during this time. It means that this model itself is static and its technique is static analysis, but that the output of the model can be dynamic if one of the model's inputs, for example, population structure, is changing over time.

To test the validity of the model, we applied it to the data of Japan and compared the results for various countries: Finland, Austria, Sweden, England, Japan, and France. The results of application show that the model can predict the fundamental part of infectious diseases, and that this type of approach is feasible in health planning.

Morbidity Models of Degenerative Diseases

Degenerative diseases are inherent to human beings. They are caused by the ageing process, and the morbidity rate in these diseases usually increases with age. In our work, we have defined three groups of diseases as degenerative: cardiovascular disease (ICD A80-A88), malignant neoplasms (ICD A45-A60), senile deaths and deaths from unknown causes (ICS A136-A137). Unlike infectious diseases, degenerative diseases have slower dynamics, and so we must take into account not only the population structure and its changes, but also the individual dynamic property of each specific disease.

In the IIASA morbidity models for degenerative diseases, different assumptions and techniques are used. Nevertheless, we shall try to describe these problems in a unified form. For this, we shall indicate the main data that we can use to estimate the morbidity of degenerative diseases on the basis of mortality statistics. These data are:

- the age distribution of *specific* mortality rates and their dynamics over time,
- the age distribution of *general* mortality rates and their dynamics over time,
- survival characteristics which describe in some sense the dynamics of disease, e.g., the proportion of individuals who were afflicted with a given disease at a certain time and age, and who did not die within a certain time interval,
- the population's age-structure and its dynamics.

It is possible to describe mathematically the dynamics of the process "health→sickness→death" by integral equations that link the statistical data listed above with morbidity rates and prevalence distributed by age. Many morbidity estimation problems can be formulated in these terms, but the HCS modeling activity in this field is focused on one particular problem:

-- how to estimate prevalence distributions and morbidity rates from general and specific data, survival probabilities, and population age-structures?

Because the quality of data is not the same in all countries, different assumptions about survival were used in the two IIASA morbidity models. In the first IIASA model of this type [8] the following assumptions were used:

1. All variables are independent of time.
2. Sick people suffering from degenerative diseases are considered as sick for the duration of their lives.
3. Persons who become ill will inevitably die at a certain definite time after contracting the disease. The duration of illness (T) is dependent only on the type of disease.

In accordance with these assumptions, the model uses as input the population age-structure, the durations of illness, and the death rate according to cause specified by age, to give as output the age-specific morbidity rate, and the age-specific prevalence rate.

In comparison with the first model, assumption 3 in the second IIASA degenerate morbidity model [9] assumes that persons who become ill at time t can die at time τ with probability $P(t,\tau) = P(t - \tau)$, and the possibility of death from other causes is not equal to zero. This model needs some inputs additional to those of the first model. They are death rates specified by age, for all causes, and the survival probabilities $S(t - \tau) = 1 - P(t - \tau)$ obtained from clinical experience. This new assumption is more realistic than assumption 3 in the first model but complicates the model's structure. Nevertheless, the estimate of prevalence and morbidity rates can be obtained as the solution of a sequence of systems of linear equations.

Estimation of malignant neoplasm prevalence was carried out for Austria, Bulgaria, France, and Japan. The direction of the development of the morbidity models is toward reducing the number of restrictions on population structure dynamics and disease dynamics. For example, we require a morbidity model for unstable and unstationary population structures. In addition, it is necessary to adapt these models to use comprehensive health study data about a specific region, to avoid the inevitable error of extending clinical survival data to the latent sick individuals. Both those aspects were taken into account in the dynamic morbidity model (DYMOD), which was tested using data from the South West Region of Great Britain and the Netherlands and was recently introduced to computer centers in the Hague and Munich. The example of an output of the model which represents morbidity/mortality ratio for the cancer of the stomach (ICD-151) in the South-West of the U.K. is given in Figure 3.

3. Health Resource Requirement Models

The IIASA HCS Modeling Group is developing several models for health resource requirements using the experience of different countries in this field. As a first step we have started from a normative planning approach. On the basis of this approach, knowledge is obtained from data about population, health status, present levels of care, their dynamics, and of how health conditions are converted into health resources. Standards can then be calculated for the number of out-patient visits per capita, the duration of one out-patient visit (in minutes), the number of out-patient visits per patient with a specific disease, etc., and for similar measures associated with other forms of care.

It is clear that the quantitative level of these standards indeed reflects the real situation of each country and differs greatly from country to country. That is why we have started with commonly used standards such as average length of hospital stay, bed occupancy rate, and bed turnover interval.

THE RATIO: MORBIDITY/MORTALITY

years	age groups									
	1	2-4	5-14	15-24	25-34	35-44	45-54	55-64	65-74	75+
1965	0.00	0.00	0.00	0.00	1.53	2.15	1.86	1.69	1.60	1.29
1966	0.00	0.00	0.00	0.00	1.62	2.67	1.76	1.73	1.60	1.31
1967	0.00	0.00	0.00	0.00	1.56	2.03	1.87	1.76	1.71	1.33
1968	0.00	0.00	0.00	0.00	2.29	1.75	2.05	1.70	1.70	1.30
1969	0.00	0.00	0.00	0.00	2.30	1.55	2.45	1.72	1.66	1.35
1970	0.00	0.00	0.00	0.00	2.41	1.64	2.12	1.80	1.65	1.35
1971	0.00	0.00	0.00	0.00	1.54	2.59	1.95	1.82	1.63	1.33
1972	0.00	0.00	0.00	0.00	2.15	1.80	1.82	1.95	1.60	1.31
1973	0.00	0.00	0.00	0.00	1.67	1.35	2.06	1.70	1.74	1.27
1974	0.00	0.00	0.00	0.00	1.70	1.02	1.37	1.58	1.73	1.26
1975	0.00	0.00	0.00	0.00	1.79	1.00	1.65	2.02	1.33	1.23

Figure 3. Morbidity/Mortality ratio for cancer of stomach (ICD-151) in the South-West Region of the U.K.

Two models have so far been developed at IIASA: AMER, Aggregative Model for Estimating Resource Requirements [6] and, developed last year, SILMOD, Sick Leave Model [10]. The basic structure of AMER and SILMOD is represented in Figures 4 and 5. As shown in these figures, the main difference between AMER and SILMOD consists in the methods of morbidity estimation and in the population groups which are taken into account in each model. To calculate outpatient doctor equivalent requirements in the AMER model, the substitution effect should be taken into account: the lower the hospitalization and the shorter the average length of stay, the greater is the number of consultations per episode. The main assumptions of AMER are linearity and stationarity of the substitution effect. In the SILMOD model, the substitution effect is not taken into account. However, both models assume stationary prevalence rates (or risk ratios and sick leave rates) over time.

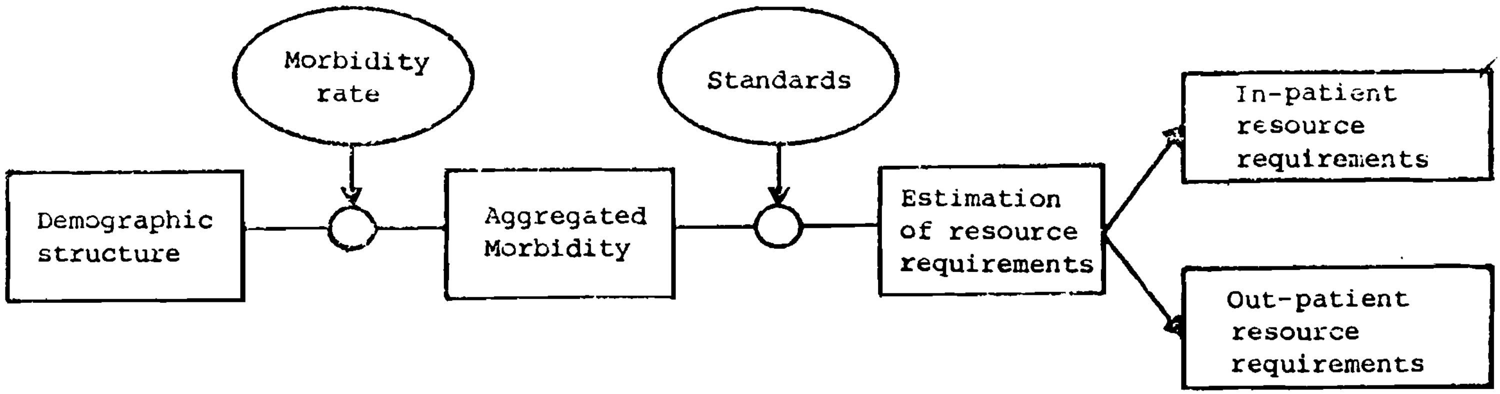
The resource requirement models will help the national level decision maker, working in an interactive regime, to test different policy options and to select the best among them. A model also makes it possible to forecast population structure changes and mortality and morbidity trends which are very important to health care.

Although these models are designed for forecasting aggregate health resources, in some cases they can be used for specific classes of disease with precise medical resources.

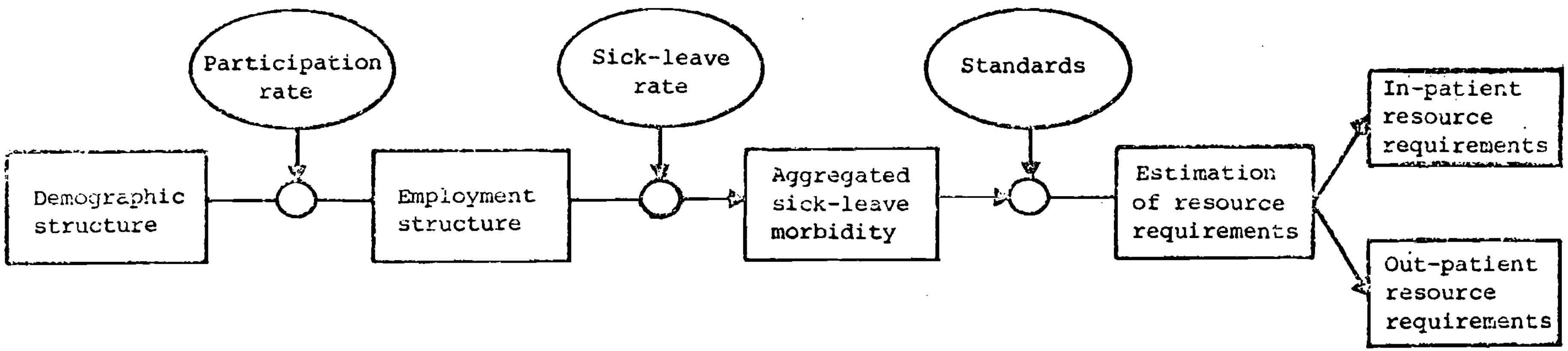
4. Health Resource Allocation Models

DRAM is an acronym for Disaggregated Resource Allocation Model. This model was proposed by Gibbs [11] and subsequently developed by Hughes [12]. In the conceptual framework shown in Figure 2, the resource allocation model lies between the estimation of ideal resource levels and the prediction of available resource levels. It seeks to represent how the HCS allocates limited supplies of resources between competing demand.

In every country, doctors have clinical control over the treatment of their patients, and it is local medical workers who



Source: Shigan, et al.[2], p. 33.
Figure 4. Basic structure of AMER.



Source: Shigan, et al.[2], p. 34.
Figure 5. Basic structure of SILMOD

ultimately determine how to use the resources (e.g., hospital beds, nursing care) which are available to them. The specific question underlying DRAM is:

> If the decision maker provides a certain mix of resources, how will the HCS allocate them to patients?

DRAM takes input data on demand and supply, uses an hypothesis about how allocation choices are made, and gives indicators of the predicted behavior of the HCS. The demand inputs are: the total number of individuals who need treatment, by category (from the morbidity and population submodels), the policies for treatment (i.e., the feasible modes of treatment for each patient category--in-patient, out-patient, domiciliary, etc.), and the ideal quotas of resources needed in each patient category and mode of treatment. The supply inputs are the amounts of resources available for use in the HCS, and their costs (from the resource supply production model). The model outputs represent the levels of satisfied demand in a HCS with limited resources. They are: the numbers of patients of different categories who receive treatment, modes of treatment offered, and the quotas of resources received by each patient in each mode of treatment. Inevitably these levels fall short of the ideal demand levels. DRAM models the different equilibria which the HCS must choose in order to balance supply and demand. These results can be used by health planners to explore the consequences of alternative policies for resource production, treatment, and prevention.

The latest achievement in the development of this model is the estimation of parameters of the model on the basis of a retrospective analysis of the decision-making process [13].

The model has been established in Berlin, London, Montreal, Munich and The Hague and one of these groups has run DRAM with nearly 100 disease categories, reporting a very efficient solution.

5. Application Experiments

Application-oriented IIASA HCS modeling activity has two directions. The first is the testing of our models on the national or regional statistics of different countries--Japan, CSSR, UK, USSR, Bulgaria, DGR, FGR, France, Austria--both by the IIASA HCS team and by collaborating scientific teams in these countries. Some results of the work have been described in earlier sections.

Since IIASA HCS models are intended also for possible interactive remote use by decision makers at regional, national or international levels, the second direction is the experimental establishment of dial-up computer links between IIASA and the offices of the decision makers. This experimental work is being carried on in close cooperation with the IIASA computer network group, who conceived the general framework for such operations.

III. CONCLUSION

In conclusion, it is necessary to emphasize that it would be very interesting for IIASA to define the direction of the development of our model, in particular the resource requirement allocation and supply block of the model, in order to take into account the economic mechanism existing in the different HCS.

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APPLICATION OF IIASA HEALTH CARE SYSTEM MODELS IN NMO COUNTRIES

D. J. Hughes

1. INTRODUCTION

This paper is divided into two parts. First I shall summarize recent progress in resource allocation modelling at IIASA, especially on the Disaggregated Resource Allocation Model - DRAM.

During my year at IIASA, DRAM has been developed in various ways: mainly to widen its range of application and to make it easier to use in centres outside IIASA. Secondly, I shall discuss more generally how the IIASA health care system (HCS) models can and have been used, by the IIASA team and by collaborating groups in the national member organisation (NMO) countries of IIASA.

2. RESOURCE ALLOCATION MODELLING

You have already heard (Kitsul, 1979) about the five areas of HCS modelling at IIASA:- population, morbidity, resource requirements, resource allocation, and resource supply. Health resource allocation models lie between the estimation of morbidity and the prediction of resource supply, and two such models exist at IIASA. The first is DRAM, originally proposed by Gibbs (1978). The second is a Model of the Equilibrium between Treatment Levels (METL), proposed by Hughes (1979). METL is important because it addresses the same problem as DRAM, using a different representation of behaviour in the HCS. However, while DRAM is now quite sophisticated, only a pilot version of METL exists and it has not been applied.

DRAM seeks to represent the way in which the HCS allocates limited supplies of resources between competing demands. Specifically, it is concerned with the question: If a certain mix of resources (e.g. beds, doctors) are available for health care, how will the HCS allocate them to patients? It is specifically not concerned with the problem of finding optimal allocations of resources. DRAM is a simulation model which predicts future allocations on the basis of past behaviour.

I can summarize the model theory with a simple example (The most recent precise statement is given in Hughes and Wierzbicki (1979)). Think about the use of in-patient hospital beds by patients in acute specialties. Suppose that just B beds are available per capita of population per year. Then the HCS, as represented by medical workers at the front line, must choose the admissions per capita of population per year x, and their average length of stay y, such that

$$xy = B$$

This equation represents a family of hyperbolae plotted in Figure 1. If we could experiment with the HCS, we could change B and plot the values of x and y chosen by the HCS. Since this is not possible, we make an assumption about the shape of solution lines in the x-y space, and we estimate

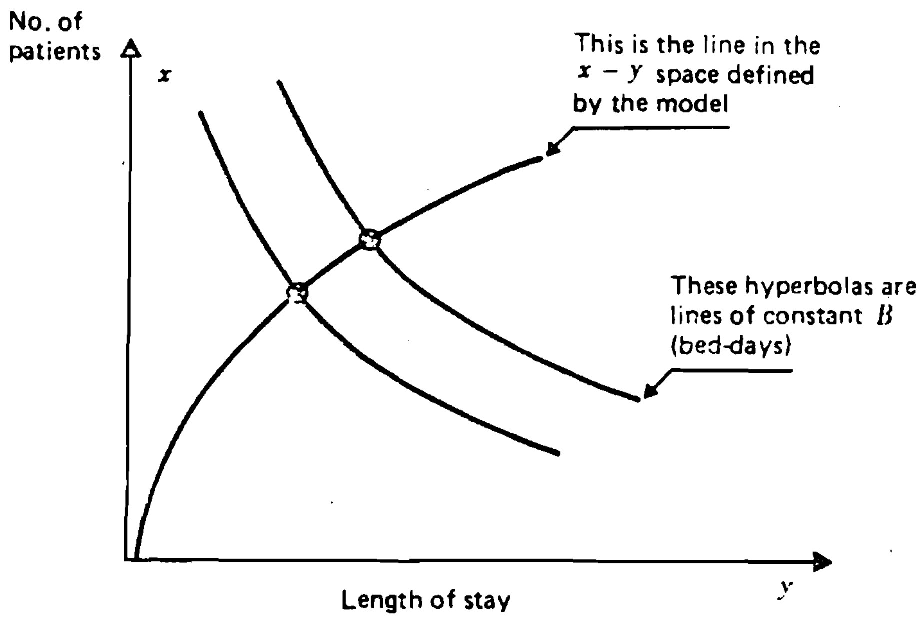

FIGURE 1 DRAM chooses solution points on the line of constant resources.

Source: Shigan, et al. (1979) p. 39.

the parameters that define the shape using historical data from the HCS.

In its simplest form, the assumption underlying DRAM is that when medical workers are faced with increasing levels of B, they will increase both x and y. In fact DRAM is more complicated than this because it can represent different

-patient categories (e.g. age groups, diseases)
-resource types (e.g. beds, doctors)
-modes of care (e.g. in-patient, out-patient)

It handles these different dimensions with assumptions about the relative utilities of care in, for example, different patient categories. By assuming diminishing returns up to some "ideal" levels of care at which marginal benefits are equal to the asset value of bought resources, the model may be formulated as an optimization problem. This formulation has several attractive analytic features, and can be quickly solved on a computer.

The implementation of the full model with many categories, resources, and modes is a task completed only recently. I don't want to imply, however, that all these features of DRAM must be used whenever DRAM is used. The point is that the capability is there to extend a simple version of the model in whichever direction seems interesting.

Any model like DRAM is useful only if numbers can be put into the model equations so as to calibrate the model for particular definitions of categories, resources and modes, in a given region. For such parameter estimation, we clearly need data, and appropriate sources include professional opinion, special surveys, routine statistics, and other models. Because the parameters of DRAM have meanings independent of the model, they can often be deduced from the first two sources, and this was our first approach to parameter estimation.

In the last year, however, we have concentrated on ways to calibrate DRAM which use and attempt to reproduce historical allocation patterns. This is useful because it indicates the reliability of the underlying assumption of DRAM. If this approach does not yield reliable estimates, it rings warning bells about the applicability of the model. On the other hand, I don't mean to imply that a good fit with the data is all that is or should be obtained. The parameters which are so estimated must also seem reasonable outside their use in the model.

Is DRAM useful outside IIASA? I hope so. It uses generalised variables (e.g. resources) which are not restricted in number or type, and as many and whichever categories can be used as desired. The computer program is transportable and has been installed at other centres. The model is not restricted to either small or large data bases. Indeed, DRAM is not even restricted to applications in health care, and might be more generally useful. For the moment, however, let me discuss application, not just of DRAM, but of all the IIASA models.

3. APPLICATION OF IIASA HCS MODELS

For me, the word <u>application</u> is rather vague. It could mean

1. Running international data through the models at IIASA and publishing the results, perhaps with comparisons.

2. Distributing the IIASA models to collaborating institutions so that they can apply the models for

their own purposes.

3. Tackling well-structured problems already identified in NMO countries with the manpower and models available at IIASA.

4. Tackling problems in NMO countries, where even the nature of the problem is unclear.

Type (1) application has already been undertaken with data from several countries including Japan, Jugoslavia, and the U.K. Shigan et al (1979) give a few examples. The IIASA team has just returned from some type (2) applications. A few recently developed models were installed and demonstrated on computers in The Hague (Netherlands) and Munich (FRG). These programs will now remain available to local scientists, together with continued support from IIASA. In the case of the Netherlands, the demonstration is being followed up by a month long visit to IIASA by Dr. Rutten. Similar demonstrations followed our November 1977 conference on HCS modelling here at IIASA, when programs were installed at Montreal (Canada), London (U.K.), Munich (FRG) and Berlin (GDR). This led to Dr. Gibbs (U.K. and ex-IIASA) visiting Dr. Rousseau in Montreal, and their jointly running DRAM on Canadian data.

Another example of type (2) application is in progress within the group in which I work (Operational Research Services, U.K. Health Ministry) in London. Here DRAM is being used to help assess the consequences of providing various levels of hospital beds in different specialties. The model is being used to reconcile what might be the ideal distribution with what can be afforded. This example is interesting because those actually using DRAM have never worked at IIASA. They have taken over IIASA work in order to use and develop it entirely for their own purposes.

The difference between type (3) and type (4) application is that in the former the IIASA models should seem likely to be useful before work begins, while in the latter it might turn out that new methods need developing. No type (4) application is in progress, and it may be too ambitious for a small IIASA team. But I can tell you briefly about some type (3) application in the U.K.

Last January, Dr. Kitsul and I visited the team of officers who manage health services in the South Western Regional Health Authority (SWRHA) of the U.K. We asked them what problems they faced in providing for a population of about three million, and they mentioned four. Two of these, to do with morbidity and resources, seemed amenable to analysis with IIASA models. Morbidity is important to U.K. health planners because of the recommendation of the Resource Allocation Working Party (RAWP) to take account of morbidity in distributing funds. The resource problem in SWRHA is that numbers of hospital beds are likely to decrease, and those of doctors to increase. Striking the balance between these two changes is not easy.

The other two problems in SWRHA, to do with community care and manpower, seemed more appropriate for an already existing local team of analysts. This team can also liaise between IIASA and SWRHA on the first two topics. However, in spite of these favourable circumstances, there will be difficulties in this application. SWRHA is about 1500 km from this room, and the number of personal contacts that can be made is therefore severely restricted. The officers in SWRHA are preparing plans for health services at this moment, and cannot wait indefinitely for IIASA analyses. These rather basic problems are just as difficult as those of HCS modelling.

How should applicational work continue in the future? There is no simple answer. Above all, I think it is difficult to expect to organise identical work in many different countries. For this reason, I am unenthusiastic about suggestions for large-scale comparative studies. Better is for the IIASA team to concentrate on a small number of useful applications which really test the approach, and which will suggest new lines of research. The latter may be the most important outcome.

4. CONCLUSION

Finally, let me ask you - Is modelling the final goal?, with the hope that you will answer - NO. I ask this because I think that we shall hear quite a bit about models during this workshop, and because it is easy to forget the reason for constructing them. Perhaps we can imagine the chair in the corner to be occupied by a sceptical general practicioner.

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PROBLEMS AND EXPERIENCES IN ADAPTING IIASA HEALTH CARE SYSTEM MODELS TO THE SPECIFIC CONDITIONS OF THE GDR

K. Fuchs-Kittowski, J. Otto, Hedi Friedemann,
T. Hager, Chr. Dahme, E. Muehlenberg

Due to an urgent need for effective long-term health care planning, mathematical models of Health Care Systems (HCS) have been developed. These instruments act as an aid in improving the quality of medical care for the population and in allocating the necessary funds for material and staff.

At present, the method of mathematical modeling is internationally tested for the planning and management of medicine in national health care systems. It has also proved efficient in the fields of natural and technical sciences as well as in economics. However, in contrast to the models developed for planning and managing the national economy, formalized models as an assistance for the management of HCS are not as yet sufficient to aid in decisions on principal policies. As described by P. Fleissner's and A.A. Klementiev's survey, most models are attempts to transfer models of operational research or system dynamics to planning and management of the health service for the population. Such international model solutions developed hitherto are first steps in this direction. On the basis of appropriate data they must be adapted to national requirements step by step.

In the past it was our main effort to gain an insight into the principles which form the basis of the models. We took into consideration the concrete conditions of application in the GDR to enable us to come to proper decisions.

We started from the following considerations:

1. The method of using models is only one element in the decision-making process and in various phases of this process models have different functions. The employment of the modeling method requires first of all thorough theoretical investigation of its field of application.
2. If the application of models is taken only as an element of a process of decision making, the necessity arises of comparing such models with the real complexity of activities and the experience gained from them.

The system of the models being discussed is of a hierarchic character with the following features:

because of the weak couplings it was possible to elaborate each model separately; they were usable for answering sub-problems of planning.

The IIASA models presented had to be incorporated into the general conception and strategic orientation of the development of the HCS of the GDR. We adapted the demographic models, the morbidity models, and the optimization models to our computing technique and then checked them separately.

In this connection we considered the following facts:

1. Investigating the state of health of the population is a prerequisite for the improvement of care organization:
   - models for the description of the demographic structure and its prognosis are to be considered basic models;
   - because at present there are no international statements on general morbidity, knowledge must be gained from the development of the specific morbidity of disease categories. In this case morbidity models may be used.
2. Based on knowledge of the morbidity of the population the following steps are necessary for the organization of medical and social care:
   a) improvement of the out-patient and in-patient care
   b) securing staff supply
   c) territorial planning of medical care

The report of the Human Settlements and Services Area "The First Five Years"* rightly states that several international research centers--among them some of the GDR--wish to apply some or all of these submodels and to implement them on the computers of their national centers.

When implementing and testing the programs in the computer (EC 1022) of the Humboldt-University the following adaptations became necessary:

1. The programs written in FORTRAN IV had to be adapted to the computer because of

   - deviations from FORTRAN IV to PDP and ESER,
   - deviations in the compiler,
   - different calculating behavior of the computers used: name conventions, data identifications, carriage control, removal of memory.

   Furthermore, programing and calculating errors had to be eliminated as for example division by zero and removal of redundant statements. Other problems arose such as incorporating program variables into a parameter-controlled program or transition of a number of sub-programs into an overlay structure.

2. We had to investigate the structure of the input-data from the structure of the models present at that time and from partly incomplete instructions for an eventual second use. Thus we were confronted with listed source-programs containing unnecessary instructions and errors as well as some model descriptions. The material was presented as working material by the IIASA Health Care Task. The most essential difficulty was the identification of the contents of the input data, not so much the formal description.

3. Starting from the structure of the models and the computing program we now had to collect data for the models and adapt them to the structure of the input-data of the models. We had to overcome differences in the form of the present data, because the data, on the one hand, had to correspond with the required input-data of the model and, on the other hand, we had to apply the recorded data with their given structure. The investigations for our test were based on GDR-data.

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*Rogers, A. (1979) *The Human Settlements and Services Area: The First Five Years*. SR-79-1. Laxenburg, Austria: International Institute for Applied Systems Analysis.

So far we have implemented on our computer:

1. Klementiev, A.A. On the estimation of morbidity, RM-77-43, IIASA, Laxenburg, Austria.
2. Kaihara, S., I. Fujimasa, K. Atsumi, A. Klementiev An approach to building a universal health care model: morbidity model of degenerative diseases, RM-77-6, IIASA, Laxenburg, Austria.
3. Klementiev, A.A. A computer method for projecting a population's sex-age structure, RM-76-36, IIASA, Laxenburg, Austria.
4. Willekens F., A. Rogers Computer programme for spatial demographic analysis, RM-76-58, IIASA, Laxenburg, Austria.
5. Gibbs, R.J. A Disaggregated Health Care Resource Allocation Model, RM-78-1, IIASA, Laxenburg, Austria.
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We will carry on this task step by step, as far as the applicability of the models to real HCS planning can be tested and modifications suiting our situation can be suggested.

<u>About the Demographic Model (Willekens, Rogers, and Klementiev)</u>

Population models may serve as a basis for long-term strategy and planning processes. Fluctuations in the age distribution of the population influence considerably the capacity of the HCS as well as other spheres of society. Overstressing as well as understressing of capacities available always cause negative effects. Population models also may give early signals of essential changes thus enabling the state and society to prepare proper medical and social measures.

A <u>direct</u> comparison of present IIASA-models with GDR-models for the analysis and prognosis of population structures is not possible at the moment. The application of both models is strongly connected to <u>constant</u> (historically unchangeable) age-specific birth and death rates. With regard to births the development in the GDR is so dynamic that the application of constant data, i.e. simply recording current changes, cannot justifiably be done. While up to the middle of the seventies the age-specific birth rates decreased we, at present , observe an increase of the birth rate as a consequence of a number of social-political measures of the government. Death rates did not change essentially during the past years: thus a certain stability seems obvious and justifies the recording of current changes. Regarding the dynamics of birth rates even a retrospective study should include data on the trends observed. A prospective study requires the formulation of hypotheses which, of course, must be backed up be sociological investigations.

It should be possible to show up the past trends and to formulate a hypothesis on future trends thus extending the present model. Nevertheless, this would be a rather comprehensive research task.

The Morbidity Model (Klementiev)

With the population structure as a basis, we are attempting, with the assistance of the morbidity models elaborated by Klementiev, to estimate the number of possible patients suffering from degenerative diseases taking as an example the cardiovascular diseases.

Applying Klementiev's population model we are also attempting to forecast trends of such diseases as well as to estimate the occurrence of a certain type of degenerative disease on the basis of the mortality of this disease.

Does the GDR-HCS need morbidity models?

The estimation of morbidity is a necessary prerequisite for planning care according to demands. The complexity of the demographic structure and the morbidity necessitate the use of mathematical models.

Are the basic assumptions of the model epidemilogically relevant?

Klementiev's model includes irreversible disease only (diseases with a convalescence rate = 0). Are the diseases recorded in the model irreversible? A register of myocardial infarctions proved that there is a convalescence rate of (> 0). In our view, the "all causes of death" statistics are not sufficiently conclusive regarding a morbidity estimation.

For certain types of neoplasms, death by other types of geriatric diseases are recorded. With the aid of the data-base of a specific territorial registering of all results of myocardial infarctions the premises of the morbidity model were checked. We found that on the basis of the data present we have to consider the disease in a more differentiated form as follows:

Group 1: acute death (before hospitalization)

Group 2: death within the first 7 days after hospitalization

Group 3: survivors of a normal life expectancy under regular follow-up, medical therapy, and adequate working conditions.

Can the real progress of a disease be reflected approximately by the morbidity model? In the case of myocardial infarction the disease progressed in a more differentiated way than the model was able to realize. These variations which may be estimated from the register of myocardial infarctions provide essential clues for HCS planners and their decisions for care.

Thus Klementiev's model may be used only if the disease to be considered

1. shows a homogenous progress,
2. is an irreversible disease,
3. causes mortality because of its morbidity.

Provisional valuation of the model DRAM (R.J. Gibbs)

The DRAM model does not serve the analysis of present structures but the shaping of favourable proportions in the allocations of resources. The hypotheses are not as striking and clear as in the case of demographic and morbidity models. The main task is to perceive the essential contents of the model and then to "re-translate" the hypothesis into the language of social hygienists. This is necessary, because the use of the model is reasonable only if the social hygienist can identify and make himself familiar with the contents and concerns of the model.

a) The basic assumptions or axioms respectively of the model must be checked in so far as they have to prove relevant for our socio-economic conditions.

b) It has to be clarified how the necessary basic information (which is available only for social hygienists of clinicians) can be gained.

At present, we are in the stage of working up the basic hypothesis which would then have to be discussed by a working group consisting of social hygienists and methodizers. This working group bases its activities on the common convictions that models able to answer the following questions would be of interest:

1. Do the allocations of beds to the special departments meet the present demands?
2. Are the beds available utilized according to needs?
3. Which departments need more beds, if their capacity is increased according to needs?

The following questions came up when this hypothesis was discussed in the context of DRAM. These questions could not be answered:

1. May the length of stay be considered a variable?
2. Can the length of stay be cut down in favour of a higher rate of admission?
3. Is, after all, the need for beds higher than the bed capacity?

A further project is in progress to implement the "Simulation Model for Sick Leave", by P. Fleissner with data from Austria, United Kingdom, and the German Democratic Republic in a joint paper, which D. Hughes, P. Fleissner and K. Fuchs-Kittowski are preparing. In this case, we also give a special interpretation to the data.

SUMMARY

It is with great interest that we have observed the work done so far in the Health Care Systems Task and on the research done in the Human Settlements and Services Area. It is our opinion that these efforts are of international significance.

This is also expressed by our endeavours of the past years to build up cooperation with groups interested in the models developed by IIASA.

Regarding the problem-analysis of the different models and the checking of the data available, we found that much of our data proved more precise than the models required. Within other models we considered, the premises were found to be not all relevant for our health care system. That means that the specific conditions of different countries have to be taken into consideration.

Our participation in IIASA has, up until now, provided us with essential stimulations for our future work. We will apply the HCS model to our real planning process and will pass on the information concerning our activities and results.

A TEST APPLICATION OF THE DRAMI MODEL TO QUEBEC DATA

Jean-Marc Rousseau

INTRODUCTION

In this paper we describe a test application of the DRAMI model to data from Québec Province, Canada. We suppose that the reader is familiar with the model DRAMI. A description of DRAMI can be found in (Gibbs, 1978). The purpose of this exercise is to investigate the realism and reliability of the model. The model is used to simulate the allocation of beds in a past year and the outputs obtained from the model are then compared with data on the allocations that actually occured in practice. The results obtained are quite satisfactory.

THE DATA

The principal source of data used is the Québec hospital form AH-101 from the Ministry of Social Affairs. The year 1975 was selected because it was the most recent year (without strikes) for which the data was complete at the time of the study. The computerized form AH-101 includes for each Québec resident hospitalized, in or outside the province, both personal data (age, sex, municipality of residence) and medical data (discharge diagnosis, surgical procedure and duration of stay).

The data on patients was classified by disease according to the 18 category International Classification of Diseases (ICD) 'A' Code. Category V, mental problems, is however excluded because only a minority of the patients in this category is hospitalized in acute hospital beds; moreover, this portion varies heavily from one region to the other. Furthermore, categories XI and XV were regrouped. Both refer to childbirth, and its complications (including miscarriage) and in practice it seems that the differentiation between these categories is not consistent from one region to the other.

Table 1

Principal Demographic and Medical Supply Characteristics of the 12 Québec Regions (for 1975)

Regions	Population[1]		Physicians[2]		Beds[3]	
1 - Bas-St-Laurent-Gaspésie	223	(16.9)	87.9	(37%)	5.7	(23%)
2 - Saguenay-Lac-St-Jean	277	(6.7)	92.4	(47%)	6.1	(7%)
3 - Québec	962	(56.6)	158.4	(54%)	6.2	(3%)
4 - Trois-Rivières	412	(23.3)	96.8	(49%)	4.7	(16%)
5 - Cantons de l'est	225	(68.0)	178.7	(59%)	6.8	(5%)
6a - Montréal-Ile	2207	(7745.5)	258.4	(59%)	6.6	(2%)
6b - Montréal-Laurentides	430	(60.6)	73.5	(37%)	2.7	(50%)
6c - Montréal-Rive-Sud	910	(196.6)	96.8	(41%)	2.0	(49%)
7 - Outaouais	258	(12.5)	91.5	(38%)	3.7	(44%)
8 - Nord-Ouest	136	(6.1)	71.3	(32%)	3.0	(26%)
9 - Côte Nord	101	(1.0)	57.4	(21%)	6.2	(30%)
10 - Nouveau Québec	15	(0.04)	40.0	(33%)	7.6	(64%)

[1] Population in 1000 (Density of population per square mile)

[2] Density of physicians per 100,000h. (% of specialists); the numbers include all physicians that receive some amount of money from RAMQ, the national insurance board.

[3] Number of acute beds per 1000 h. (% of total bed-days used outside the region)

To test the model, the 12 sociosanitary regions, as defined by the Québec government are used. This choice is justified because the planning of resources is done on a regional basis. Table 1 summarizes the principal demographic and medical supply characteristics of these regions. Region 10, New Quebec, however is excluded. It is the northern part of the province (as large as France) with extremely low population density and practically non-existent medical services (6 physicians, 110 beds). We realize from table 1 that the regions are very different from one and other. The island of Montreal (region 6a) is a large urban area with a very high density of physicians. Cantons de l'Est (region 5) and Quebec (region 3) have both a high density of physicians and a high hospital bed supply. Finally Côte Nord (region 9), a low density populated area, has very few physicians but a high hospital bed supply. Some regions (regions 6b, 6c, 7, 8, 9) also use a relatively large proportion of bed-days in other regions.

CALIBRATION

In order to run the model for each of 11 regions an input value is required for B_r, the number of bed-days available for occupation per thousand population per year. Because of the large number of patients hospitalized outside their region of residence, it was decided to set this value equal to the total number of bed-days used by residents of a region, including usage both within and outside their home region. Similarly the data on regional admission rates and lengths of stay are calculated from all hospitalizations of residents of a region.

The estimates, $\hat{\gamma}_i$ and $\hat{\eta}_i$, of the elasticities of admission rates and lengths of stay with respect to total bed availability are calculated from the data for all 11 regions using regression equations described in (Gibbs, 1978). Results are shown in table 2. Following this, the parameters X_i and U_i, the ideal admission rates and lengths of stay are derived as described in Gibbs report using data on average values of bed availability admission rates and lengths of stay for Quebec province as a whole.

Table 2

Estimates of Elasticities of Admission Rates and Lengths of Stay with Respect to Total Bed Availability; Standard Errors in ( ).

ICDA Chapter	Title	Admission rate elasticity		Length of stay elasticity	
I	Infectious, parasitic	2.02	(0.25)	-0.21	(0.27)
II	Neoplasm	0.01	(0.14)	0.02	(0.14)
III	Endocrinal, metabolic	1.28	(0.17)	-0.01	(0.11)
IV	Blood	0.96	(0.25)	-0.57	(0.15)
VI	Eye, ear, nervous system	0.72	(0.13)	0.34	(0.30)
VII	Circulatory	0.58	(0.14)	0.40	(0.28)
VIII	Respiratory	1.52	(0.15)	0.36	(0.10)
IX	Digestive	0.84	(0.23)	-0.11	(0.21)
X	Urinary, genital	0.96	(0.15)	0.15	(0.13)
XII	Skin	1.07	(0.23)	0.31	(0.16)
XIII	Organ of movement	0.69	(0.25)	0.40	(0.24)
XIV	Congenital	0.45	(0.18)	0.53	(0.17)
XVI	Ill-defined	1.36	(0.36)	0.34	(0.12)
XVII	Accidents, trauma	1.22	(0.25)	-0.32	(0.16)
XVIII	Supplementary	0.57	(0.32)	0.29	(0.12)
XI - XV	Childbirth & complications	0.47	(0.18)	0.26	(0.07)

RESULTS

The model DRAMI was run for each of the 11 regions. In each of these runs the input data was identical except for one item: the value of B_r of regional bed availability. In order to assess the performance of the model we shall compare the model's predictions of regional admission rates and average lengths of stay, by disease category, with data on the actual values that occured in practice. However, in order to test the model's performance move stringently we shall also compare the accuracy of its predictions with a very simple model based on the following 3 assumptions:

- all bed-days available to a region are used;
- the regional average lengths of stay, by category, are equal to the corresponding values for Quebec Province as a whole (i.e. length of stay is unaffected by total bed availability)

- the regional admission rates by category, are directly proportional to the total bed availability (i.e. if bed availability increased by a given percentage all admission rates increase by this same percentage).

This very simple model is equivalent to a special case of the DRAMI model in which all the admission rate elasticities are unity and all the length of stay elasticities are zero; for this reason we term it the 'one-zero' model.

Let us start by examining the DRAMI model's predictions for Region 2, which has a bed availability 34% above that of the Quebec Province average. The results are displayed in table 3 and reveal a good fit with the data on actual admission rates and average lengths of stay. For disease categories such as 1 and 8, for which the estimated admission rate elasticities are high, DRAMI correctly predicts values of admission rates considerably above the Quebec average rates. Moreover these predictions are considerably closer to the actual values than the prediction of the 'one-zero' model. Similarly for a category such as 2, for which the estimated admission rate elasticity is very low, DRAMI correctly predicts admission rates close to the Québec average rates whereas the 'one-zero' model wrongly predicts higher values.

On the other hand, for some categories (e.g. 2), the admission rate in a region might be below the Québec average despite the fact that its overall bed availability is well above the Québec average. In such cases the model, wrongly, predicts above average admission rates (even though in the results for this region, the magnitude of error is small). This suggests that certain factors which influence admission rates in practice are not represented in this model; for example, it is believed that there are significant variations between regions in the incidence for some groups of diseases like neoplasm.

The model's predictions for lengths of stay are also good (see table 3). However most estimated elasticities for length of stay are small and thus the results for both DRAMI and the 'one-zero' models are very close to the Québec average. The results, for all disease categories combined of the model are very close to the

Table 3

Results for Region 2

ICDA Chapter	Title	Admission Rates					Lengths of Stay			
		Elasticity	Actual value	Model DRAMI	Model one-zero	Québec average	Elasticity	Actual value	Model DRAMI	Model one-zero (Québec average)
I	Infectious...	2.02	5.7	5.2	3.9	2.9	-0.21	12.28	10.35	10.35
II	Neoplasm	0.01	7.7	8.0	10.7	8.0	0.02	16.14	16.17	16.06
III	Endocrinal...	1.28	3.8	3.7	3.4	2.6	-0.01	13.17	15.05	15.04
IV	Blood	0.96	0.9	1.1	1.2	0.9	-0.57	10.55	12.83	12.83
VI	Eye, ear...	0.72	6.8	7.4	8.1	6.0	0.34	15.31	12.33	11.21
VII	Circulatory	0.58	11.4	12.7	14.5	10.8	0.40	26.58	19.82	17.72
VIII	Respiratory	1.52	21.2	21.2	18.5	13.8	0.36	8.08	8.00	7.24
IX	Digestive	0.84	19.1	20.9	22.1	16.4	-0.11	9.25	9.42	9.42
X	Urinary & genital	0.96	14.4	14.6	14.9	11.1	0.15	8.41	8.47	8.13
XII	Skin	1.07	3.3	3.2	3.1	2.3	0.31	8.86	8.97	8.22
XIII	Organ of movement	0.69	6.1	6.3	7.0	5.2	0.40	11.67	12.85	11.47
XIV	Congenital	0.45	3.1	2.7	3.1	2.3	0.53	10.60	10.36	8.92
XVI	Ill-defined	1.36	4.6	6.5	5.9	4.4	0.34	10.55	10.39	9.44
XVII	Accidents & trauma	1.22	10.0	12.5	11.9	8.8	-0.32	10.29	10.89	10.89
XVIII	Supplementary	0.57	20.4	20.2	23.1	17.2	0.29	5.21	5.59	5.15
XI & XV	Childbirth...	0.47	27.9	24.9	29.2	21.8	0.26	5.55	5.62	5.22
All categories		----	166.7	171.1	180.7	134.6	-----	10.08	9.82	9.30

actual observation. The total admission rate and the average length of stay predicted by DRAMI differ by about 2% from the actual values whereas those predicted by the 'one-zero' model differ by about 8%.

Table 4

Bed-days, Admission rates and Length of Stay per 1000 h.

	Bed-days used / 1000 population		Total admission rate and average length of stay in [ ]					
Region	Actual Value	Difference with Quebec Average	Actual Value		Model DRAMI		Model one-zero	
1	1548	+24%	171.8	[9.01]	160.0	[9.67]	166.5	[9.30]
2	1679	+34%	166.7	[10.08]	171.1	[9.82]	180.7	[9.30]
3	1406	+12%	143.6	[9.79]	148.0	[9.50]	151.3	[9.30]
4	1611	+29%	147.6	[10.92]	165.3	[9.75]	173.3	[9.30]
5	1455	+16%	177.6	[8.19]	152.1	[9.56]	156.5	[9.30]
6a	1084	-13%	114.4	[9.48]	119.8	[9.05]	116.6	[9.30]
6b	942	-25%	112.9	[8.35]	107.0	[8.81]	101.4	[9.30]
6c	1103	-12%	128.2	[8.60]	121.5	[9.08]	118.6	[9.30]
7	1282	+ 2%	156.0	[8.22]	137.3	[9.34]	137.9	[9.30]
8	1573	+26%	180.6	[8.71]	162.2	[9.70]	169.2	[9.30]
9	1846	+48%	207.7	[8.89]	184.8	[9.99]	198.6	[9.30]
Prov.of Quebec	1252	0%	134.6	[9.30]	134.3	[9.32]	134.6	[9.30]

Unfortunately the results are not as good for all regions. Table 4 summarizes the global (all categories) results for the eleven regions. For regions 1, 6a, 6b, 7, 8, 9 the actual global average length of stay is smaller than predicted by the model and is lower than the Québec average and correspondingly the actual admission rate is higher than the one predicted by the model. From table 1 however, we note that these regions experience a great amount of hospitalization outside their regions. Because of the absence of specialized hospitals and physicians in these regions there are several transfers of patients from their hospital to hospital in Montréal or Québec City. When a transfer occurs, two separate records of hospitalization are produced for each case, one at each hospital. In the first hospital in the region of residence, the length of stay may be very short (just to assess or stabilize the patient's condition), while the second length of stay may probably be somewhat over the expected average. This factor distorts the data, increasing the recorded admission rate and reducing the recorded average length of stay, which partly accounts for the apparent error in the prediction of DRAMI.

From table 4, it can be seen that for region 9, the 'one-zero' model produces more accurate global prediction than DRAMI. However, an analysis of results by category (see table 5) shows DRAMI performing better. For admission rate, the 'one-zero' model predicts worse than DRAMI model for 10 out of 16 categories (1, 2, 3, 7, 8, 9, 12, 14, 16, 17) and the sum of the absolute errors is smaller for DRAMI. Performance of DRAMI in predicting lengths of stay is less good. For 6 categories it predicts better than the 'one-zero' model and for 5 categories worse. In the paragraph above, we suggested that this may not be simply due to a failure of DRAMI model, but, at least partly, to distortions in the data.

Tables 6 and 7 summarize the accuracy of the predictions of the DRAMI model and compare it with those of the 'one-zero' model. Table 6 shows results by region. In each case the quantity calculated is the percentage error of the predicted value relative to the actual value. For example, for region 2 DRAMI model predicts admission rates considerably better than the 'one-zero' model, the average error being 8% and 15% respectively, DRAMI also performs better on lengths of stay; its error rate is 10% compared to 14% for the 'one-zero' model (see table 6). In assessing the model's performance over all 11 regions we need to recognize that for region 7 the total bed availability is very close to the Québec average and so both DRAMI and the 'one-zero' models predictions are very close to the Québec average figures. (This explains why the errors for the two models are approximately equal in this region). Thus we need to direct our attention to the remaining regions. Of these the DRAMI model predictions of admission rates are better in 8 regions (1, 2, 3, 4, 5, 6b, 6c, and

Table 5

Results for Region 9

ICDA Chapter	Title	Admission Rates					Lengths of Stay			
		Elas-ticity	Actual value	Model DRAMI	Model one-zero	Québec average	Elas-ticity	Actual value	Model DRAMI	Model one-zero (Québec average)
I	Infectious...	2.02	7.4	6.2	4.3	2.9	-0.21	9.15	10.35	10.35
II	Neoplasm	0.01	7.3	8.0	11.8	8.0	0.02	15.51	16.21	16.06
III	Endocrinal...	1.28	5.0	4.1	3.8	2.6	-0.01	14.03	15.04	15.04
IV	Blood	0.96	1.6	1.23	1.3	0.9	-0.57	8.78	12.83	12.83
VI	Eye, ear...	0.72	8.4	7.9	8.9	6.0	0.34	9.69	12.70	11.21
VII	Circulatory	0.58	12.3	13.4	16.0	10.8	0.40	14.74	20.52	17.72
VIII	Respiratory	1.52	22.8	24.3	20.3	13.8	0.36	7.91	8.26	7.24
IX	Digestive	0.84	21.5	22.4	24.3	16.4	-0.11	9.04	9.42	9.42
X	Urinary & genital	0.96	16.9	15.8	16.4	11.1	0.15	8.96	8.58	8.13
XII	Skin	1.07	4.3	3.5	3.4	2.3	0.31	9.44	9.21	8.22
XIII	Organ of movement	0.69	7.8	6.7	7.7	5.2	0.40	11.29	13.31	11.47
XIV	Congenital	0.45	3.0	2.8	3.5	2.3	0.53	13.04	10.85	8.92
XVI	Ill-defined	1.36	10.9	7.3	6.5	4.4	0.34	11.74	10.71	9.44
XVII	Accidents & trauma	1.22	16.9	13.9	13.1	8.8	-0.32	8.11	10.89	10.89
XVIII	Supplementary	0.57	29.9	21.3	25.4	17.2	0.29	5.41	5.73	5.15
XI & XV	Childbirth...	0.47	31.6	25.9	32.1	21.8	0.26	6.23	5.75	5.22
All categories		----	207.7	184.8	198.6	134.6	-----	8.89	9.99	9.30
Sum of |Predicted-Actual|				30.3	33.8					

9) and equal in 2 regions (6a and 8). As regards lengths of stay, DRAMI's predictions are better in 7 regions (2, 3, 4, 6a, 6b, 6c and 8), equal in 1 region (1), and slightly worse in 2 (5 and 9).

Table 6

% of Error* Between the Models and the Observed by Regions

	Bed-days/1000 h	Rate of admission (error)		Length of stay (error)	
Regions	Québec mean: 1252	Model DRAMI	Model one-zero	Model DRAMI	Model one-zero
1	1548	9	14	13	13
2	1680	8	15	10	14
3	1407	7	10	5	6
4	1611	13	19	9	13
5	1455	16	17	16	14
6a	1084	7	7	5	6
6b	943	8	14	5	9
6c	1103	8	9	5	6
7	1282	12	12	11	10
8	1573	13	13	11	12
9	1847	15	16	16	15

$$* \ \% \text{ error} = \frac{\sum_{\text{categories}} |(\text{predicted}-\text{actual})|}{\sum_{\text{categories}} (\text{actual})}$$ rounded to nearest integer

Turning now to the results by disease category (table 7) the predictions by DRAMI for admission rates are better than those of the 'one-zero' model for 12 categories (and much better for 2 of these (1 and 2)) and equal for the remaining 4 categories. With regards to lengths of stay the DRAMI predictions are better for 10 categories and equal for the remaining 6. Naturally the predictions of DRAMI are similar to those of the 'one-zero' model for admission rate for those categories where the estimated elasticity for admission rate is close to unity (4, 10, 12) or for length of stay when the estimated elasticity for length of stay is close to zero (or negative) (1, 2, 3, 4, 9, 17); these account for most of the cases where the prediction errors of the two models are equal.

Table 7

% of Error* Between Models and Observed by Diagnostic Category

ICDA Chapter	Rate of admission (error)			Length of stay (error)		
	Elasticity	Model DRAMI	Model one-zero	Elasticity	Model DRAMI	Model one-zero
I	2.02	13	25	-0.21	13	13
II	0.01	8	24	0.02	7	7
III	1.28	9	12	-0.01	7	7
IV	0.96	14	14	-0.57	12	12
VI	0.72	7	9	0.34	17	18
VII	0.58	7	10	0.40	14	16
VIII	1.52	8	13	0.36	5	8
IX	0.84	10	11	-0.11	10	10
X	0.96	7	7	0.15	6	7
XII	1.07	12	12	0.31	7	9
XIII	0.69	12	13	0.40	12	14
XIV	0.45	9	14	0.53	8	12
XVI	1.36	19	21	0.34	5	9
XVII	1.22	15	15	-0.32	10	10
XVIII	0.57	17	18	0.29	5	8
XI & XV	0.47	10	11	0.26	3	6

$$* \ \% \text{ error} = \frac{\sum_{\text{regions}} |(\text{predicted-actual})|}{\sum_{\text{regions}} (\text{actual})} \quad \text{rounded to nearest integer}$$

From these results we conclude that DRAMI has performed reasonably well in predicting admission rates and lengths of stay in the 11 Québec regions.

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MODELLING THE EFFECTS OF NATIONAL HEALTH INSURANCE IN THE UNITED STATES

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A major goal of our research is the development of models capable of analyzing the effects of alternative National Health Insurance proposals in the United States. Such models will require a series of component analyses including the demand for medical care, the supply of medical care, the effects of alternative income tax treatments on the demand for medical care, and the effects of existing public programs such as Medicare and Medicaid on the use and costs of personal health care. Historically these types of analyses have been severely hampered by the absence of appropriate data. In an attempt to remedy this situation the National Center for Health Services Research, DHEW, funded a major data collection effort, the National Medical Care Expenditure Survey (NMCES). NMCES is an analytically driven survey, designed to support the analyses of alternative National Health Insurance proposals and other major issues of national health policy. The data collection phase has been in progress since 1976 and will continue until the end of 1979. The analyses based on this data are expected to proceed for at least the next five years.

Description of NMCES

NMCES consists of three major surveys: 1) a survey of 13,500 randomly selected households in the United States each interviewed six times over a 15 month period during 1977-78, 2) a survey of the physicians and hospitals that provided care to household respondents during 1977-The Medical Provider Survey (MPS) and 3) a survey of insurance companies and employers responsible for the private insurance coverage of the household respondents.

The primary source of information about the U.S. population comes from the household survey. In addition to standard demographic information, the sampled families were asked a core set of questions for each family member. These include questions about the number of disability days, health insurance coverage, and charges for and amounts paid by family or third parties for physician, dental, or hospital services. Special supplementary questions were also administered periodically during the household interview. These included questions about the household's perception of their health insurance coverage, each family member's current employment situation, traditional measures of access to medical care, a detailed series of income measures, and federal income tax information.

Approximately 50 percent of the providers were contacted in The Medical Provider Survey in order to supplement the information provided by households. The providers were asked to provide information about all visits made by the respondent during 1977 including the date and the purpose of each visit, the total charges and source of payment associated with each visit, the medical diagnosis, and the major procedures performed during each hospital stay. In addition, a sample of physicians rendering care to NMCES respondents were asked about characteristics of their practices, including the number of aides and nurses they employ, the hours they work, and whether they are self-employed or in a partnership. During the health insurance/employer survey, employers and insurance companies were asked about the total costs and sources of payment of insurance premiums, and the type of coverage provided. They were also requested to provide a copy of each insurance policy covering NMCES respondents. Employers were asked similar questions about options or plans available which an employee could have chosen but did not. Employers of individuals who do not report group coverage were asked to verify the absence of coverage and to provide information on plans offered to employees. Medical providers and employers were contacted only when the respondent had granted permission for the contact.

Analyses

The data encompassed by the NMCES surveys are capable of supporting a series of analyses ranging in complexity from descriptive reports of insurance coverage and health care utilization to multivariate analyses of demand and supply integrated into a dynamic microsimulation model of alternative national health insurance proposals. The descriptive analyses will include reports on the health care expenditures and utilization of the American people, the type and depth of health insurance held in the U.S., the costs of severe illness, and the charges and sources of payment for medical care all for various socio-demographic groups in the population.

This basic information about the use and costs of health care will provide the first step for any analyses of the cost, use or financing implications associated with alternative National Health Insurance proposals. The basic approach we expect to use in modelling the effects of NHI is outlined in the remainder of this paper. Although we are still at a preliminary stage in the development of these models, more detailed statements than are possible here about our analysis plans are available from the authors. We expect to begin with a series of analyses which will focus on explaining the most important components of medical care behavior e.g. the demand for various types of medical care, and the supply of physician services, and the responsiveness of various parameters of demand and supply to changes in the financing, cost or delivery of care. Initially these behavioral equations will be placed within a comparative static framework in order to produce estimates of the monetary costs and the gross and net monetary effects of alternative NHI proposals. This framework is similar to one which has been used in the U.S. to analyze the effects of alternative negative income tax proposals. This approach offers several advantages. First, it permits specification of eligibility changes to various component programs according to the demographic characteristics of the population. It allows estimation of the demand and supply of health care, given various changes in the market price of medical care. Finally, it is possible to estimate the aggregate budgetary costs associated with a particular program, both before and after prices have been allowed to adjust to clear any disequilibrium, and the financing needed to meet the government's cost according to the taxing mechanisms specified in the proposal.

The effects of some types of proposals can be more accurately estimated than others. Proposals which focus on changes in coverage and on the costs of medical care will be easier to estimate than proposals which make profound changes in the structure and delivery of medical care. Proposals which result in marginal changes in coverage and prices will be easier to estimate than proposals which result in inframarginal changes. All estimates will initially be made using the 1977 data. Population, prices, employment and income will be adjusted forward to 1980 and 1982 using aging adjustments developed by other researchers. Concurrently, we expect to begin work on a more dynamic simulation model, with the regression coefficients associated with behavioral equations serving as the conditional probabilities used to start the simulation.

Demand Equations

The model which we are developing focuses more explicitly on the behavior assumed to underly observed changes in medical care utilization than the IIASA, or IIASA related models. Most economic modelling in the U.S. dealing with the demand for health care makes use of standard neoclassical assumptions. Individuals are assumed to be rational welfare maximizing consumers whose demand for medical care is a function of their income, relative prices and tastes. We adopt this model, noting that while money prices may only be important in the U.S. or in countries with market oriented health plans, time prices are important in both planned as well as market economies. We anticipate estimating separate demand equations for different types of medical care and possibly also by severity of illness. Thus, separate demand equations will be estimated for ambulatory physician care, hospital care, dental care, and prescribed medicines. We also anticipate distinguishing between entry and non-entry visits on the assumption that entry visits are more likely to reflect individual consumer preferences, and non-entry visits are more likely to reflect the preferences of the medical providers. The data also allows us to analyze the demand for medical care by episode of illness to permit a more refined and precise estimate of the effect of coinsurance and deductibles. We expect to measure demand as quantities of visits, rather than expenditures, in order to facilitate converting predicted values to expenditures in terms of prices in the current year. It is also clear that several of the variables we are interested in may be endogenous to the system and therefore will be estimated using instrumental variables techniques. Economic theory suggests that the quantity demanded, the coinsurance rate, price and possibly disability days are endogenous.

Table 1 shows such a set of demand equations with the general categories of predictor variables expected to be associated with each equation. The number of physician visits demanded per year is shown to be a function of the endogenous net price of care (i.e. gross price times the coinsurance rate), a cross price variable (e.g. per diem for a hospital bed times the inpatient coinsurance rate), health status indices, time price and various demographic characteristics. In the first price equation, the average gross price for the visits in the demand equation is shown to be a function of the endogenous number of visits, waiting time for an appointment, and search costs. In the second price equation the coinsurance rate is shown to be a function of the endogenous number of visits, premium costs, health status and various demographic characteristics. There is some debate as to whether the coinsurance rate is in fact endogenous. The basis for the endogeneity argument is that sicker people buy more complete insurance coverage. This is an hypothesis that we will test empirically. The introduction of an NHI plan, however, is likely to make the coinsurace rate exogeneous. This system of equations will be estimated using a double regression procedure which is a variant of a two-stage least squares estimation.

Table 1

SIMULTANEOUS EQUATION MODEL OF DEMAND

Demand Equation:

#Visits Demanded Per Year	=	f (Endogenous Net Price, Cross Price, Time Price, Population Characteristics)

Price Equations:

Average Gross Price	=	f (Endogenous Physician Visits, Queues, Search)
Coinsurance Rate	=	f (Endogenous Visits, Premiums, Health Status, Population Characteristics)

Supply Equations

The experience of the United States with Medicare and Medicaid has more than adequately demonstrated the futility of ignoring supply considerations in assessing the aggregate costs and distributional effects of a national health plan. Unfortunately, neither the theoretical underpinnings nor the econometric specifications are as well specified on the supply side as they are for demand.

The supply response which has generated the most concern is that of the physician. For purposes of our model, we assume the physician is a utility maximizing owner-manager. Unlike demand, where the expected effects of a change in price are unambiguous, the expected effects of a change in price cannot be determined with respect to the physician's work effort. We must therefore rely on an empirical determination of physician supply behavior.

The system of supply equations we plan to estimate are shown in Table 2. The labor supply equations show hours worked as a function of endogenously determined income, the characteristics of the physician and the characteristics of the physician's practice. Income is treated as endogenous since the marginal productivity of the physician declines as the hours worked increase and this in turn affects income. Income is shown as a function of an endogenously determined price, hours worked, the physician's characteristics and the amount of capital used in the practice. These two equations represent a simple model which could be estimated by means of two-stage least squares. A more complete model would include a production function and a price equation. Output here is shown as a function of the physician's own input and the inputs of other factors of production. Price is determined by the endogenously determined quantity of visits, the physician's own characteristics and the characteristics of the physician's practice. This system of equations would yield predicted responses to changes in the supply price for the physician's hours worked and quantity of visits supplied.

Table 2
SIMULTANEOUS EQUATIONS MODEL OF PHYSICIAN SUPPLY

Labor Supply Equation:
Hours Worked = f (Endogenous Income, Physician Characteristics, Characteristics of Practice)

Income Equation:
Income = f (Endogenous Price, Hours Worked, Physician Characteristics, Physician Capital in Practice)

Production Equation:
Visits Per Week or Year = f (Physicians Hours Worked, Inputs of Other Factors)

Price Equations:
Price of Output = f (Visits Per Week, Physician Characteristics, Characteristics of Practice, "Quality")

The data available from NMCES will allow us to calculate demand and supply in each of the market areas in our sample, aggregate across market areas, and calculate regional and national expenditures on health care. Although the NMCES sample will only allow us to present disaggregated estimates of supply and demand at the Census division level or above, we will be able to allow disequilibrium between demand and supply to occur below this level, at the local market area. Money price and time price can then be allowed to adjust in order to bring the market back in equilibrium. This will be especially important when we allow the coinsurance rate to vary or the physician fee schedule to change as part of the analyses of an NHI proposal.

To illustrate how the model would work, assume that a national health insurance proposal is introduced which changes only the share of the bill which the individual pays for ambulatory care. In this case, the coinsurance rate is exogenously determined and would no longer be regarded as an endogenous variable. The demand for physician visits is estimated using visits and the gross price of the visit as endogenous variables. The net price of the visit would be the specified coinsurance rate times the gross price faced by the individual in his own market area. Aggregating these predicted values across individuals in a market area will give us the number of visits which would need to be supplied in a given area to meet demand. These estimates could be valued in money terms and aggregated to yield a dollar amount which would need to be financed by the tax transfer portion of the model in order to meet demand. In a proposal which did not change any of the values in the supply equations, estimates of the visits supplied in the market area would come from the observed values. If the initial estimates of the quantity of visits demanded and the quantity of visits supplied in an area are not equal, we can assume either that gross money prices would adjust or that queuing would develop (i.e., the time price adjust) or some combination of the two. Several sets of time and price adjustments could be postulated depending on one's views regarding politically "allowable" levels of price increase in a given period or the speed with which the market can adjust to local disequilibriums. Because time price is a variable in the demand equation and gross money price a variable in both the supply and demand equations, both the supply of visits and the demand for visits could be re-estimated until equilibrium is attained. Given assumptions about the rate at which prices adjust and the implicit time adjustments required, the adjustment paths toward equilibrium could be plotted in the local market areas. The dollar cost of the visits produced at equilibrium would be aggregated across individuals and across markets to produce the required amount that would need to be financed under a National Health Insurance system.

If in addition to changing the coinsurance rate, a mandatory fee schedule were introduced, the system changes are more numerous. The model would proceed in the same manner altering the appropriate exogenous variables to specified levels, predicting new levels of supply and demand, allowing local markets to come to equilibrium through combinations of time and money price adjustments, aggregating the implied costs of such a program across market areas and financing the program.

All of this can be explained conceptually in just a few words. Actually implementing the model is a major undertaking which will develop over the next several years. Our initial efforts will focus on short run changes resulting from NHI proposals which produce only limited changes in the system. Over time, greater complexity will be introduced into the model, allowing us to estimate the effects of more generalized changes in a dynamic setting.

ON THE ANALYSIS OF REGIONAL HEALTH SERVICE UTILIZATION

P. Ruotsalainen, P. Nokso-Koivisto

INTRODUCTION

Health care service systems (HCS) form a very complex socio-economic process. Many system analytical studies, analyses, models and simulations are shown in the literature [1],[2]. Most of them are operating at a national or global level and it seems that HCS modeling is value to decision makers at national and higher levels [5]. Our study operates at a regional level (district in IIASA terminology) and has a starting point "from bottom up".

The hospital system in Finland is strictly regionalized, urgencies are nearly the only exceptions. The fundamental tenet of the hospital in Finland is mainly of local and regional responsabilities. The hospital care is provided by the communes. Hospitals are superintended by medical officers of health (provincial) and by the National Board of Health. The country has been divided into central hospital districts (CHD) for general hospital care (population in Tampere CHD is 350.000 and included 34 communes). There is one central hospital (CH) in each district and it services the whole district. Local hospitals (LH) are owned by one or two communes and services their own population. Primary health care centers (PHCC) are also owned by communes or communal federation and they service patients of their own area. So the structure inside a district is hierarchically organized in the mind of organization and hospital use. In the first phase of our study we are analyzing only the hospital system, outpatients and private sector are out of focus because of the scattered statistics, but it is also possible to discover reliable data from private sectors.

GOALS OF THE STUDY

Our first focus is to analyze and describe the HCS use at a district level. Other interesting problems are:

- model the present HCS use of population at a district level
- find and explain differences between communes and districts of use of hospital care
- try to develop a resource allocation method for planners and calculate alternative allocation plans for them
- study the hierarchical structure of HCS and develop a simulation model for calculating resource sharing alternatives between hiearchical levels.

Later we hope to use our methodology at a national level. We also hope that we can try to check the usefulness of IIASA's models at our district level (and also at a national level).

SPECIAL FEATURES OF REGIONAL ANALYSIS

Our country has a very unique HCS statistic. The information which includes personal data but also diagnoses and facts about the place of treatement, etc. forms a nationwide databank [3],[4]. It is based on individual reports and accordingly the aggregation is possible at any level and in all directions. At national level it is possible to operate with mean values and so bypass the stochastic nature of health care activities, but at communal level the situation differs. Numbers are in most cases so small that the use of standard statistical methods is impossible, especially if the whole range of rare diagnoses is included. At the level of communes it is difficult to discover any rules how the HCS use and supply is organized. Table 1 shows

Table 1 Tampere Central hospital district 1977, health service use distribution (tot. number of communes 34)

	TCH	DH	MH	PHCC
Mean value of use	37%	19%	31%	13%
Commune group 1 mean	64%	0%	36%	0%
Commune GR 2 mean	26%	6%	63%	5%
Commune GR 3 mean	32%	67%	0%	1%
Some separate commune % values				
VR	96	1	0	3
UR	77	3	0	20
KU	6	36	58	0
VKL	22	78	0	0
NKA	32	0	35	33
LÄ	24	1	50	25

Symbols: TCH = Tampere Central Hospital, DH= District Hospital
MH = Mental Hospital , PHCC=Primary Health Care Center

one example from Tampere district. Mean values show that in 1977 37% of hospital use is CH use and only 13% PHCC use, but some communes use nearly only CH and some other only mental hospital and PHCC. Therefore we are trying to develop a new methodology for handling communal level data for planning and modeling.

For modeling, the dynamic linear programing method (DLP) is good at a national level, but its usefulness at a district level is very interesting but open to question. Our aim is to test its usefulness. Because the variation in data at a district level is high, it is necessary to check the validity of collected data, and pick up all anomalies and methodical variations between communes.

A third question is the possible "saturation" of demand resources at community level. Principally demanded resources are directly related to available resources and it seems that saturation is impossible. But at communal level when the quality of use is taken into account, we can find that at a certain level of supply the quality of use is changing. This means that we are servicing illnesses better and sooner and taking in more types of illnesses. Our preliminary data shows that this kind of "saturation" is possible in some communes and we are trying to model the situation. The need of hospital demand is basically a function of age and sex distributions and of the socio-economic status of population. Also the level used medicine has an influence. Because we have very good databank on hospital use, diagnoses, etc. it is possible to calculate from "known" incidence, prevalence and death rate forward, number of needed beds, contacts, etc. Further, we can continue and model resource allocation problems inside the district and between different hierarchical levels.

The quality of use is also important because, as mentioned earlier in Table 1, it is in practice possible to service the same kind of diseases in central or mental hospital or in PHCC. But CH day costs about three times as much as PHCC day. This is a kind of internal "elasticity" in health care at district level.

Practically we must try to minimize this effect so that at every hierarchical level of HCS we use right number of beds for right diseases.

USED PARAMETERS

In our study, we are using the standard data collected yearly from hospitals and other service units. We are testing this data if it is useful and valid or what kind of new numbers are needed for modeling and calculating resource allocation choices. Basic parameters are:

- contacts of doctors, nurses and non-medical persons
- number of beds
- average stay and number of patients
- used manpower
- non-labor costs

Because diseases are dependent on age and sex, it is necessary to divide some parameters to subgroups. We have also many parameteres to describe the commune and its population.

At regional level it is possible to use many parameteres without great difficulties and test which of them are significant (if any).

DISCUSSION

In our country, HCS is developing relatively fast and at the same time the population is ageing. The small difference in mortality shows that infection diseases are under control (also tuberculosis). As in other industrialized countries cancer, different kind of "urbanization disesase" and degenerative diseases cause that continuously the need of service is higher than supply. Because the community has primarily the responsibility to organize and finance the needed service, a resource allocation method is necessary for them.

In our study we are using system theorectical approach for analyzing and modeling HCS at district level. Our aim is also to make a longitudinal study of HCS use among society and analyze its development.

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THE ROLE OF SENSITIVITY ANALYSIS IN HEALTH CARE SYSTEMS MODELLING

Norman T. J. Bailey

1. INTRODUCTION

In the good old days, that is when I was an undergraduate, 'applied mathematics' was my favourite subject. It was more or less synonymous with 'mathematical physics', but the 'physics' could be interpreted in a very broad sense. Statics and dynamics, electricity and magnetism, waves and tides, dynamical meteorology, quantum theory etc. were of course all included. The basic concern was with mathematical theories of what went on in the real world, extremes of mathematical rigour were avoided whenever possible, and the value of the mathematics was ultimately judged by its power in explaining and predicting real phenomena. Nobody talked about 'models'.

Models were of course being used all the time. The Ancient Greeks had done the same, and so had many of their successors. The pace began to accelerate in the seventeenth century, and still continues to do so. As physics is, or was, an exact science, any serious discrepancy between theory and observation meant that the theory was at least partially wrong and needed modification. But with the rise of applied mathematical work in the social and biological sciences somewhere towards the end of the nineteenth century a new element entered the field. The sciences concerned were no longer quite so exact: natural variation tended to blur the clarity obtained in previous mathematical theories. Probabilistic notions had to be used on an increasing scale, and discrepancies between theory and observation no longer meant for sure that the theory was wrong: the discrepancies might be due to chance variation. Hence the development of modern statistics, dating from the work of R. A. Fisher in the 1920's.

Scientists gradually came to be more conscious of the philosophical status of their mathematical theories, when applied in less exact areas than physics. The notion of deliberately constructing a 'mathematical model' of reality seems to have first appeared explicitly in econometrics around 1940, though the use of the term soon became widespread in both the exact and non-exact sciences.

Health care systems modelling as such has appeared only in recent years. It is clearly subject to great natural variation, because of the biological element introduced by the existence of the people who need or receive care and the diseases that threaten them. But it is also liable to the additional uncertainty that arises from all man-made systems (as opposed to naturally occurring systems) where the rules of the game can to some extent be changed arbitrarily. Even when numbers are large enough for statistical variations to be small, there is frequently considerable doubt as to the effective values of large numbers of parameters in the systems, not to mention arguments as to the approximate structure of the system.

In the face of such intrinsic vagueness and uncertainty, many challenging questions arise, not the least of which is 'Why should I believe your model, anyway?' To get somewhere near an answer, or at least guiding methods of arriving at an answer, which may be favourable or unfavourable to the proposed model, we must take a closer look at the role of modelling and the process of validation.

2. THE ROLE OF MODELLING

This is really quite a long story, but I shall have to cut it very short. It seems to me that two very big priority areas in the health field are 'disease control' and 'health services'. In disease control it is of enormous advantage if one has a detailed understanding of the biology and epidemiology of the disease in question. With luck the consequences of any proposed control strategy can then be evaluated in quantitative terms - the associated mathematical theory will consequently have some very practical implications which can be objectively tested. This process has so far been most highly developed in infectious disease control.

Health services, on the other hand, cover a wider and more organizational area, which may in fact contain a number of disease control programmes within it. Questions of planning, administration, management and decision-making tend to take precedence. And I believe it is not unreasonable to see the decision-making aspect as quite central. In any situation there is liable to be a number of possible courses of future action, i.e. the available options or strategies, and a choice has to be made amongst them. Traditionally, the decision-maker has relied on his experience and judgement to predict the likely consequences of any given strategy, and to choose the strategy with the most preferable consequences. But the situations under review are nowadays often so complex that more objective ways of reaching rational decisions are being demanded.

In any case, since decision-makers have their own hypotheses, though they usually try to reach conclusions using words rather than symbols, they are already using a simplified form of modelling. And if models are going to be used, we might as well know as accurately as possible what the consequences would be if the hypotheses were true - this means using a mathematical approach. In particular, when we clearly see the implications of a given theory we may decide to reject it.

Models must therefore be taken seriously, and may be conveniently seen as an interface between the real world, apprehended directly by an epidemiologist or public health administrator, and a theoretical formulation that is susceptible to mathematical or computerised investigation. Models can be very simple like elementary flow-charts, or they may involve detailed dynamics with complicated differential equations. They may be used deductively, to discover the purely logical consequences of a set of assumptions, or they may be used inductively, to explain given data. Models may describe only the surface phenomena of a 'black box', or may attempt to elucidate underlying mechanisms and structures. Again, one can model at a technical or scientific level, an operational level of executive decision-making, or a broad strategic level of overall planning.

3. THE VALIDATION OF MODELLING

We return to the question 'Why should I believe your model?' The development of models is a fascinating activity, but deciding whether they are credible or useful is what finally counts. It is convenient to identify five stages of validation, which I have described in detail elsewhere (Bailey, 1978). To begin with, there are two deductive stages: the first concerned with the general classification of concepts and thought, the second dealing with an in-depth logical analysis to ensure that a model is logically sound and coherent. Then come two inductive stages: the first involving the statistical fitting of the model to real data, and requiring modification or rejection if the fitting fails, the second submitting the model to the even more stringent test of making verifiable predictions. This latter stage is really crucial: for what decision-maker would be impressed by a model that was not capable, within reasonable limits, of making some kind of forecast of future events? The fifth and final stage has to do with 'consumer satisfaction'. No matter how intrinsically good and reliable a model is, it will not be used in real life unless it can be understood and applied in general commonsense terms by those decision-makers whose work the model is designed to facilitate.

This whole matter of justification and validation needs further development. I believe that it is a matter of fact that a large number of health care models proposed today have hardly passed the first of the five stages referred to above. Sooner or later such models will become discredited - perhaps unjustly. If, however, a deliberate attempt were made to face and overcome explicitly the difficulties of all the stages of validation mentioned, some really effective instruments might emerge that were demonstrably capable of giving practical assistance.

Validation should be approached in an open and objective manner. It costs time and money to carry out properly. But if the costs are carefully assessed and explicitly presented it is possible to weigh them against the expected benefits. In this way promising modelling work is not brought to a standstill simply because the logical basis is unclear or the cost of development seems out of proportion. Conversely, modellers who are forced to submit their work to such a validation process undoubtedly benefit from an improved operational programme.

A major aspect of validating models is the problem of sensitivity to uncertainty in the assumptions, already referred to at the end of Section 1. This properly belongs to the second deductive stage of in-depth logical analysis. Even if we have a good model with a generally agreed structure, it may be that there is a large number of parameters whose values are very uncertain. If this affects conclusions about the behaviour of the model in a substantial way, the model may well be useless.

The importance of this is that in practice rigorous criteria of statistical fitting and tested prediction may not be immediately possible. Nevertheless, given a set of reasonable assumptions (implying some kind of model) a decision-maker may ask what the logical conclusions are. If the latter are liable to change considerably for only small variations in the assumptions, then there may be no reliable basis for rational choice, and if so this fact should be known.

4. ELEMENTARY NOTIONS OF UNCERTAINTY

Having just briefly introduced uncertainty and sensitivity analysis into the discussion of model validation, we should now look at these notions in more detail. The use of rough and ready ways of dealing with uncertain information is already a familiar part of commonsense usage. It is exemplified by everyday decision-making based on intuitive judgements, where one has to balance up intuitively the pros and cons of the different possibilities: e.g. a lady says, "I want to wear my new hat today, and I hope that it won't rain. If it rains the hat will be ruined, though I could carry an umbrella. But an umbrella is a nuisance, and the one I have doesn't match the hat, etc."

While excessive logical analysis of the recurrent events of everyday life may be inappropriate in practice, it is clear that there is a widespread appreciation of the fact that uncertainty in assumptions leads to uncertainty in conclusions, and that this must be handled in some kind of probabilistic terms. Hence the widespread use of such qualifying phrases as "probably about right", "probably not too far off", "probably unlikely", "there is a reasonable chance that", etc. All this is, however, highly subjective though often dealing with intensely practical issues.

Another important aspect occurs in simple arithmetical calculations where we may have to be especially careful with the number of significant figures involved. The possibility of a serious loss of accuracy when a denominator consists of the difference between two not very dissimilar numbers is well-known. Although involving only elementary school-level mathematics, this difficulty is often ignored by the higher-level practitioners of numerical computing. Consider, for example, the calculation:

$$\frac{5.0}{5.1 - 4.9} = 25. \qquad (1)$$

An error of half a unit in the decimal place of the numerator, e.g. 5.05 instead of 5.0, means an overall error of no more than one per cent in the answer. But similar errors in opposite directions in the two numbers in the denominator can lead to the answer being out by a factor of <u>two</u>, e.g.

$$\frac{5.0}{5.05 - 4.95} = 50. \qquad (2)$$

Of course, this would be an extreme case, and with a random distribution of errors the quantities in 5.1 and 4.9, the error in the figure of 25 would in general be much smaller but would have its own statistical distribution. But it is not difficult to show that, if the error distributions of the three numbers on the left are independent and all have the same coefficient of variation, then the coefficient of variation of the answer is about 35 times as great!

This can easily be shown by considering

$$y = \frac{a}{b-c}, \tag{3}$$

where $\underline{b}$ and $\underline{c}$ are approximately equal to $\underline{a}$. Following a standard procedure, we take small increments of both sides, square and then take expectations. When the distributions are independent we easily find

$$C_y/C \doteq (1 + 2y^2)^{\frac{1}{2}}, \tag{4}$$

where $\underline{C}$ is the common coefficient of variation for $\underline{a}$, $\underline{b}$ and $\underline{c}$; and $\underline{C_y}$ the corresponding quantity for $\underline{y}$. With $\underline{y} = 25$ in (4), the result follows.

5. SIMPLE SENSITIVITY ANALYSIS

Whatever the errors or uncertainties in our assumptions, whether they are simple numerical values, more sophisticated parameters, or system structure, we want to know the consequences for any derived results that might be of practical importance to us. An example from over 200 years ago is in the work of Daniel Bernoulli, who in 1760 (see Bailey, 1975) was investigating the expected public health consequences of variolation (i.e. inoculation, in distinction to the then unknown vaccination) in combating the effects of smallpox. He constructed a mathematical model, derived and solved the relevant differential equations, and showed that if inoculation were completely effective there would be a gain of three years in the average life expectancy. He showed, in addition, that, if the risk of dying from the inoculation itself were at what he regarded as the upper limit, the increased life expectancy would be reduced by less than two months. A more recent example is in tuberculosis control, where Feldstein, Piot & Sundaresan (1973) showed, in their treatment of resource allocation problems, that the consequences for decision-making were very insensitive to variations in a number of demographic and epidemiological parameters.

However, when a model has a large number of parameters, it is impossible to examine all their interacting effects in an ad hoc way, especially when using computer simulations. And the selection of a small number of supposedly critical parameters may be affected by unconscious bias. It is better therefore to try to assess the effect of variations in all parameters simultaneously to see what the total effect might be, and to identify by actual investigation rather than intuitive guesswork the relevant contributions of the different parameters to the uncertainty in results.

In certain engineering applications it is sometimes possible to side-step some of these difficulties by the following device. Suppose that in the design of a rocket there are five components, each of which is characterised by a single index and believed on strong a priori grounds to have little effect on performance. Appropriate upper and lower bounds are set for each specification, giving a total of $2^5 = 32$ combinations. The relevant computations, carried out directly or by simulation as the case may be, are completed for all 32 combinations. If one is lucky the performance figures will not differ appreciably amongst the alternatives, and one could then say with strong justification that the performance was insensitive to variations in the five factors concerned.

However, if the number of factors was much larger, and if it were essential to work with a distribution of values for each specification, the work required might become astronomical in time and cost. Of course, even with a favourable theoretical sensitivity investigation the presumed predictions of performance still have to be validated by actual experimental testing.

6. GENERAL SENSITIVITY ANALYSIS

A theoretical basis for general sensitivity theory has been well developed in control theory, for which the standard text of Tomović & Vukobratović (1972) may be consulted. In handling a well-defined dynamic system the essence of the approach is to define a matrix of sensitivity functions which are given by the partial differential coefficients of the system state variables with regard to the parameters involved. Thus if the basic model entails k differential equations with p parameters, it can be shown that kp additional differential equations for the sensitivity functions can be specified. The whole system thus contains $k(p+1)$ simultaneous differential equations. These are usually too complicated for explicit analytical solution, but can be dealt with by standard computerised techniques of numerical integration. Special devices are, however, required to handle expeditiously the considerable complexity thus arising. Again, there are difficulties of interpreting the results in practical applications.

The general theory is of course very powerful, and provides required solutions in continuous time. In principle, we can envisage a deterministic model with k compartments, whose state variables at time t are given by the column vector $\mathbf{x} \equiv \{x_i\}$, $i = 1, \ldots, k$. Also, let there be p essential parameters indicated by $\boldsymbol{\theta} \equiv \{\theta_j\}$, $j = 1, \ldots, p$. The dynamic equations of the system are

$$\partial\mathbf{x}/\partial t = \mathbf{f}(\mathbf{x}, \boldsymbol{\theta}, t), \qquad (5)$$

where $\mathbf{f}$ is a vector of functions reflecting the model structure. There is a large literature on the general qualitative behaviour of such systems (e.g. Brauer & Nohel, 1969).

In principle, we solve (5) to give

$$\mathbf{x} \equiv \mathbf{x}(\boldsymbol{\theta}, t). \qquad (6)$$

The sensitivity matrix $\mathbf{H}$ is accordingly defined by

$$\mathbf{H} \equiv \{h_{ij}\} \equiv \{\partial x_i/\partial\theta_j\}. \qquad (7)$$

If we further write

$$\mathbf{F} \equiv \{\partial f_i/\partial x_j\},\ \mathbf{G} \equiv \{\partial f_i/\partial\theta_j\}, \qquad (8)$$

it is not difficult to show that

$$\partial\mathbf{H}/\partial t = \mathbf{F}\,\mathbf{H} + \mathbf{G} \qquad (9)$$

Computationally, we can combine the sets of equations in (5) and (9) for the purpose of numerical integration, giving a single enlarged set of $k(p+1)$ simultaneous differential equations.

Suppose that we now consider the multivariate prior distribution of small variations in $\boldsymbol{\theta}$, with mean value $\boldsymbol{\theta}_0$ and covariance matrix $\mathbf{V}(\boldsymbol{\theta})$. Taking a small increment in $\mathbf{x}$, supposed known for some given t, yields

$$\delta\mathbf{x} = \mathbf{H}\delta\boldsymbol{\theta}. \qquad (10)$$

If we now write $\mathbf{V}(\mathbf{x})$ for the covariance matrix of $\mathbf{x}$, it quickly follows that

$$\mathbf{V}(\mathbf{x}) = E(\delta\mathbf{x})(\delta\mathbf{x})' = \mathbf{H}\mathbf{V}(\boldsymbol{\theta})\mathbf{H}'. \qquad (11)$$

The derivation of $\mathbf{V}(\mathbf{x})$, given $\mathbf{V}(\boldsymbol{\theta})$ and $\mathbf{H}$, thus reduces to straightforward matrix manipulations.

If, in particular, we concentrate on steady states we put the partial differential coefficients in (5) and (9) equal to zero. The equation corresponding to (5) is then simply

$$\mathbf{f}(\mathbf{x}, \boldsymbol{\theta}) = 0, \qquad (12)$$

with a solution corresponding to (6) given by

$$\underset{\sim}{x} \equiv \underset{\sim}{x}(\underset{\sim}{\theta}). \tag{13}$$

In particular, equation (9) gives $\underset{\sim}{H}$ as

$$\underset{\sim}{H} = -\underset{\sim}{F}^{-1}\underset{\sim}{G}. \tag{14}$$

In the special case where the θ_j are uncorrelated, and writing $\mathrm{var}(\theta_j) = \sigma_j^2$, we have the simple result that

$$\mathrm{var}(x_i) = \sum_{j=1}^{p} h_{ij}^2\,\sigma_j^2. \tag{15}$$

Thus we can easily identify those parameters to which any given $\underline{x}_i$ is most sensitive, and perhaps take appropriate steps to improve the corresponding prior distributions.

7. TYPHOID MODEL APPLICATION

It is uncommon to find any developed use of sensitivity analysis in epidemiology (see Section 5 for isolated references), although quite complex models with large numbers of parameters, especially in infectious disease control, are often used to provide general orientation (see Bailey, 1975). In order to investigate possible implications Bailey & Duppenthaler (1979) reported briefly on their analysis of the well-documented simulation model of typhoid fever developed by Cvjetanović, Grab & Uemura (1971). This has a total of ten compartments, and over 20 parameters.

So far as steady states were concerned, it turned out to be possible, using a technique due to Békéssy (1971), to solve the basic equations directly in spite of certain nonlinear aspects, thus avoiding extensive computer simulation altogether. The influence of uncertainties in parametric values on model behaviour was illustrated by supposing all parameters to have the same prior coefficient of variation, $\underline{C}$. For one typical endemic level of disease, well above the threshold with about 57% of the population affected in one way or another, the percentages of population in the individual states could be estimated with coefficients of variation around $2\underline{C}$. Although this result would be quite gratifying if $\underline{C} = 0.1$, far higher values than this could easily occur in practice making all derived estimates unusable. Moreover, as one came closer to the threshold with lower endemic levels, only the coefficient of variation for the percentage of susceptibles remained around 2C: the remaining classes showed coefficients that increased rapidly.

It could also be seen that the main contributions to variations in the estimated proportions of susceptibles came from only six parameters out of a total of 22. Two of these, the infection-rate and the birth/death rate, each contributed about a quarter of the total variance involved.

The extent to which overall qualitative conclusions could be trusted in any actual application would therefore depend on whether the most sensitive parameters were known with sufficient accuracy. General impressions are unlikely to be reliable, and it may be concluded that specific models for any infectious disease should be investigated individually in the manner indicated.

8. IMPLICATIONS FOR LARGE HEALTH CARE SYSTEMS

Many systems are very much larger than the typhoid model of Cvjetanović et al., and questions of their sensitivity status may occur in a much more acute form. System dynamics models occur with scores, if not hundreds, of compartments, and with thousands of parameters. (For example, Mesarovic & Pestel, 1975, say in a footnote to p.34 that "In our model about 100 000 relationships are stored in the computer, as compared to a few hundred in other well-known world models.") Epidemiologically relevant problems occur even more acutely in polyparasitic disease situations where populations are simultaneously afflicted with several complex and mutually interacting diseases. A typical and urgent problem is where the expected benefits from irrigation schemes, involving the construction of dams and artificial lakes, are liable to be offset by health problems arising from the increased incidence of malaria and schistosomiasis.

Similar considerations also apply to a whole range of health care models, some of which have quite complex structures combined with an extensive parameter set. Such models may well satisfy some of the validation criteria of Section 3, e.g. in regard to clarifying concepts or exhibiting an internally coherent structure. But their computed behaviour may easily be subject to very large uncertainties if the parameters involved are numerous and known to only low orders of accuracy.

It follows that health care systems models should be systematically examined for their sensitivity characteristics, lest the multiplicity of parameters and complexity of structure preclude the derivation of any meaningful conclusions. This seems a task which IIASA is especially equipped to promote or carry out. The use of sensitivity analysis is widely developed in the area of control theory, but the methods adopted may need specially tailored modifications if they are to be successfully applied to modelling for disease control and health care delivery, as well as to other operational and systems aspects of the health field.

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TOWARDS SYSTEMS ANALYSES OF HEALTH SERVICES IN THE FEDERAL REPUBLIC OF GERMANY

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1. INTRODUCTION

Systematic analyses of health services in the Federal Republic of Germany are still in their beginnings. Three different approaches dominate the current discussion:

1. General proclamations in favour of interdisciplinary systems analyses of a "complex dynamic social system" as the health services are labeled.1
2. Broad scepticism as to the presumed untheoretical nature of systems analyses due to confounding simple graphs with systems analyses.2
3. Naive imitation of studies carried out in countries with considerable tradition in health services research.3

Proclamations favouring systematic health services research general scepticism for it and naive imitation of foreign analyses of health systems are symptoms of infancy of the interdisciplinary and systems oriented health services research in the FRG. A sudden development towards maturity is not in sight.

For this reason, we can only mention some ongoing research projects, which might serve as starting points towards a systems oriented health services research. In order to understand these projects, it will be necessary to outline their scientific and political background and some of their preliminary results. Last but not least, we would like to point out some methodological problems which must be solved, if that area of research and action is not to be mere empirics but rather methodologically and theoretically sound as well. Especially elusory is the hope for a sudden growth of health services research through naive imitation of foreign studies. Systematic health services research, as we understand it, must stem from concrete realities. We cannot detail all the special features of structure and process of our health system here: self administration, sectoral division of labour among drug delivery, outpatient, inpatient and public health care, fee-for-service-system, and the impact of the tradition of an almost general social insurance. All this must be considered, if one does not want to efface history, society and reality in systems research.

2. POLITICAL AND INSTITUTIONAL BACKGROUND

Part of this reality is that health services research in the FRG has got strong impulses from health care organizations outside the universities. We shall mention only some research groups dealing predominantly with outpatient care.

The Federal Association of Sickness Fund Affiliated Physicians and their regional organizations founded a "Central Institute" in 1973, in order to do "research...in the field of outpatient care by physicians".[4] One of the most important legal counterparts of this physicians association is the Federal Association of Local Sickness Funds which in 1976 founded the "Scientific Insititute of Local Sickness Funds" to carry out "research and training in the area of obligatory health insurance" with the obligation that the research should have practical significance.[5] A private "Institute for Health Systems Research" was founded in Kiel in the same year.[6] At the same time, the non-university "Science Center" at Berlin set up an "International Institute for Comparative Social Research"; the main topic of studies there is health systems research.[7] In 1978, the Hartmann-Union, which is more or less a union-like interest group of physicians in the FRG, founded the "Scientific Institute of German Physicians". In 1979, the "Institute for Medical Data Processing" of the "Society for Radiation and Environmental Research", which is totally financed by the Federal Ministry for Research and Technology and by the Free State of Bavaria, was transformed into an "Institute for Medical Informatics and Health Services Research" (MEDIS). The "Health Care Research Group Berlin" is the only larger university affiliated institute in health services research.[8]

The background of these research institutions indicates that the "level of politics"[9] is the core of beginning health services research in the FRG. Most of the research projects of the mentioned institutes underline this. In no way, however, do we want to imply that their scientific work is biased by this political origin. A non-political research--and this is not in the sense of party disputes--does not seem possible at all, and has no meaning. We want to discuss this later on under methodological points of views.

The increase in expenditure for health systems research seems to be proportional to the cost explosion in health services. Are these expenditures nonproductive? Do we build pyramids a la Keynes, in order to give jobs to otherwise unemployed epidemiologists, social scientists, mathematicians, statisticians and biomedical specialists? The claim of the existing health services research institutes and the hope of their financing bodies is different. The institutes above are heavily involved in applied research which should help to discuss and to fulfill legislative innovations in the General Insurance Laws (RVO). A lot of research activities were, and still are, related to the "Law for the Further Development of Sickness Funds" (KWG) from 1976, which aims at changing the spacial distribution of physicians in certain regions. Other research activities tried to fulfill the "Sickness Funds Cost Containment Law" (KVKG) from 1977, a law for cost containment which has structural implications. The "Federal Government's Program for Promotion of Research and Development of Health, 1978-1981" supports with a considerable amount of DM 450 million, especially such research which leads to the "utilization of existing knowledge of health assurance and health care" so that "discussions on health policy will be more rational by means of objective scientific results".[10]

From the beginning most approaches towards systems research in the FRG have been imbedded in the "level of politics", which means in our political and historical constellation: the level of interests and conflicts and the level of bargaining over priorities and resources between different groups and organizations. This feature of the FRG's health system has been institutionalized through the "Sickness Funds Cost Containment Law" since 1977 as a "Concerted Action in Health Care"; all relevant interest groups in the health care delivery system (legal sickness funds, physicians, odontologists, associations of hospitals, pharmacists, pharmaceutical industry, trade unions, employers associations, representatives from the Laender and the communities) are obliged to meet twice a year with the Federal Minister of Labour and Social Affairs "to discuss and to develop

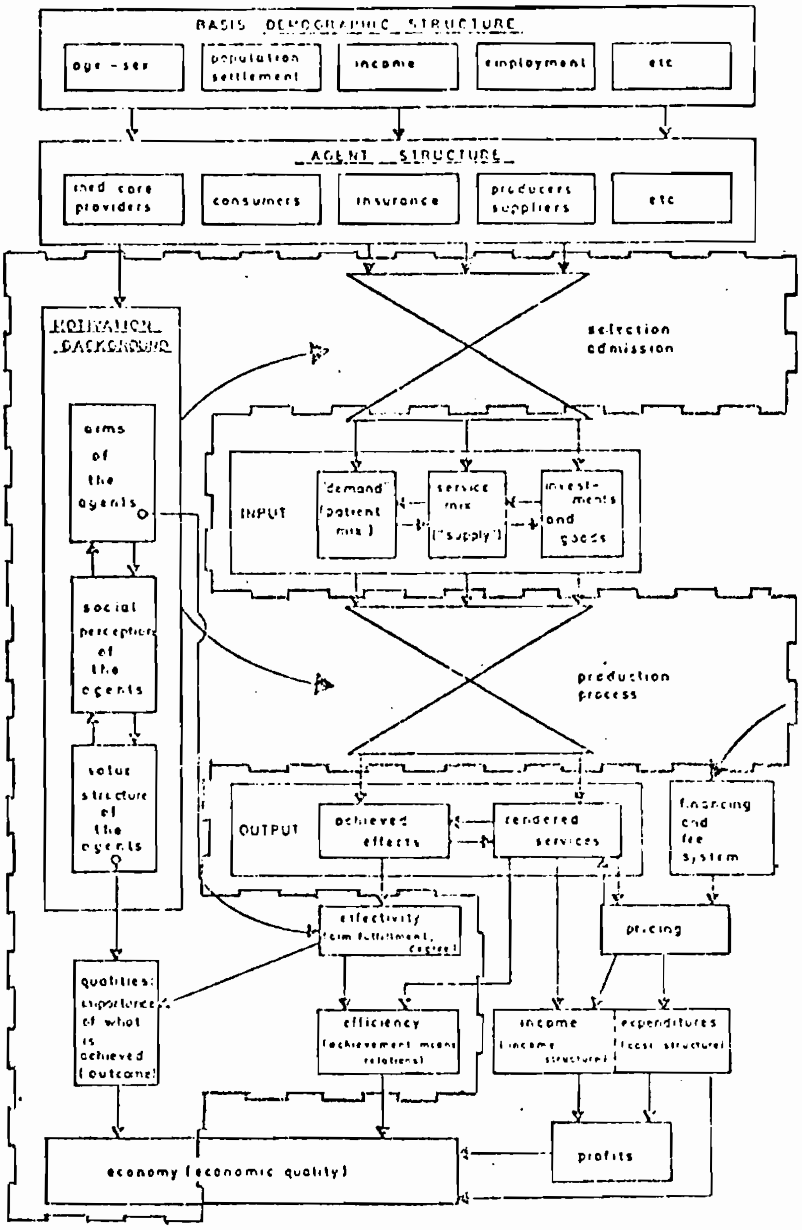
1. medical and economical data or orientation, and
2. to suggest proposals for rationalization, increasing effectivity and efficiency in the health services",

"with the common goal of a health care system according to need, based on the state of art, of medical sciences and according to a balanced distribution of costs".[11]

Without mentioning this political background of health services research in the FRG, it is not possible to understand the current systematic and interdisciplinary studies about aspects of the health care delivery system in our country.

3. SOME ASPECTS AND FALLACIES

The federal program for reseach promotion in the health field stresses the following assessment criteria: equity, performance, need orientation, efficiency, capability of financing.[12] Similar notions are known from the discussion about criteria for evaluation in the health field.[13] In order to make such judgements, reliable and valid information about the most important areas of health services are needed. Figure 1 outlines some aspects of structure and process of health care.



___ = up till now insufficiently analyzed research regions

Figure 1. Aspects of systems analysis

These aspects are presented in their assumed connection: demographic structure, structure of providers, interest structure, economic structure and input-output structure. The figure also shows that some areas are still too little explored, especially the connection between input and output, i.e. the processes of selection and production, the problem of the interest structure and, last but not least, the question of output and outcome of health services. Without research in these fields, the health services cannot be judged to the above mentioned "political criteria".

Health services are not material objects of natural scientific research, but rather a part of society and social life. Therefore, merely statistical descriptions of the systems elements are no suitable basis of systems research. Since we are dealing with a dynamic, social and interacting system, we have to avoid at least three fallacies:

1. The fallacy of aggregation: it is understandable that health care systems research tends to start with the existing body of information. In the FRG we do have an immense body of routine data on physicians services. This data is based on our fee-for-service system and aggregated into national statistics. When one looks closely at the quality of information by means of going into details of data generation in the individual practice, then one often is confronted with very grim processing problems and quality distortions. The only solution then seems to be to undertake case studies on a more or less microscopic level, in order to get reliable and valid data. This solution indicates a difficult dilemna for systematic health services research which tries to be precise and methodically sound, without loosing actuality and political significance at the same time. Actual political decisions, if based on data at all, are based on routine data, but these data often may not be reliable and valid.

2. The fallacy of neutrality: as in every realm of social life, there are also interest conflicts in the health services, i.e. conflicts between providers and consumers among various groups which offer competing services, between physician and administration. Social and economic interests intervene in the process of data generation and coagulation, especially when it comes to data which is to be used for control, steering and payment of services. Data and information are mirror images of a social man-made, not natural reality. This reality contains conflicts among goals, needs and interests. Data is therefore one instrument for the realization of interests and for carrying out interest conflicts. Hence routine data on health services cannot be seen as neutral mirror images of health care reality. In our view, the concept of need in most cases is only a fake substitute for the concept of demand.

3. The fallacy of tradition: Historical development has given every health system its special form with respect to boundaries and interaction of the various system parts. In the FRG, the division of labour between outpatient and inpatient care with only a small amount of inpatient care by non-hospital physicians and a small amount of

outpatient care by teaching hospitals has led to the situation that relatively little is known about the connection between these two system parts. The same is true for the connection between institutionalized health insurance and health care in the lay system. The functional relativity of such historically grown boundaries between various system classes manifests itself most clearly through the comparison of health systems in different countries. An applied health care systems research which, for example, does not know about alternatives to primary health care practised in other societies not only falls into the trap of tradition but cannot fulfill the demands of a scientific--and science is always international--assessment of health care.

These three fallacies or traps in which the systematic and analytic research of health services can fall into are especially important to overcome if such system analysis is to contribute to evaluating the health services system under the aspects of need-relatedness, equity, performance, efficiency, capability of financing, and last but not least, under the aspect of relevancy of a provider oriented health care system.

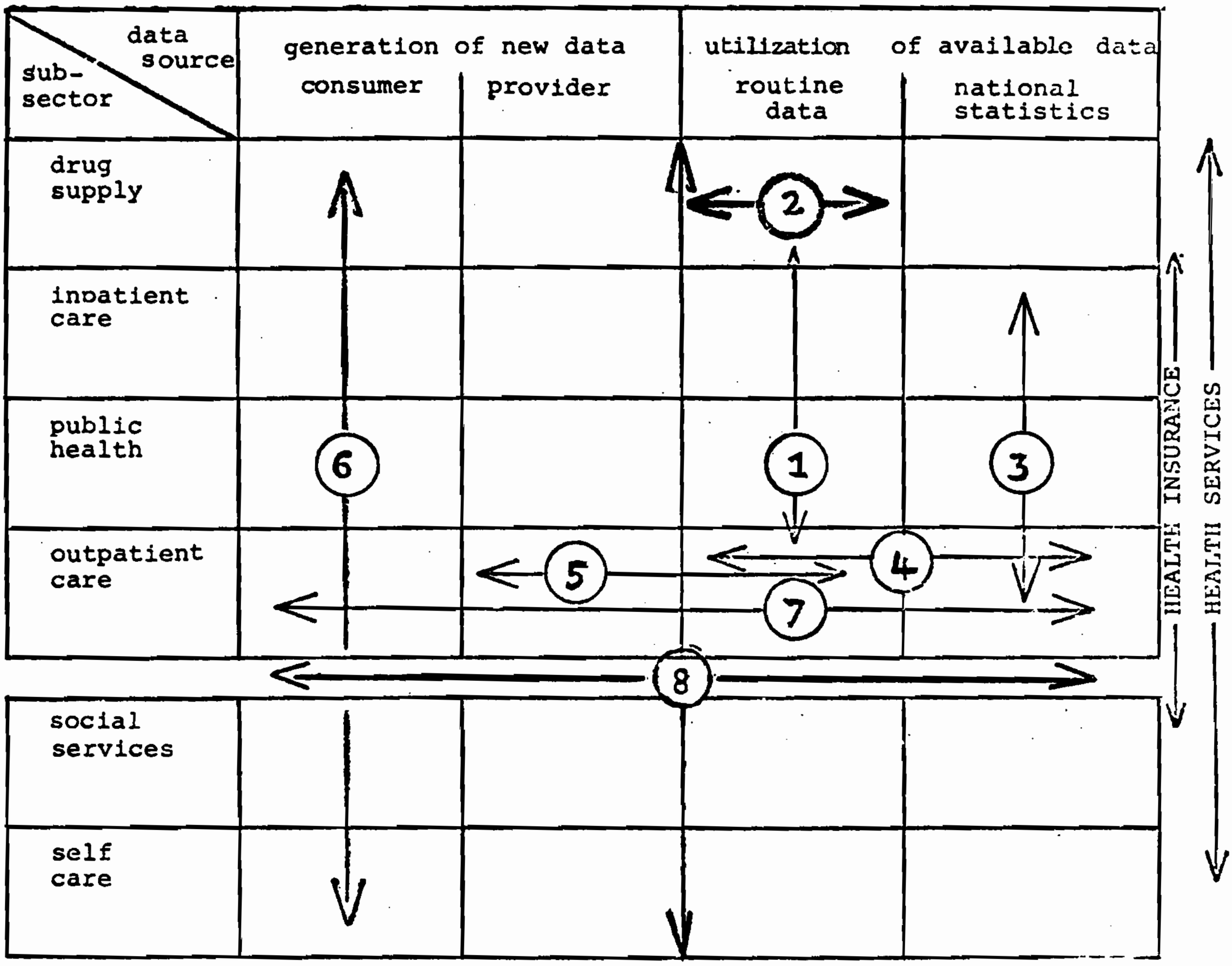
4. EMPIRICAL ENDEAVOURS

Considering the infancy of health services research in the FRG, the logical tendency is to begin with the available data. This data relates above all to aspects within the traditional subsectors of health services: inpatient care, outpatient care, public health services and drug supply. In order to get rid of the three above mentioned fallacies--aggregation, neutrality and tradition--it seems reasonable to examine some of the current research projects as to:

- whether they work entirely with aggregated data,
- or with data stemming from the routine process of sectoral health care,
- or also with procedures trying to explain the background and origin of data.

The greatly simplified Figure 2 attempts to reduce the multi-dimensional topic to only two dimensions. This figure shows some complex research programs which are presently being worked on in the FRG.

FIGURE 2: SOME APPROACHES TOWARDS SYSTEMS ANALYSIS OF HEALTH SERVICES IN THE FRG



Example of Ongoing Projects

1. Social class, illness and use of health services (Jahn)
2. Evaluation of drug prescription (Greiser)
3. Prognoses of physicians supply (ZI, WIDO, IGSF)
4. Spacial allocation of physicians (ZI, WIDO, IGSF)
5. Verden-Study (Moehr)
6. Medical-sociological research (Badura)
7. Analysis of outpatient care (ZI)
8. Intervention studies

This illustration indicates that the evaluation of routine data is considered most important. This class of projects deals essentially with collection, storage and analysis of information which is contained in the accounting forms, used primarily for paying out the physician for his services rendered. The basis for this data is therefore the highly differentiated fee-for-services-system in the FRG. One of the most ambitious projects of this type[14] tried to collect all treatment forms from a sample of insured persons in a local sickness fund during several years. All different kinds of treatment forms were collected, giving information about inpatient care, physicians visits, dental care, drug prescriptions for instance. This data on services rendered is combined with data about diagnosis and social characteristics of the insured persons. The goal of the project is to find differences both in the course of illness and in the pattern of utilization of health services due to differences in social class.

Another class of research projects bases itself on data and information as it is available on the national level. Similar projects of the various above mentioned institutes[15] try to get prognoses about the future supply of physicians, using for this projection highly aggregated national statistics about students, universities, migration for example. The aim of these projects is to clarify unforeseen and unintended consequences of a non-existing regulation of physicians supply.

Only a few studies relate to what actually occurs in the physicians' practices from the point of view of the providers[16], checking simultaneously the descriptive values of routine data obtained from the practice. If compared with the preliminary results of studies based on aggregated routine data, the results of such studies arise serious doubts about the descriptive and analytical value of routine data. It can be seen, for example, that routine data cannot possibly include all the background information which is necessary for interpretation, e.g the demands of patients, the communication between physicians and the involvement of paramedical personnel. The goal of examining practices is to give light to the real activities of the physician as opposed to what appears on accounting forms to be physicians' activities. A fourth class of research projects concentrates on specific aspects of health services as seen and experienced by consumers. This medical-sociological research deals mainly with patient behaviour and patient careers as well as with aspects of the lay system. We can only mention that a variety of such research projects is carried out in the FRG at the moment.[17]

Very rarely the attempt is made to join the different levels mentioned above with one another, trying to avoid the fallacies mentioned at the beginning. One of these projects[18] attempts to check the descriptive value of routine data on a regional level by means of comparing them with more or less qualitative data on the history of data generation in the provider-consumer interaction. This comparison tries to enlighten the basic constellations of interest in the process of data production and to check by means of that, reliability and validity of routine data. Concurrently plausibility checks of routine data are attempted, comparing it with macrostatistics from other sources, i.e., with highly aggregated socio-economic data about demographic industrial and other characteristics of regions. By means of comparison the third fallacy may also be avoided: We step over the border of health related subsectors with the help of macrostatistics in calculating, for instance, the regression coefficients on the substitution of inpatient care by outpatient care on a regional level. We also try to step over the border of the system in the more microscopic way of looking at the physician-patient relationship. But nevertheless, there remain uncertainties in relationships among the traditional subsectors in the health services and between professional and lay services, being based on the fact that this project concentrates on outpatient care and not on the more interesting research area between outpatient and other care. There is a double goal to this project: to call attention to data quality and at the same time to produce first results on differences in the use and delivery of outpatient health services.

Especially the third fallacy--that of tradition--is to be overcome in a currently starting project on the cost-effectiveness of different community oriented interventions with the objective to reduce the risk of cardio-vascular diseases and malign neoplasms by primary prevention. This project[19] will be financed by the Federal Ministries. The fallacy can here be met by two approaches: once, by studying the relevance of intervention particularly with respect to unintentional side effects and secular trends, and then, by exceeding the traditional sub-sectors of health services, including social services and self care. In this project a shift takes place from an insurance oriented systems analysis to a health oriented systems research.

5. PRELIMINARY RESULTS OF HEALTH SERVICES RESEARCH

The above mentioned studies are not finished yet. Up till now, only preliminary results are available. They may be outdated very soon. Let us give you a short overview from the methodological point of view.

5.1 Data Coverage

The majority of routine data comes from isolated treatment forms. All running projects try to bring together the different treatment forms of every individual insured user of health services. Additionally, in one study the attempt is made to identify by means of internal plausibility checks all family members of the insured.[20] Here, unplausibilities in attributing individuals to families can only be eliminated if they are extremely obvious, e.g., insured users with many wives, or, clergymen with hundreds of children. Mistakes on the more microscopic level and the distortion caused by them remain entirely unnoticed. They could only be controlled if sample surveys of the relevant families were made parallel to the routine data evaluation.

Because of differing composition and number of clientele from different care units and insurance companies such data bodies usually have a limited coverage. Using data files from insurance companies brings the advantage of covering all different areas pertaining to the sickness insurance system: prescriptions, inpatient services, outpatient services. This advantage is effaced by the fact that the socio-economic and demographic characteristics of the different insurance populations are altogether different. Therefore, it is impossible to project the results to a larger population. The opposite is true for evaluating routine data, when they are in the hands of physicians associations. Here, all the routine data on outpatient care for individuals belonging to different insurance companies are taken together. Nevertheless, the sectoral coverage of data remains limited to outpatient care.

This dilemma reflects the social and political reality of health services in the FRG. Here, health services are made up of many different and sometimes competing groups of providers, intermediaries and consumers. At the first sight this dilemma may only be solved by means of population surveys. The fascinating advantages of population surveys - representing the point of view of scientists and consumers - are wiped out, when the access to routine data - representing the point of view of the providers - is not granted. Hence, the functional, sectoral and population coverage of routine data can only be increased by the "political bargaining power" of "uninterested" scientists - a naive fiction. The data coverage therefore is practically always diminished.

- Either the data covers the whole population, in which case the access to all routine data is problematic,
- or the data covers all health services financed by one insurance company, in which case the access to routine data of other insurance agencies is problematic,
- or the data covers all outpatients, in which case the access to routine data on the use of other health subsectors - e.g. inpatient care - is problematic.

For this reason a monolithic collection of data covering all insured users, all physicians and the entire population - what may very well appear theoretically significant for systems analysis - is hardly possible in the health care services system in the FRG. That is one of the scientific-political implications of a non-centralized health care service.

5.2 Data Quality

Only a few studies pertain to any extent to the question of data quality. Because most studies concentrate on a single data body, they can only conduct internal quality checks. In one of the few projects in which this was possible, the experience from various studies on reliability and descriptive value of routine data in other countries was fully verified.[21] Let us clarify this problem taking as an example the outpatient "diagnosis" written on treatment forms.[22]

1. In the every day activity of a physician, the analytical separation between diagnosis and therapy is very often arbitrary or even irrelevant. Ex-iuvantibus diagnoses are more frequent than 10%.

2. Style and quality of diagnosis documentation vary with the individual practice. Sometimes diagnoses are not documented by the physician himself but by paramedical personnel. Once documented on the accounting forms, the diagnoses are not always updated corresponding to the physicians decision-making process which sometimes leads to falsification of first diagnostical hypotheses.

3. A validation of diagnoses is not always convenient in the outpatient service, partly for economic reasons and partly to assure the effectiveness of treatment, especially when a treatment is very urgent.

4. Diagnoses on treatment forms occasionally dramatize the health condition, because of the intrinsic connection between documentation, justification of services rendered, and fee-for-service-payment.

5. The coding of outpatient diagnosis is only partly possible. Over 23% of the diagnoses could on the first attempt not be coded by a 7-digit ICD code based on 27000 different diagnoses in the code books.

6. Coding errors were frequently made even with physicians as coders. In our study the error rate was over 23%. Only by analysing the external sources of the mistakes very harshly and afterwards altering the method of coding did we reduce this rate to a tolerable 5%.

These results clearly illuminate the lacking quality of routine data collections. At the same time they point to a further problem that we are going to discuss next.

5.3 Data and Interests

At the beginning we mentioned the possible fallacy of neutrality in very general terms. The example of diagnoses taken from routine reports shows quite clearly the interference between data quality and interests. Even when the collection and coding of data is highly controlled, interests still influence data, e.g., the interest of the physician to defend and justify his services before the social bureaucracy. By dramatizing diagnoses, the physician acts conform to the interest of his client. Sometimes the physician hides the "real" diagnosis from bureaucracy in the interest of the patient. These are only very few examples of the interference of data quality and interests.

This interest interference affects data on services or therapies, too. In our highly differentiated fee-for-service system the accountability of different services is subject to many bureaucratic restrictions such that the physician tends to report what he usually can account for rather than what he is really doing. Another problem complicates as a rule this situation: Usually the Federal Board of Physicians and Health Insurance defines and prices services without the support of precise descriptions of what actually happens in practices. Diagnoses and services are only two examples of data areas, where socio-economic interests distort data quality.

Also, on macrostatistical levels this interference of data and interests could easily be demonstrated, e.g., indicating the professional and political interests behind infant mortality rates which are much too often used as real data for systems comparisons, or, indicating the fact that in small enterprises sickness leaves go up when business goes down, in order to transfer financial risks to other enterprises using insurance companies as intermediaries.

The stemming of data from needs and interests of the data producers points to three aspects which must be considered before interpreting data on health services:

1. Data about health services have a relative and no absolute meaning; that means, they are only comparable, if the interest constellations and need constellations of the data producers can be assumed to be similar.

2. Data about health services have a connotative meaning; that is, one has to account for emotional, attitudinal, historical and needs-and interest-related aspects of data production and consumption.

3. Data about health services have at the same time also pragmatic meaning; that is, they cannot be isolated from actions and social roles.

Obviously, data on health services must also be interpreted under less critical aspects, stressing, for instance, their aggregational function, i.e. their function to give access to "large-scale-realities" and their economic function.

5.4. Resumé

The preliminary results of the empirical endeavours towards systems analyses in the FRG demonstrate that the confrontation of a microscopic and a macroscopic approach, using and interpreting carefully the immense body of routine data simultaneously, will be an essential step towards sound systems research. Confronting the different data bodies means confronting interests of clients, intermediaries and providers at the same time. Therefore, it is especially important to study the interest constellations of the different health care partners to be capable of interpreting the data correctly. In this sense, the starting point of systems research cannot be merely to describe crude aspects of health services and to think that statistical evaluations of available data could contribute to an applied health systems research.

5. ASPECTS OF THE FUTURE

Future research on health services in the FRG must avoid the fallacies of aggregation, neutrality and tradition. The time of naive data collection and data processing is over.

The Institute for Medical Informatics and Health Services Research (MEDIS) is trying to reorient its research philosophy and its research activities in this direction. The research and development program for 1979-80 reads as follows: "Better preparation, collection and availability of information are decisive contributions to qualitative and quantitative improvements in health care. In addition to practical medicine, medical and health service research is more and more concerned with methodologically based information processing, and is therefore dependent on efficient methods of data processing.

To meet these overall objectives, the Institute ... is developing, testing and making available suitable tools, especially in the following fields:

1. Effective and efficient strategies of prevention and early detection of diseases for large scale application (e.g. cancer and coronary artery diseases).

2. Utilization of computers as a supporting and integrated technological tool for large scale medical application (e.g. automatic analysis of ECG and EFG, radiographs, scintigrams and sonographic pictures).

3. Design and implementation of valid, and useful information systems and software for statistical evaluation.

4. Methods to assess performance in the health sector (e.g. health indicators of indices).

5. Development of methods for health system analysis (e.g. models for planning health care facilities)."

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A PROGRAMME FOR THE ELABORATION OF PUBLIC HEALTH MODEL FOR SILISTRA DISTRICT IN BULGARIA

Eug. Apostolov, Ang. Zenov, S. Bačev, E. Petkova

INTRODUCTION

Protection and improved level of population's health in P.R. of Bulgaria appears the basic trend of social management. It is achieved by personal health preservation of the members of society and by mass prophylaxis. That high objective requires the concentration of a considerable material and human potentialities in public health system (PHS) and the application of the organizational forms for the enhancement of its potentialities. The state property of the material wealth determines the planned approach of management as the only possible scientific approach. The planned approach guarantees a rapid growth rate and high provision of the population need of medical attendance throughout the country. The notion high provision includes both timely and qualified, high effective medical aid.

Good planning is impossible without its continuous perfection and without the implementation of the modern achievements of science and of the technical possibilities of computers.

Planned management of public health system in P.R. of Bulgaria has a history of 35 years. Both current health measures and perspective development of health system are planned. The results obtained at a national level are positive. A reliable structure of the public health system is organized (Figure 1), guaranteeing the availability of medical attendance for the population and medical treatment by stages. It has 5 hierarchial levels of atten-

Hierarchic Structure of Health Care System

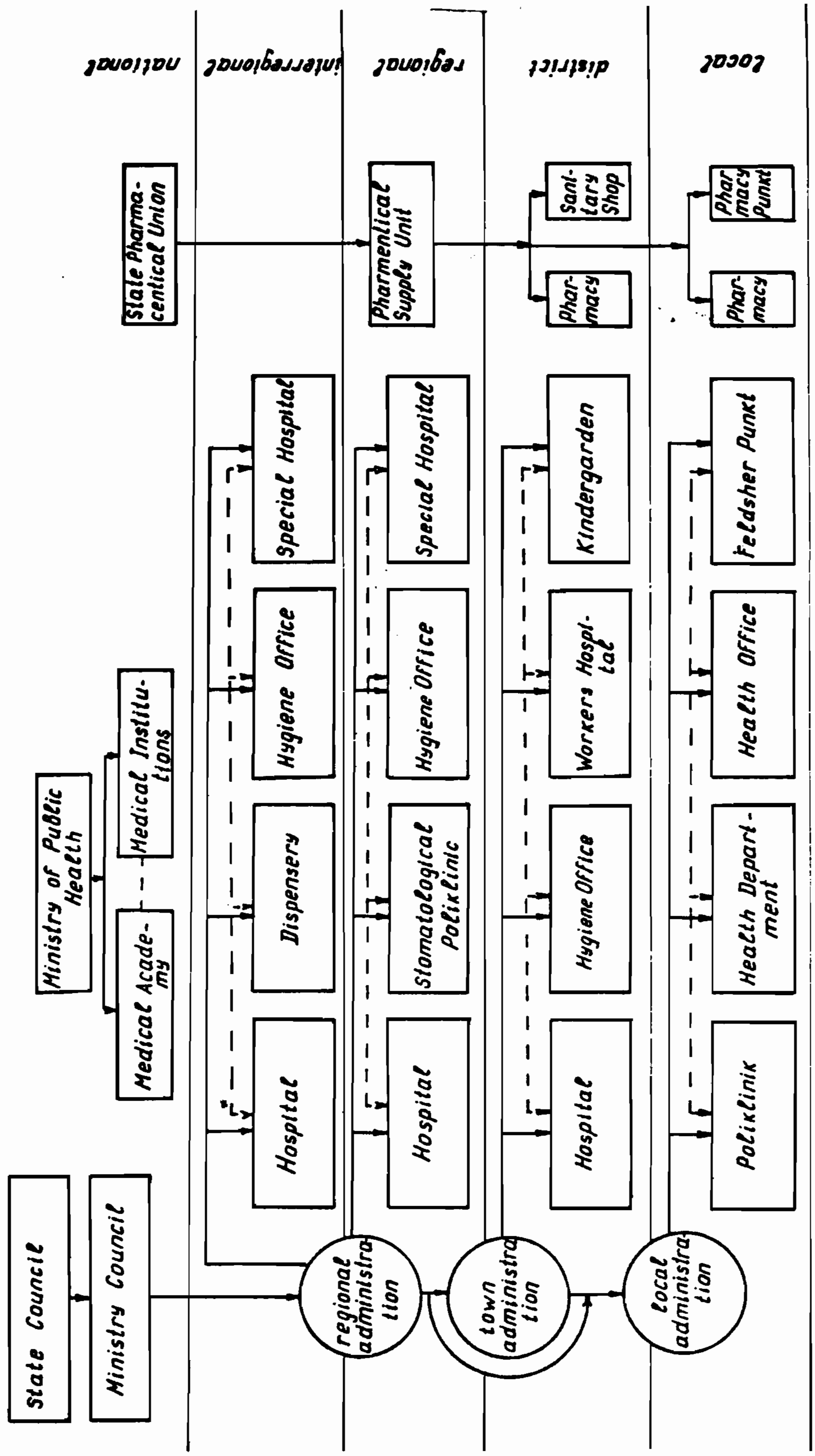

fig. 1

dance in its structure. Each level has its distinct objective, being provided with resources for its achievement. The institutions at each higher level of medical attendance carry out the therapeutic-diagnostic functions of the medical institutions being under them in hierarchial respect. When the institutions of a higher hierarchial level are in larger settlements, they provide more accessible and more qualified medical attendance to a larger portion of the population in the country. One of the main objectives of planned management of development is the equalization of the medical attendance for the village and town population, within the frames of the allowable differences.

The great experience in planning of public health determines the leading place of the norm approach. In agreement with it, the current and perspective plans for the public health development, at each hierarchial level are elaborated on the base of the ratified national norms.

The "GENERAL SCHEME FOR THE DEVELOPMENT OF PUBLIC HEALTH SYSTEM IN P.R. of BULGARIA UP TO 1990" was elaborated with the aid of routine methods and normative approach. As an element of the GENERAL SCHEME FOR TERRITORIAL DISTRIBUTION OF THE PRODUCTION FORCES IN P.R. of BULGARIA - a new variant is developed - up to the year of 2000 at the Institute of Social Hygiene and Public Health Organization. The positive in that mode of management is the attempt at scientific argumentation of the future dislocation of the public health institutions.

The empiric approach in planning the development of the lower levels of the hierarchy of the system could still be found. With a view to meeting the need of scientific planning of the perspective development of the regions in P.R. of Bulgaria, a theme for realization was set, having two tasks, being complementary to one another.

1. Provision of a higher degree of mathematization of plan-prognostic and optimization elaborations, to an extent so that with the aid of the mathematical models, to simulate the behaviour of the social attendance system.

2. Guaranteeing the complexity of the plan-prognostic elaborations. On the base of reciprocally bound models to provide such elaborations, able to reflect the social development, as a united whole.

A complex programme is ratified in our country aiming at the accumulation of scientific and practical experience in the field of human activity. Silistra district is appointed the experimental region. The complex character of the task and its significance for the future of planned management of social-economic development at a regional level raised it to a task, followed up and managed by the government. The coordinator is the Institute for social management (ISM), at the Academy for Social Sciences and Social Management (ASSSM). The separate tasks are fulfilled by the department institutions, the Institute of Bulgarian Academy of Sciences (BAS) and some other scientific bodies.

With a view to the scientific orientation to similar problems, the personnel of IIASA plays a special role in the functional system for the realization of the complex theme (Figure 2).

The executor of the public health system appears to be the Institute of Social Hygiene and Public Health Organization (ISHPH), Ministry of Public Health. The task is under the superintendence of Ministry of Public Health and the coordinator ISM.

The objectives of the complex theme are as follows:

<u>A. SCIENTIFIC-RESEARCH</u>:

- to elucidate the emerging problems with the complex planning of regional development;

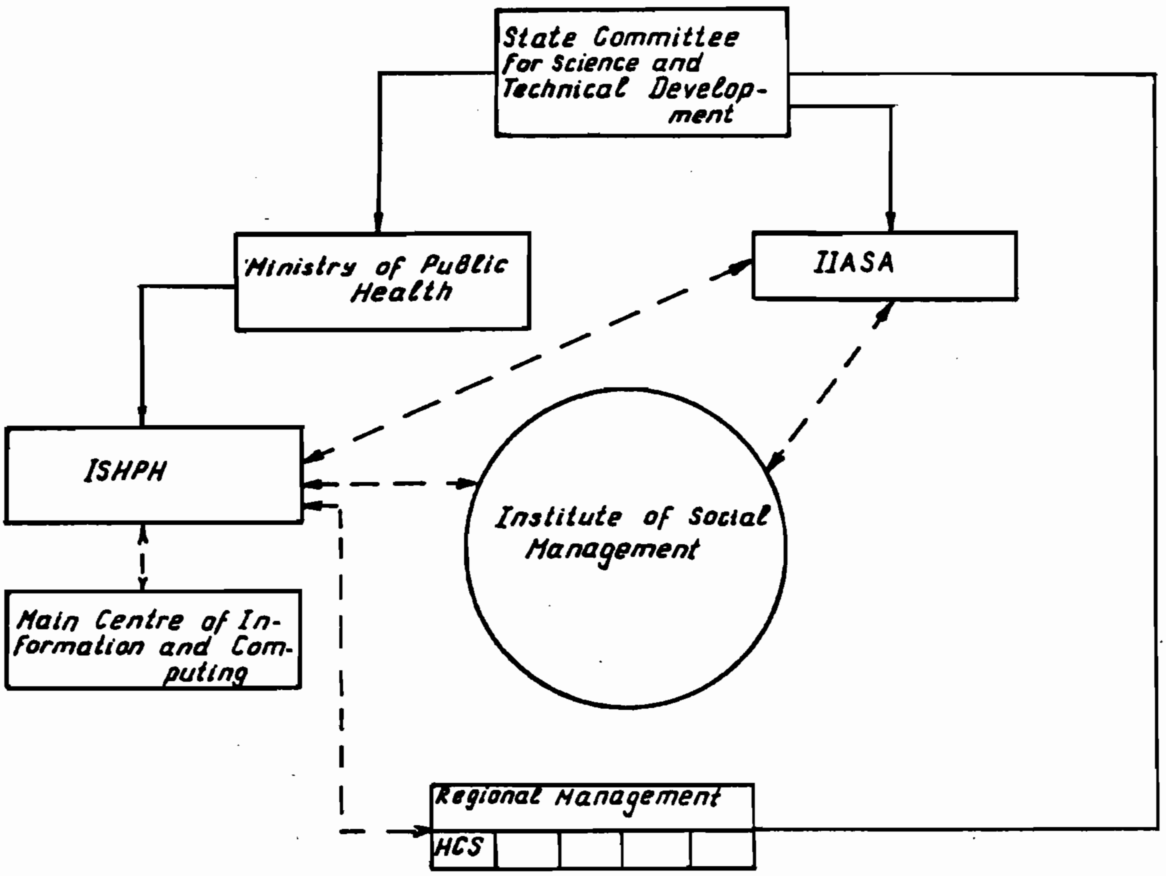

fig. 2
Co-ordination of task fulfilling

——— co-ordination
- - - - co-operation

- to improve the methods of planning, searching sufficiently reliable information indices and criteria for plan-manaagement decisions making:

- to define the exact role of the mathematical-statistical methods, indicating the algorhythm of their application;

- to elaborate mathematical methods, supplementing the analysis of the systems (subsystems) and making the management decisions.

- to elaborate a methodology, applicable to all methodical approaches in planning the social development that had confirmed their heuristic qualities.

B. SCIENTIFIC-APPLICABLE:

- rational bound of the results of the scientific investigations to the planned-prognostic practice at a district (regional) level of social management;

- proportional distribution of the productive forces, guaranteeing a high public labour productivity and meeting the needs of services;

- enhancing the effectiveness of the social system at a regional level by enhancing the effectiveness of all elements and its multiplication at an optimal management of the region;

- providing a balance bound of the plan-prognostic elaborations by departments at a regional level and with the national development programmes.

The objectives of public health system are the above mentioned ones, respectively concretized, depending on the characteristics and needs of the system. The scientific-research objectives are specified by the applied approaches in the determination of the population's health state, by the elaborated mathematical, etc. models for the needs of management of public health and the proposed automated information and management sys- systems, indices and criteria for optimization the behaviour of public health system and its separate elements.

The elaboration is realized by stages. The task of the first stage is to create a concept for the complex management of social-economic development of the region with the aid of mathematical battery of modern science and computer technique. The second stage - to elaborate the approaches for binding all mo - dels in a united whole on the base of the principle "input-output-input" of the information, running among the separate subsystems and the models developed for their management. That neces sitates the organization of a united information and computer base. The third stage will implement the models for the needs of the social management and perspective planning of the district development. In parallel to the tasks, mathematical models are elaborated at every stage, assisting the optimal management.

Management of the district system of public health

The system of public health develops as object differentiated. Regardless the fact, that health aspects exist in all the other social spheres, that compact part, under the direct con - trol of Ministry of Public Health is defined as the object of the elaboration.

As already underlined, the health system is organized at 5 hierarchial levels (Figure 1). The three lower levels of attendance - local, regional and district appear as the object of the elaboration. The models elaborated, reflect the relationship of those three levels within them and among the higher inter-district and national ones. The significance of the work carried out for the management of public health could be assessed, consideration given to the fact that in our country exist as follows: 27 district hospitals, 142 regional hospitals and about 5000 bodies for first medical aid.

The multiaspect and complexity of the planned elaborations so far forced the creation of the principle scheme for their realization (Figure 3). The national plan presents control (norm) indices, which should be taken in consideration in plan development of the district. Via the same direct way, the rest of the social spheres have received planned objectives, specifying the general trends of their development. The elaboration of variant decisions of the plan (current and perspective) follows their assessment and optimization being the achievement of purposeful function of the health system. The plans are subjected to severalfold specification in connection with the requirements for maximal effect of the whole social system and of public health as well.

The current plans appear as detailed elaborations of the perspective plans. The improvement of the prognoses, by the achievements of public health system and v.v., concretization of the current plans in connection with the corrections made of the perspective elaborations, proved to be a continuous process in the planning system proposed.

The mathematical models appear to be the tools in planned management. A mathematical model implies a mathematically formularized scheme, reflecting adequately the basic processes in the modelling system, formation and development of the phenomena assessed.

The mathematical-statistical models suggest mathematical formularizations based on the regularities, studied via statistics.

In its logic essence and information properties for modelling of public health and the processes in it, the regression

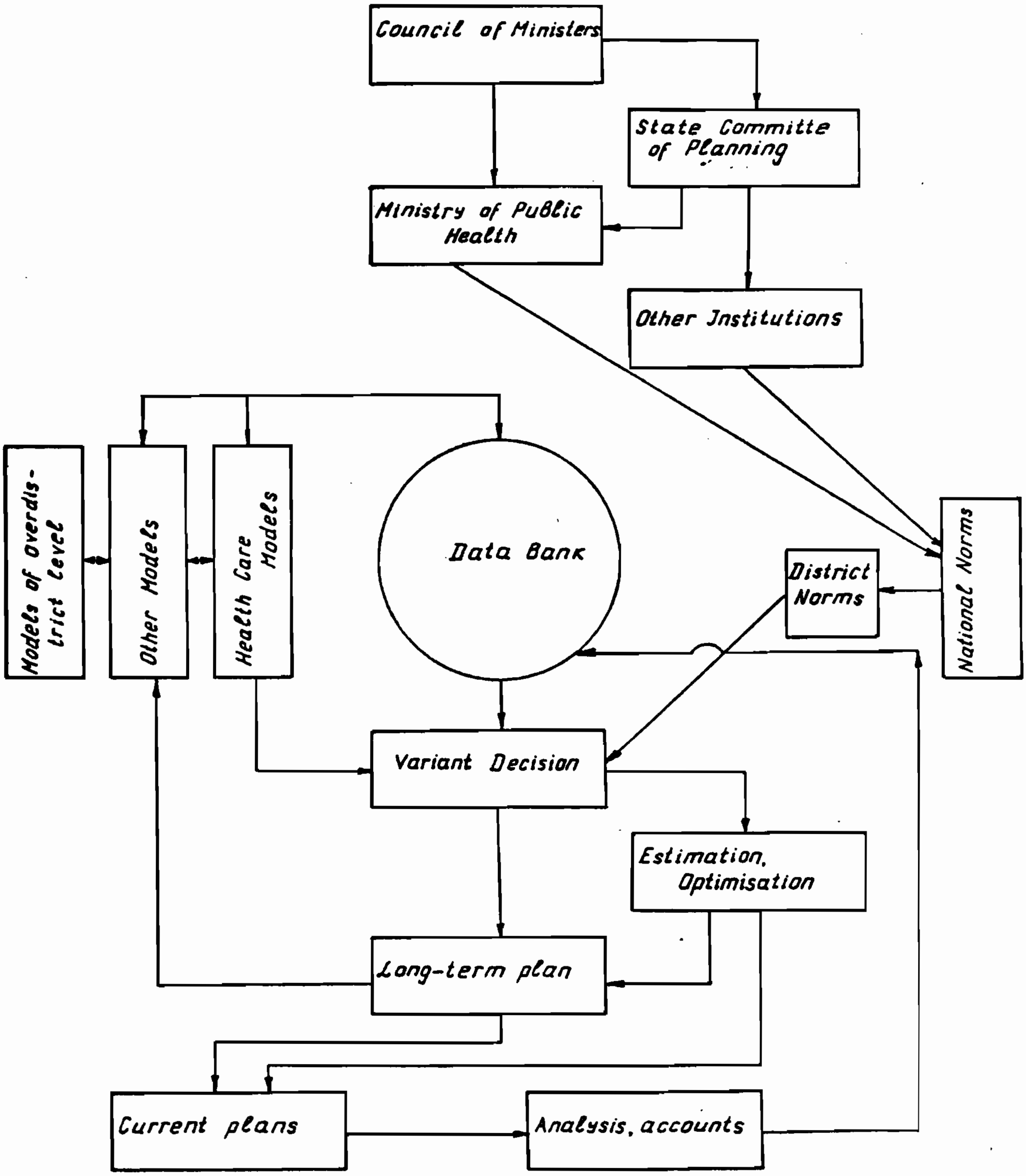
Council of Ministers
State Committe of Planning
Ministry of Public Health
Other Institutions
Models of overdis-trict level
Other Models
Health Care Models
Data Bank
District Norms
National Norms
Variant Decision
Estimation, Optimisation
Long-term plan
Current plans
Analysis, accounts

Fig. 3

and dynamic linear models proved to be most appropriate.

The models, created according to the modelled object are grouped as follows: (Figure 4)

- models for the public health state and its elements;
- models for the population's health state;
- models for the medical institutions activity.

The problems that could be solved by them are:

- simulation
- prognostication
- norm planning and prognostication
- optimization.

The optimal battery of models, able to present possibilities for a proper management at a district level are indicated on figure 4. Some of those models are a combination of submodels but some others - exist that cannot be described via mathematical ways, with the present potentialities. When they are needed, the potentialities of the system analysis in its descriptive type will be used.

Part of the models, considered necessary are elaborated and implemented in the country (regulation of hospital admission in the town of Botevgrad; analysis of the activity of public health institutions in the town of Gabrovo, Tărgovište, etc; control of the prophylactic immunizations in most of the districts of the country; needs of higher medical personnel in ISHPH for the country and for the districts). All of them will be adapted and used for the management of the public health system in Silistra district.

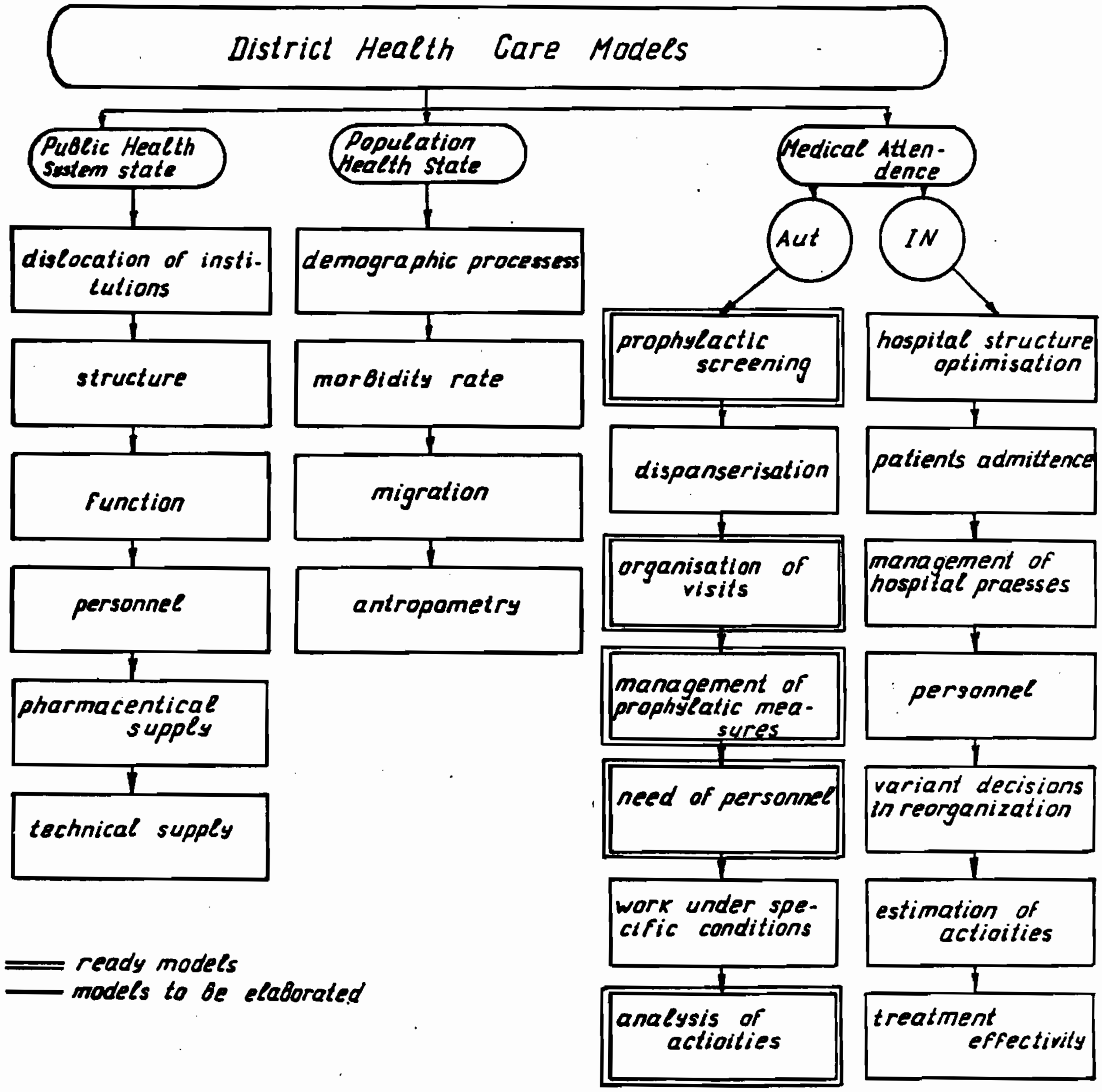
District Health Care Models
Public Health System state
Population Health State
Medical Attendence
Aut
IN
dislocation of institutions
structure
function
personnel
pharmacentical supply
technical supply
demographic processess
morbidity rate
migration
antropometry
prophylactic screening
dispanserisation
organisation of visits
management of prophylatic measures
need of personnel
work under specific conditions
analysis of actioities
hospital structure optimisation
patients admittence
management of hospital praesses
personnel
variant decisions in reorganization
estimation of actioities
treatment effectivity
ready models
models to be elaborated

Fig. 4

Attention is drawn also to the created models in some other countries and organizations in order to attain a rapid implementation of the achievements in the field of modelling of public health for the needs of the elaboration of Silistra district. The models, elaborated by the research workers of IIASA are followed by a special interest. The most suitable of them will be adapted to the conditions of Silistra district.

The complex character of the models and the necessity of information exchange between them, determines the high requirements to the information system at a district level. It should enable the use of one and the same information for different models and for various needs of the social management. The output of one group of models should present grounds to become the input for another model, or group of models of a higher order.

"Data bank" will answer the needs of all spheres of social management. Public health, as a complicated dynamic system, will have a considerable share in it. With a view to meeting the specific information needs of the models for public health, the information collected should meet certain requirements, the main being as follows:

1. The official statistical account and obligatory documentation, kept at the public health bodies - to be the basic source of information;

2. The necessary special statistical observations to be representative and realizable with the potentialities of the public health system, the object being the health state of the population;

3. The collection, stage and processing of information to be automated with a guaranteed rapid access;

4. The additional information collected to be informative to the highest extent, representative for the whole population of

the district and necessary for a series of elaborations;

5. The meeting of the needs of information at a national level as well;

6. The technical mathematical and code provision to be unified for all systems at district and national levels.

CONCLUSION:

New approaches are sought for the needs of regional planning and prognostication of the public health development. The basic in it appears, on one hand, the complex examination of the district as a system of subsytems, united by purpose and function, and on the other - looking for mathematical approaches for the solving of the problems for optimization and effectiveness. In this light, the elaboration for the public health appears as a fragment of the integral battery of models for management of social development of one district.

The presented data reflect the contents of one complex scientific research programme with a term for its realization 1983.

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OUTPUT MEASURES AND THE INTERACTION OF PUBLIC EXPENDITURE PROGRAMMES*

C.E.R. Tristem

INTRODUCTION

It would perhaps be useful to begin by a short explanation of the role of Her Majesty's Treasury in the United Kingdom. The Treasury has two principal functions. The first is to give advice to the Chancellor of the Exchequer on the management of the British economy. Among its many facets, this will include an assessment of the consequences of different levels of overall public expenditure. The second main function is to help in the process of planning public expenditure levels over a five year rolling period. The latter function gives the Treasury an interest in the distribution of resources between various programmes such as health, education, defense, etc., forecasting likely expenditures on them, monitoring that expenditure through the course of a financial year and encouraging departments to seek means of improving efficiency.

My responsibility in the Treasury is to run an Operational Research Division. Its interests include forecasting and monitoring levels of public expenditure for particular programmes

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*The views expressed in this paper are the author's and not necessarily those of H.M. Treasury.

and recently the examination of the use of output measurements in public expenditure planning. Output measurement might eventually help in the setting of relative priorities and the development of indicators by which the efficiency of services can be assessed. These activities are being carried out to support Treasury administrators in their tasks of negotiating with individual departments and the management of public expenditure as a whole.

THE USE OF OUTPUT MEASURES

Even if output measures are readily obtainable, the way in which they could be used needs some discussion. Perhaps the first area of application may be in helping to determine relative priorities between public expenditure programmes (i.e. resource allocation). Traditionally the discussions that take place on relative priorities have revolved around the amount of extra money required for a particular programme or conversly what sort of reduction it could take. In the past the consequence in output terms of such increases or decreases in expenditure where seldom quantified but in recent years there has been a general move towards attempting to do so. If a reasonably comprehensive and structured set of output measures is developed it should, in future, be possible to consider relative priorities in terms of what extra money will buy or what decrease in service level will result from a reduction in expenditure. This information will not directly indicate the most deserving case, but it may help those who have to make the final decision which, in the end, must be a political one, to make a more considered judgement.

Another role for output measures is to encourage greater efficiency in the use of public money. It is not possible to judge the efficiency (output divided by input) of a public service industry unless output can be quantified. The existence of these measures and the realisation by management that they are being monitored and used for resource allocation purposes may well cause the managers of public services to direct more attention to improving efficiency. In the case of the health service in

Great Britain for example, one might look at the number of inpatients treated per available bed for the various area health authorities. If great discrepancies can be observed after the differences in population structure have been allowed for, then there may well be a case for asking management in the less efficient areas to suggest how they might improve performance.

A third area where output measures may prove to be valuable is in measuring the out-turn of a particular public expenditure programme against its plans. When bids for public expenditure are made, if they are accompanied by an output statement, it becomes possible after the event to monitor their realism. The knowledge that a particular programme either falls below the planned target, or above it, could well be valuable to the Treasury during subsequent negotiations for more resources.

OUTPUT MEASURES FOR PUBLIC EXPENDITURE

For many years a number of people have suggested the desirability of developing output measures for public expenditure, to facilitate decisions on resource allocation between programmes, to help determine their relative priorities and to encourage the efficient use of resources. There are few who would disagree with the desirability of these aims. The problem is in achieving them. It is difficult to agree on suitable output measures for most areas of public expenditure, for example, defense, health, and education. In those areas where they have been developed and used, they often only partially cover a programme's objectives.

In order to help in the systematic development of output measures, we have found it useful to distinguish between various levels of finality. At one level, many of the measures in current use are only surrogate output measures being in fact a measure of resource input. An example of this in the health programme is the number of beds per 1000 population. At a higher level, there are intermediate output measures. Pursuing the health example, one of them might be the number of cases treated per 1000 population. Lastly, in some cases, final outputs for expenditure are available. An example for health is the perinatal mortality rate.

It is tempting to suggest that standardised mortality as a final output measure for the health service might be used. It is, however, recognised that standardised mortality rates (SMR's) are dependent on many factors other than the level of health care and therefore do not uniquely measure the output of a health service. Further, a significant proportion of expenditure on health is not directed at curative treatments but at caring for the chronically sick and this objective is not quantifiable by the use of SMR's.

Using the three categories of surrogate, intermediate, and final measures, we set about discovering what measures were currently being used. This process enabled us to get a feel for programmes where measure, which existed incompletely, covered the objectives and hence indicated where more needed to be developed. The next step has been to take two or three programmes, look at them in detail and try to construct as full a hierarchy of output measures as we believe is meaningful. Areas covered include agriculture, education, nationalised industries, etc. One such programme has been health and personal services. In this case we have gone further and used those outputs available to monitor the development of services, taking into account demographic changes, over the past ten years. We were also able to monitor how various regions differed in their provision of services.

THE INTERACTION OF PUBLIC EXPENDITURE PROGRAMMES

There is a *prima facie* case for believing that the various programmes, for example, health, education, and industrial support may, in some ways, intereact with each other. It is important to know whether money spent in one area is reinforcing that spent in another or working against it. This can only really be ascertained by the systematic use of output measures. Further because of this interaction there will be no right proportion of public expenditure to spend on any particular programme. Rather an effective balance has to be struck between resource allocation to the various services so as to minimise the adverse affects of these interactions. A simple example here is the problem of the passenger transporting services where over allocation to one area may cause operating difficulties in another and inefficiencies overall. In practice the general level of activity in the economy as a whole, will also have a significant effect on the absolute amount of money spent on each service and perhaps the relative amounts as well.

INTERNATIONAL COMPARISONS

From time to time, researchers attempt to compare one nation's public services with another. However, the interaction between different expenditure programmes, and between private and public sector activities makes it extremely difficult to carry out valid international comparisons even where output measures exist. In the case of health care, a publicly provided service, which is centrally planned, will probably differ in pattern of delivery from that which operates on a private enterprise basis. Intermediate output measures will pick up these differences but only the development of final output measures could help resolve the debate as to which better fitted the needs of the population. Thus although in one or two carefully defined cases such comparisons may be useful, I cannot envisage that they will, in general, help in the setting of expenditure priorities.

THE WAY FORWARD

During the recent past, some progress has been made in the United Kingdom in the development of output measures for public expenditure planning purposes. There do remain, however, many areas left uncovered. Further, the application of the outputs in a consistent fashion to help in resource allocation and efficiency questions still needs to be actively pursued. The use of intermediate output measures in the health field, for planning purposes, is now quite well advanced in the United Kingdom. Large sectors of the service do have appropriate output measures but, I believe there are till difficulties on the community health side. Thus, as far as health care modeling is concerned, improvement in resource allocation, particularly where a trade off between hospital and community care is concerned, may need to concentrate on appropriate output measures for the latter.

In many cases, these measures may be easier to define than to quantify, but, for effective planning, measurement is required. As far as trade offs between programmes are concerned, if outputs can be agreed and measured, there is hope that this added information will help in the process of priority setting. Advances may also come if interaction between programmes can be identified and quantified. In the case of housing and health, for example, there could be advantages if compatible outputs can be developed. A starting point might be to quantify the different levels of morbidity, due to different housing standards. This may allow a sliding scale of demand for health care depending on housing conditions to be constructed, which in turn might enable some specific trade offs between expenditure on housing or health to be made.

In all the problem areas discussed above, it seems to me that the best chance of progress is through a gradual process of investigation of issues as they become topical. In any case, the needs of society are almost bound to change with time and this should be reflected by changes in the stated objectives of public expenditure and therefore, the output measures used to quantify them. This is then likely to encourage a gradual and controlled evolution in the nature of the services provided towards the requirements of the society.

RESOURCE ALLOCATION PROBLEMS
IN HEALTH CARE SYSTEMS

M.Bojańczyk

1.Introduction

In the paper the problems of Health Care System activity evaluation and optimal decision making for short time planning periods have been considered .A special attention has been paid to resources allocation rules and mechanism .

2.Health services supply

The productions functions of multiplicative form [similar approach has been introduced by [Feldstein,1967]] have been chosen to describe both of the main HCS activities [the attention has been limited to] : in-patient care [IPC - subscript z] and out-patient care [OPC - subscript o] .

The main principle of the description of activities was to divide the whole population into the age [superscript i] and disease [superscript k] groups ; all input and output variables are understood as statistical one-year data values .

As it has been sketched out in Fig.1 [time t,i-th age group, k-th disease group, IPC [OPC]] the following quantities have been chosen as input variables : $B_z^{ik}/t/$ - number of hospital beds for IPC and $G_o^{ik}/t/$ - number of consulting rooms for OPC , number of physicians [$L_z^{ik}/t/$ - for IPC, $L_o^{ik}/t/$ - for OPC], number of auxiliary medical personnel [$S_z^{ik}/t/$ - for IPC, $S_o^{ik}/t/$ - for OPC] and cost of medicines [$I_z^{ik}/t/$ - for IPC and $I_o^{ik}/t/$ - for OPC] .

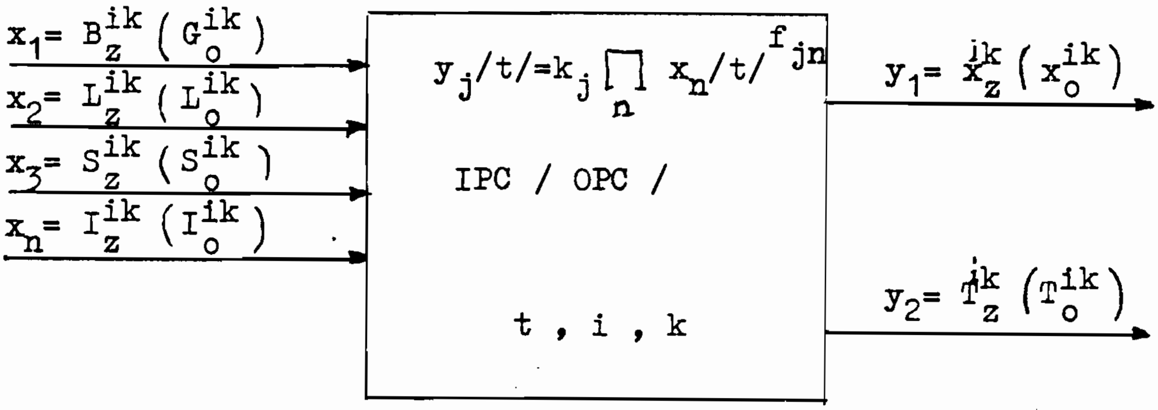

Fig.1 Health services production

The output variables defining the activity level are as follows :

- for IPC : $x_z^{ik}/t/$ - possible number of hospital patients and $T_z^{ik}/t/$ - mean duration of their stay in IPC units ;
- for OPC : $x_o^{ik}/t/$ - supply of consultations and $T_o^{ik}/t/$ - mean time of prescribed therapy for out-patient services .

The mathematical formulation of above mentioned relationships will be presented [for IPC] beneath :

$$x_z^{ik}/t/ = k_{1z}^{ik} \left[B_z^{ik}/t/\right]^{a_B^{ik}} \left[L_z^{ik}/t/\right]^{a_L^{ik}} \left[S_z^{ik}/t/\right]^{a_S^{ik}} \left[I_z^{ik}/t/\right]^{a_I^{ik}} \quad (1)$$

$$T_z^{ik}/t/ = k_{2z}^{ik} \left[B_z^{ik}/t/\right]^{b_B^{ik}} \left[L_z^{ik}/t/\right]^{b_L^{ik}} \left[S_z^{ik}/t/\right]^{b_S^{ik}} \left[I_z^{ik}/t/\right]^{b_I^{ik}} \quad (2)$$

where :

- k_{1z}^{ik}, k_{2z}^{ik} - constants ,
- [$a_B^{ik}, a_L^{ik}, a_S^{ik}, a_I^{ik}$] and [$b_B^{ik}, b_L^{ik}, b_S^{ik}, b_I^{ik}$] - corresponding elasticities of the production functions.

For OPC similar relationships can be written in analogous way [for details see -[Bojańczyk,1976]] .

3. Definition of the performance index

To solve planning tasks i.e. to allocate scarce resources in optimal way one needs to choose and define appropiate performance index which evaluates the quality of system activity. The quantitative measure of the health status of the society - adopted in this paper - is the following quantity : total time socially lost due to diseases and deaths caused by these diseases- [Bojańczyk, 1976].

It is - according to the definition cited above - the total amount of time lost by all members of the society being under consideration because of diseases [to loose the time means to be excluded from generally speaking any social activity e.g. from work for employed people, education for pupils and students, leisure time for everybody etc.].

One can admit, that this time depends ceteris paribus on the activity of HCS [more precisely spoken on the level of expenditures on HCS, the way of their distribution and the natural material constraints].

Let the chosen category of health services [i.e. for specified : activity area - IPC, all age groups, disease group- k] in year t be considered.

Thus the time socially lost in a year t due to diseases belonging to k-th disease group [and deaths caused by theses diseases] by the patients who require treatment in IPC units - $A^k_z/t/$ - can be expressed with the help of the following formula:

$$A^k_z/t/ = \sum_{i=1}^{I} x^{ik}_z/t/\cdot T^{ik}_z/t/ +$$

$$+ \sum_{i=1}^{I} x^{ik}_z/t/\cdot m^{ik}_{1z}/t/\cdot [T^{i,\infty}/t/ - T^i/t/] +$$

$$+ \sum_{i=1}^{I} [\bar{x}^{ik}_z/t/ - x^{ik}_z/t/]\cdot \bar{T}^{ik}_z/t/ +$$

$$+ \sum_{i=1}^{I} [\bar{x}^{ik}_z/t/ - x^{ik}_z/t/]\cdot m^{ik}_{2z}/t/\cdot [T^{i,\infty}/t/ - T^i/t/] =$$

$$= AI^k_z/t/ + AII^k_z/t/ + AIII^k_z/t/ + AIV^k_z/t/ \quad . \qquad (3)$$

To calculate $A^k_z/t/$ one needs to know :

- $\bar{x}^{ik}_z/t/$ - demand for health services in k-th disease group, i-th age group, IPC area ;
- $m^{ik}_{1z}/t/$ - mortality in i-th age group, k-th disease group for the group of hospitalized patients ;

- $m_{2z}^{ik}/t/$ - the same as above but for the patients who stay beyond the IPC but need hospitalization ;
- $T_{z}^{ik}/t/$ - mean time of self- therapy for the patients who stay beyond the IPC but need hospitalization ;
- $T^{i,\infty}/t/$ - average life expectancy for i-th age group ;
- $T^{i}/t/$ - average age of the i-th age group ;
- I - number of age groups .

The meaning of the components of (3) is as follows :
- $AI_{z}^{k}/t/$ - the total time of disease for the persons treated in IPC units ;
- $AII_{z}^{k}/t/$ - represents the time socially lost due to deaths of persons treated in IPC units ;
- $AIII_{z}^{k}/t/$ - the total time of self-therapy for the ill persons staying beyond the IPC units ;
- $AIV_{z}^{k}/t/$ - the total time lost due to deaths of persons staying beyond IPC [it is one of the results of unsatisfying of demand - see [Bojańczyk, 1978]] .

4.Optimal resources allocation rule

Having introduced the performance index with the help of formula (1) one formulates the optimization problem as follows :
- to minimize the total time socially lost due to diseases of k-th group [by patients needing hospitalization]

subject to material and financial constraints . The index can be enlarged by the similar to (1) components for more disease groups and other activity areas [OPC or rehabilitation].

Thus the problem of optimal allocation of resources being at the disposal of the management body of HCS just under consideration consists of minimization of the time socially lost due to diseases and deaths within chosen planning horizon [here- 1 year].

In the paper an optimization problem for the health services category described by Eq.Eq. (1)-(2) for hypothetic values of parameters and with simplifying assumptions made * has been solved.

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* - only two production factors : $B_{z}^{k}/t/$ and $L_{z}^{k}/t/$ taken into account, - known overall demand $\bar{x}_{z}^{k}/t/$ with given age structure, - one aggregated age group considered, - aggregated production factors [no decomposition for age groups].

One seeks for

$$\min_{(B_z^k,\ L_z^k)\in H_z^k/t/} A_z^k/t/ \qquad 4$$

where the set of constraints $H_z^k/t/$ is presented in Fig.2 .

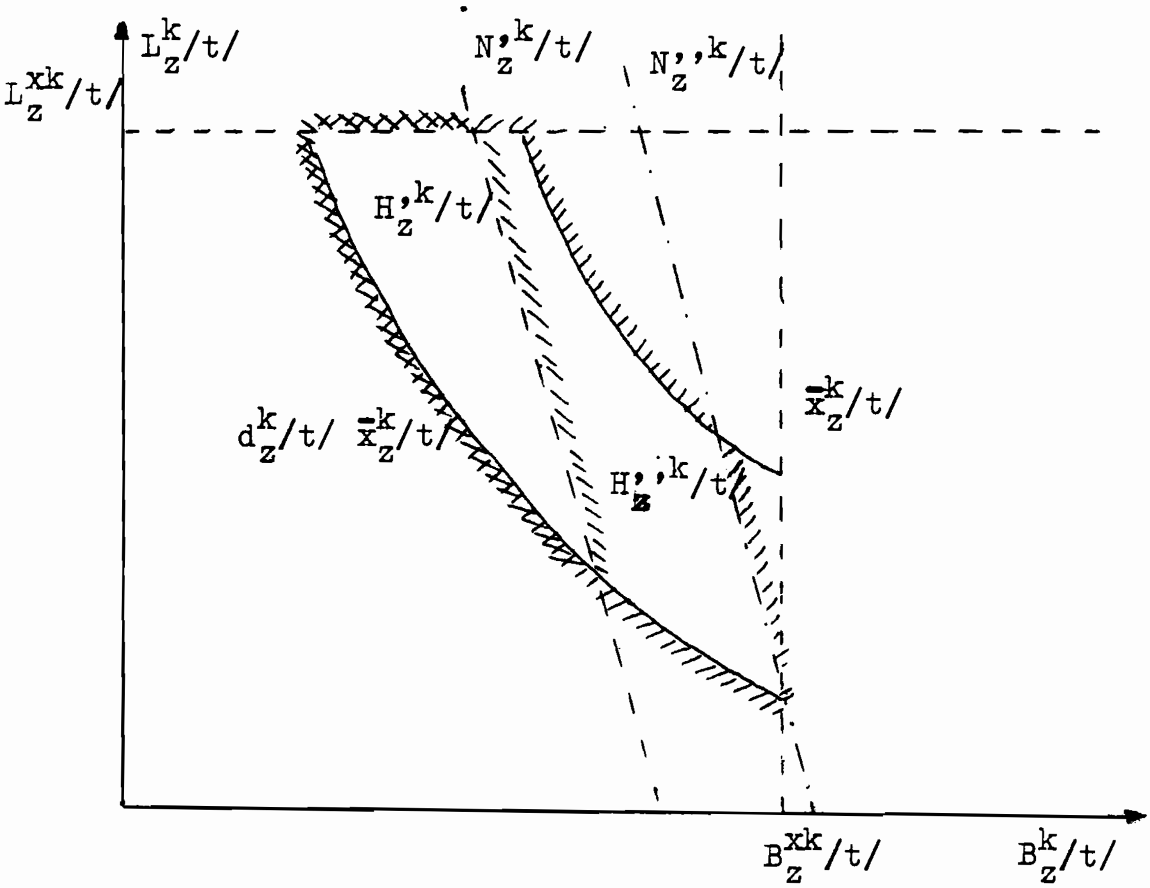

Fig.2 Set of feasible decisions

The computations have been performed for different sets of parameters and variables appearing in the performance index itself and also those defining the feasible set of solutions [set $H_z^k/t/$ formed by constraints] . The special attention has been paid to the investigation of the relationship

$$\min_{(B_z^k/t/,L_z^k/t/)\in H_z^k[N_z^k/t/]} A_z^k/t/ = \hat{A}_z^k [N_z^k/t/] \qquad 5$$

where - $N_z^k/t/$ - is the expenditure level [total expenditures for k-th disease group in IPC area] .

The optimal trajectories in the space of decision variables and the results of computations of (5) are shown in Fig.3 and

Fig.4 respectively .

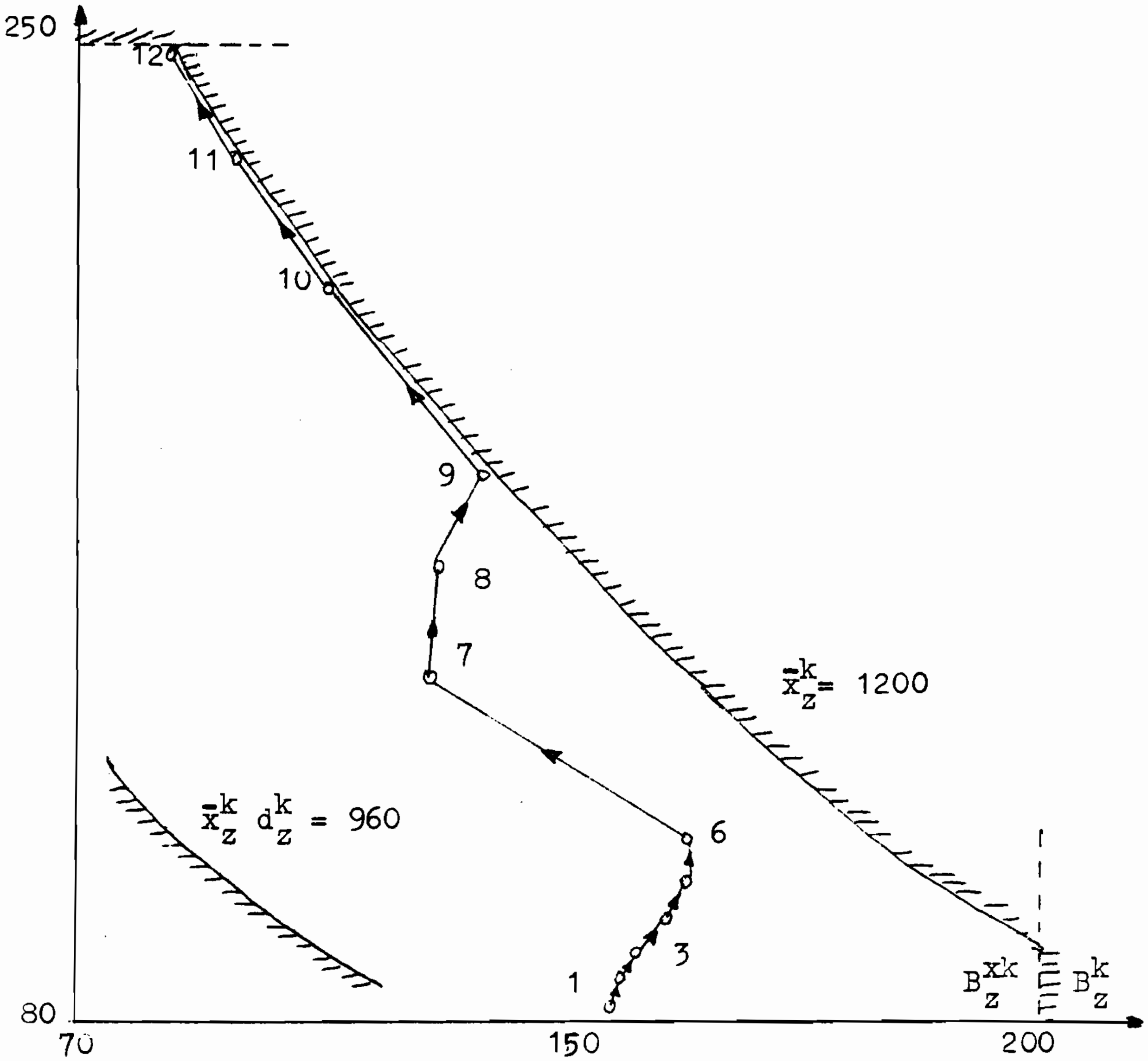

Fig.3 Optimal trajectories for different expenditures

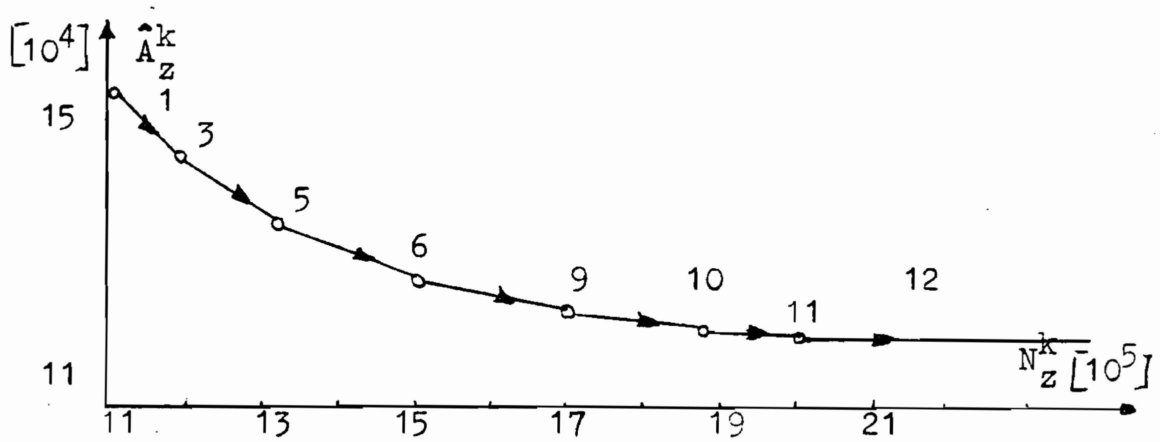

Fig.4 Minimal values of performance index

The sequence of minimal values of performance index $\hat{A}_z^k \left[N_z^k/t/ \right]$ decreases monotonically with the increase of the involved expenditures level $N_z^k/t/$.

5.Choice of the optimal health services level

Realization of health services by HCS units requires expenditures . As it has been shown in Fig.5 the expenditures increase with the increase of health services supply level [here-supply level = expenditures level $N_z^k/t/$] . On the other hand for given demand for health services and certain health services level obtained there exists a corresponding cost of the time lost due to diseases and deaths [here - the total time socially lost $\hat{A}_z^k/t/$ multiplied by a cost of the unit of time lost - $dp_z^k/t/$].

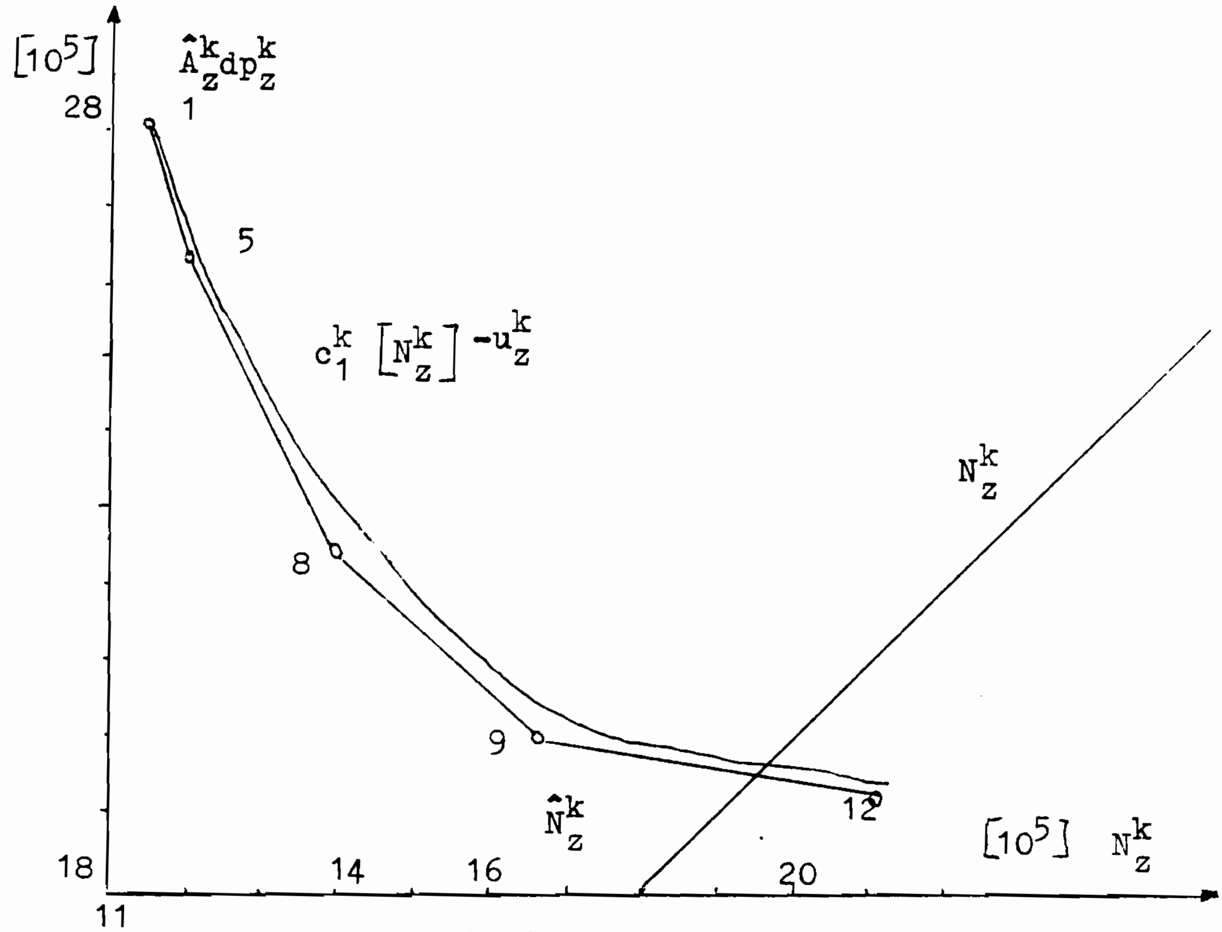

Fig.5 Optimal health services level

There appears an important problem of the choice of optimal health services level which minimizes the total cost [understood as the sum of the services cost and the cost of lost time connected with the realization of a chosen strategy of the health care].

6. Conclusive remarks

In the paper the methodology of the description of HCS activity has been presented on a very simple model . The performance index has been defined , the production process of health services has been described - finally the optimization problems have been formulated and numerically solved . These numerical results seem to be encouraging .

The paper's considerations are limited mainly to the resource allocation problem thus leaving apart such fundamental questions as of morbidity estimation , population submodel [see- Shigan, 1978 , Kiselev, 1975] .

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SUGGESTIONS FOR IIASA'S ROLE IN MODELING THE ECONOMIC MECHANISMS IN HEALTH CARE PROVISION

F.F.H. Rutten

1. INTRODUCTION

In this paper the work currently carried out at IIASA on models, which describe the allocation of resources in the health care sector, is considered. Special emphasis is laid on the economic aspects of this allocation process. Then the work at IIASA is set against current health economics research in this area and the conclusion is drawn, that IIASA's role should extend to the area of traditional, quantitative based, health economics research. Finally, suggestions are made about how to further pursue research at IIASA into this direction and how to coordinate and stimulate the research in this field. It is indicated that use can be made of econometric modeling activities in the Netherlands, about which some information is provided.

2. IIASA ACTIVITIES IN GENERAL

In making plans for modeling activities at IIASA, which concern areas where different countries deal with various problems, one has to make a choice between roughly two alternatives: to develop a very general model which is applicable for all countries, or develop models that take account of specific characteristics of a country or a set of countries.

Following the first alternative, one may find oneself ultimately with a model that can only be used to give very general answers to problems and to make rather rough projections of future developments.

In the case of the second alternative, the general purpose of IIASA activities, viz. to provide answers to the common international problems, might be affected.

The problems in the health care sector indeed differ substantially from country to country. Last year, Prof. Shigan, leader of the health care systems task group at IIASA, visited the Netherlands. In a meeting with the Dutch research- and policy experts, it was suggested that one should distinguish between countries with market type economies as opposed to centrally planned economies. From the presentation of IIASA activities, one had the impression that this work, following the logical line from population/morbidity models to resource supply models, somehow did not incorporate the internal mechanisms towards autonomous growth that characterized so many Western health care systems (and probably also some others). To shed some further light on this aspect, the differences between centrally planned and market type systems with respect to the health care sector will be considered shortly.

3. SOME DIFFERENCES BETWEEN A CENTRALLY PLANNED AND A MARKET TYPE SYSTEM

For the sake of argument it is useful to consider the different levels of decision making in the health care sector. One can very roughly distinguish between the following types of decision making:

- decisions concerning the share of GNP allocated to the health care sector;
- decisions about the capacities of different health care facilities (the number of hospital beds, the number of doctors, nurses, etc.);
- decisions about the treatment of specific patients (yes/no admission to a hospital, length of stay, etc.).

We like now to distinguish between centrally planned systems and market type systems (including some form of social security, public insurance) and see at what level decisions are taken. With respect to the first type of decision making one might say that it is only present in a centrally planned system, and in most cases it will take place at a national level. In market type systems, decisions on this level can only be made for the limited part of health care expenditures that are financed out of general government funds. Control of expenditures financed out of social security funds or private funds can only be established through indirect ways.

The second type decisions are made on the national or regional (for smaller facilities on the local) level. Most market type systems now have some planning instruments that can be used for controlling supply conditions, at least in some areas of provision of health care. In the Netherlands, for instance, the Hospital Services Act provides a tool for setting regulations with respect to the capacity of hospitals. Both these decisions and those on the national level concerning the share of GNP to be allocated to the health care sector are made by health or government administrators who like to base their decisions on rational expectations about the performance of the system, which depends on the third type of decision making. So modeling activities, that are designed to help health administrators, should really be concerned with describing the third type of decision making which takes place at a decentralized level in both planned and market type systems. This implies that in both systems, one can make use of models that describe the behaviour of decision makers, such as physicians, hospital administrators, etc. Obviously, different factors will play a role in these decision processes in the different countries depending on remuneration systems, organizational restrictions, etc. The incentives towards an increase in services offered and rendered are present, precisely at this level of decision making. Therefore, building models of physician and hospital behaviour should be concerned with describing also the internal mechanisms towards growth mentioned in section 2.

Finally, the role of the consumers will, in general, depend on the amount of out-of-pocket payment or, when there is extensive insurance coverage, on their opportunity cost of time. When prices have to be paid by consumers, one might be able to estimate consumer demand functions, although other market imperfections frequently present in the health care sector, might prevent one from finding reasonable results (see Feldstein 1974). In the case of extensive coverage, time prices may take the role of money prices (see Acton 1973, 1975). An other approach followed in the Leyden health economics project (see Rutten 1978), is to see the physician as an agent for the patient, who delegates the authority to make decisions on his behalf to the physician. The decision process of this physician agent can then be described in terms of demand,--supply--and other variables. This will be further elaborated in section 5.

4. THE IIASA MODEL ON RESOURCE ALLOCATION

As it can be inferred from page 15 of the Status Report on Modeling at IIASA (SR-79-4), quite apart from the scheme of submodels indicated in section 2, IIASA has developed a disaggregated resource allocation model (DRAM). The general underlying hypothesis of this model is that the health care sector attempts to optimize a certain utility function. In other words, the actors in the system are supposed to strive to attain some ideal pattern of behaviour within resource constraints. A utility function, describing the eagerness of actors to close the gap between needs (standards) and actual consumption for different patient categories (disease types) given certain restrictions on supply, is maximized. The coefficients of this utility function, including the ideal standards, can be inferred from empirical data.

As inputs for the model, supply elasticities of health care consumption are used, resources being the only instrument variables in the model (apart from "ideal standards"). The model, therefore, leans heavily on the assumption that health care consumption is supply determined. Apart from the fact that this model describes the allocation of resources behaviour in a very global way, this very characteristic seems to limit the applicability of the model. Only in subsectors of the system, which are for a large part supply determined (in the restricted sense that consumption depends on resources), this model will perform well. But major changes in organization, financing, etc. might affect the model predictions, even in these subsectors, since the model does not take these factors into account.

Given the elegant mathematical framework of the DRAM and the possibility to disaggregate, it should be investigated if the above-stated disadvantages of this model could be overcome. One way would be to state the different variables in the utility function as a function of other factors, that are supposed to influence the allocation of resources. This, however, would increase the complexity of the model drastically and may not be feasible at all. Another approach recently proposed by Hughes (IIASA working paper WP-79-15) evolved from earlier discussions with the IIASA team, about the DRAM, which concentrated on the suggestion to take into account the hierarchy of health care supply levels and specific categories of explanatory variables with respect to physician behaviour (see Rutten 1978). Also this pilot model of "the equilibrium between different levels of treatment in the health care system" seems to grow very complicated when more explanatory variables are allowed for. Further elaboration of this model should be concentrated on the issue of applicability.

The research in health economics falls into two broad categories, which can be said to relate to the allocation of resources <u>between</u> health care facilities on the one hand and <u>within</u> health care facilities on the other hand. The first problem is mainly tackled with economic theory, using econometric methods to quantify relations in the behavioral type models. Problems of management and efficiency within health care institutions are usually solved with the operations research methods, where some objective function is optimized under certain restrictions. The DRAM developed at IIASA is rather special in the sense that it is clearly concerned with the first category of problems, but uses the optimization of a utility function as a basic principle. Next to exploring further possibilities of these optimization models, it seems self evident that IIASA should also make an effort to contribute to the traditional economic research, which constitutes by far the largest quantity of health services research. In the following section we propose to develop a general framework for health care modeling, which may provide a reference for actual work in different research centers and can be a stimulus for further coordinated research in this area.

5. DEVELOPMENT OF A GENERAL FRAMEWORK FOR HEALTH CARE MODELING

As we have seen in section 3, the relevant area of decision making, that should be modeled, is that which we call "decisions about the treatment of patients" and which mainly concerns the behaviour of the physician as the main decision maker at this level. In this respect it is necessary to distinguish between the first contact of a patient with the health care system and all the following medical consumption. Only the first contact results from a decision which is exclusively made by the patient. For this part of the medical consumption, the traditional economic theory might apply and demand--and supply--equations might be estimated. For the follow-up of the medical consumption, which is by far the largest quantity, a general approach could be followed. The ideas, upon which such a general approach might be based, are briefly set out below.

First, it is useful to state some specific characteristics of the health care sector, which are common to most countries:

- there is a serious information gap on the demand side of the market for health care; the consumers do not know what medical treatment they require and how effective this treatment will be;
- health care is a special good adjusted to a particular person and therefore cannot be transferred to another individual;
- in the case of (partial) insurance against costs of illness, the individual consumer faces a marginal price at the point of receiving care that is less than the true social cost of provision, which may result in excess consumption (the phenomenon of moral hazard, Pauly 1968).

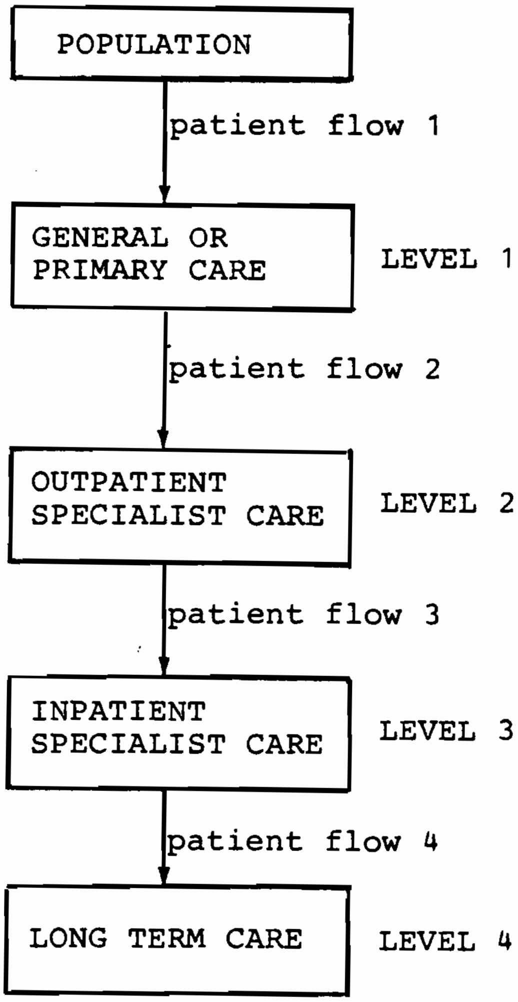
These and other market imperfections have troubled straightforward estimations of the demand and supply equations in several instances (see Feldstein 1974) and has led to the suggestion (Berki 1972, Evans 1974) to give special attention to the role of the physician in the decision process concerning the quantity and quality of the care provided. It seems very useful to see the physician as an agent for the patient, who delegates the authority to make decisions to the physician, because only the latter has the necessary information for rational decision making at his disposal. Now, the physician agent can hardly be expected to be a perfect agent in the sense that the outcome of the decision is the same as in the "optimal" case (all information with the patient). First there is a loss of information as a consequence of transferring relevant information about preferences and health status from patient to physician, but secondly, conflicts of interest between the physician agent and his client may occur. Therefore this complex decision process can be said to be influenced by a number of variables, belonging to one of the following five categories:

- demand variables--the characteristics and preferences of the patients, who are referred to the physician agent;
- supply variables--the capacity of facilities offering alternative means of treatment;
- physicians preferences variables--variables entering the preference function of the physician such as income (depending on payment systems), professional status, quality of work, etc.;
- colleague-relation variables--influences of other actors providing medical goods or services (cf. advertising of pharmaceutical industry, referral patterns, etc.);
- institutional variables--regulations of the public insurance system, medical organizations, price setting institutions, etc. (for instance, in the Netherlands one has to see his general practitioner before contacting a medical specialist).

This general scheme of describing the medical consumption as the result of several decisions of physicians in some agent role, influenced by variables, that belong to these five categories, might be a first step towards a general framework. But also some general conclusions about the functional form of the equations could be reached. For instance, if we consider the way the physician's decisions are influenced by his preferences, one can point out a number of studies (Reinhardt 1975, Smallwood, et al·1975, Zweifel 1979) where the decisions are described as maximization of a utility function, which includes variables like income, leisure time, quality of work, etc. These, and other, studies might come up with some general answers on how to specify the above proposed equations.

Another ordening principle, in a general framework, could be to consider the health care system as a system of patient flows from lower to higher levels of care. Each new facility, encountered by the patient during his course through the system, can be considered as a filter in the flows of patients (see figure 1).

Figure 1. The medical channel system



The costs of treatment gradually increase if a patient moves from the first level of care up to the fourth level of care. A general policy principle might be to increase the filter function of these levels of care. The link with our observations on decision making of physicians above is obviously that the functioning of these filters depend in general on this type of decision making, viz. that of the general practitioner in the first level and that of different medical specialists at the higher levels of care. So combining the equations explaining physician behaviour with this principle of structuring the health care system gives an outline of a structural equation system explaining the use of health care facilities at different levels of care. A special submodel explaining the demand for health care (first contacts with the system, patient flow 1) could be linked to this system to complete the picture.

When specifying equations one has to see to it that the different instruments, which are available to decision makers at national, regional and local levels in the health care system, are represented by one or more exogenous variables in the equation system. Even when there is no variation in an instrument variable for a certain data set in a country, there might be other data sets in other countries that allow for an estimation of the coefficient of precisely this variable. For instance, in the Netherlands, plans are made to introduce deductibles in public health insurance. Obviously, it is not possible to infer the effect of such measures on health care consumption from Dutch data. Therefore, we carefully use American studies to make some estimates of the consequences of introducing these plans. Although the dissimilarities in health care provision, in different countries, might prevent one from drawing firm conclusions, it can be stated that there is an advantage in using not only national data, but looking also to other countries for data, which contain enough variations in a certain variable, which influence on the system one is eager to estimate. Before turning to the final section on the concrete role of IIASA in this field, we will illustrate the potentials of this framework by giving some results of Dutch econometric work, where a rather similar framework was used.

6. THE LEYDEN HEALTH ECONOMICS PROJECT

This project, granted by the Dutch Ministry of Health and Environmental Protection, started in 1972 and was inspired by econometric analyses of health care systems by Feldstein (1967), Fuchs and Kramer (1972), Davis and Russel (1972) and others. The very general assignment of the Dutch Ministry was to build an econometric model of the Dutch health care sector. We proceeded by analyzing the patient flows between the different levels of care (see figure 1) and specified a model along the lines set out in section 5. With respect to the demand for primary care (first contacts with the health care system) a special investigation was performed to see what motivates the patients to seek care. This analysis was on a micro level, taking individuals as units of analysis. We found a.o. a clear negative price elasticity of demand for primary care and a large so-called "interdoctor variation", which means that some doctors are contacted easier than others (see Van der Gaag, et al. 1978).

The analyses of consumption in higher levels of care used both pure cross-section data sets (84 regions) and a mixed time-series/cross-section data set (11 provinces in the period 1960 to 1975). The main results with respect to the patient flow from general practitioner (GP) to outpatient specialist facilities can be shortly summarized as follows (see Rutten, et al. 1977, Rutten 1978, Van der Gaag 1978):

- population density had a large positive influence on the referral rate from GP to specialists;
- there is clear substitution between first and second level care;
- the capacity of second level care influences positively the consumption at this level;
- the GP's paid on a fee for service basis are less inclined to refer than those on a capitation-based payment system.

Finally, the clinical consumption appeared to be almost completely determined by the capacity of hospitals measured as the number of beds. This must be interpreted keeping in mind that during the period, which was analyzed, hospitals in the Netherlands had to reach a 90% occupancy rate in order to stay in a financially healthy position (see Rutten 1978, and Van der Gaag 1978). Substitution possibilities, with both general and long-term care, seemed to be present at a minor extent. Finally, there were indications, that specialists tend to treat relatively more private patients, who pay higher fees, when the average number of beds per specialist decreases.

Several options are open to apply such a model for policy evaluation. We used this model, for instance, to calculate the consequences of a proposed cut in acute hospital beds from 5.5 per thousand population to 4.0 per thousand population (see Van der Gaag, et al. 1975). Furthermore, we are planning to make predictions of future consumption with the model on a more regular basis. Next to these applications of the model, a new grant of the Dutch Ministry is given to elaborate further in two directions. First one would like the model to be more detailed and to include more health care facilities such as ambulant care, home-nursing, etc. Secondly one has asked to develop a submodel for manpower in the health care sector. More information about the current activities can be given by the leader of the project, Professor Dr. B.M.S. van Praag, at the Leyden University.

7. SOME SUGGESTIONS FOR IIASA'S ROLE IN HEALTH SERVICES RESEARCH

Before making suggestions for future IIASA activities it should be stressed that manpower at IIASA is limited and partly already engaged in other health care system modeling activities. So instead of putting the emphasis on active research in health economics at IIASA, we would like to propose IIASA's role be more oriented towards research carried out in other centres throughout the world. This role could be specified as follows

- IIASA should be a clearing house for information on health care modeling in centres of excellence through out the world.

- IIASA should place existing research activities in the context of a general framework as, for instance, proposed in this paper; in this way comparisons could be made between different modeling activities and lacunae in research could be identified.

- IIASA should organize workshops on specific subjects, where specialists in the field are invited to discuss problems in research and to inform about progress made. These subjects could relate to urgent policy problems or concern certain difficulties or lacunae in research.

- It should be possible for IIASA to invite scientists for relatively short periods to:

    - update their knowledge at IIASA on health care system modeling
    - discuss current research and policy issues
    - help organize workshops
    - test their models on data of other countries
    - be informed about activities in other centres
    - write papers on the "state of the art" in health care modeling.

Besides these tasks, with respect to the coordination and the stimulation, it might be possible to identify a few clearly defined areas in econometric modeling, where IIASA can make its own contribution. We tentatively mention the following obvious problems in the current research.

- How should the behaviour of the decision makers, at the level of the treatment of the patient, be modeled? What variables are important and what specification of equations should be used?
- What motivates the patients to seek care and what instruments could be applied to stimulate self-care and to restrain the use of professional care.
- What instruments can be used to improve the efficiency of health care provision and to stimulate the cost-conciousness of the actors in the system. How can these instruments be incorporated into a model in order to evaluate their usefulness?

These admittedly broad problem areas should be divided into smaller sections, of which one or two might be interesting enough to allocate some of IIASA's resources to.

My home institution, the Ministry of Health and Environmental Protection in the Netherlands, is rather interested in health care modeling, as already could be inferred from the fact that several grants have been provided to the Dutch research centres. We have organized some meetings with both IIASA scientists and the Dutch specialists in this field. We would like to promote an active cooperation of one or more Dutch centres with IIASA. The ideas, set out in this paper, might prove useful for establishing this link between IIASA and the Netherlands.

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THE SPATIAL ORGANIZATION OF URBAN HOSPITALS

L.D.Mayhew

INTRODUCTION

Nowhere is the problem of determining the correct spatial organization of hospital services more apparent than in large cities where increasingly more of the world's population live. London, the chief subject of my research (Mayhew, 1979), contained in 1971 over 500 institutions of all types and sizes and in various states of repair. It seems reasonable to ask of this city -as well as others like it- whether this number is too many or too few; whether the existing locations reflect the present distribution of population; if they do not, what do they reflect instead and should they be changed; and finally, if change is necessary, what are the sensible methods for accomplishing it. Such an important analysis demands considerable conceptual understanding to justify the advantages and disadvantages of one mode of spatial organization over another. As will be argued, the form which obtains at any time depends heavily on the locational environment.

The Locational Environment

Except for a small percentage which is supra-regional, patient inputs into the urban hospital system can be considered a subset of the population of the region of interest. Patient inputs, as with the population, are normally observed to be increasing functions of time. Although it depends on the city, patient inputs seem likely to increase at a faster rate. This is not because the population is becoming less healthy, but because of factors such as new services and clinical techniques, legislative changes affecting utilization rates, an ageing population, a general increase in the expectations of the population, and an increase in the total resources available for hospital services.

The urban region itself tends to increase in area with a partial, yet demographically selective, redistribution of population from city centre to periphery. Contributing to this process are changes in the urban transportation system, which though facilitating movement, constrain patient flows to preferred lines of communication. Depending on its design, the network specific to each mode of travel ensures that some locations serve better as sites for hospitals than others. For example, early this century cars were few so that patients, travelling to hospital by either bus or train, were very much radially orientated. With the enormous rise in car ownership, however, flow patterns today are more complex, with circumferential travel, say, becoming steadily important. This, together with the redistribution of population, has arguably reduced the attractiveness of central hospitals and raised the importance of hospitals in the suburbs.

Hospital Behaviour

In such environments the rapidity and diversity of change prevents hospital authorities from adjusting quickly to accommodate the desires expressed in the new set of travel preferences and distribution of demand. This makes for difficult hospital planning with the result that investments in some facilities intended to last for fifty years may become redundant in half that time. In large cities like London it is possible to find instances of hospitals being run down, converted to other functions, temporarily expanded, permanently enlarged, demolished, rebuilt or relocated. Every alteration or addition, aside from general maintenance, anticipates the creation of a new service, a change in the structure of the service population, or an adjustment to exogenous factors such as developing technology or budgetary constraints.

Partitioning the Urban Area

Although it is not possible here to provide a detailed account of this research into the effects of urbanization of hospital systems, it is hoped that the following brief illustrations will serve to identify the approach taken. The task of this paper then is to argue the appropriate size and spacing of facilities necessary to serve a large and unevenly distributed population and to apply the results to London.

Although many factors contribute to locational decisions, one which will always be important in any analysis of acute hospitals is the subject of patient accessibility. How facilities are spaced in an urban region, however, clearly depends to a considerable extent on the prevailing costs of travel. If these costs are high, it can be argued that locations will be chosen so that corresponding catchment areas avoid extremes of distance; if they are low, then other factors will operate that give more weight to the size of the service population, so enabling a more cost-effective pattern of services.

A useful introduction illustrating this point is provided on figure 1 which shows the complications caused by a variable population density. In the

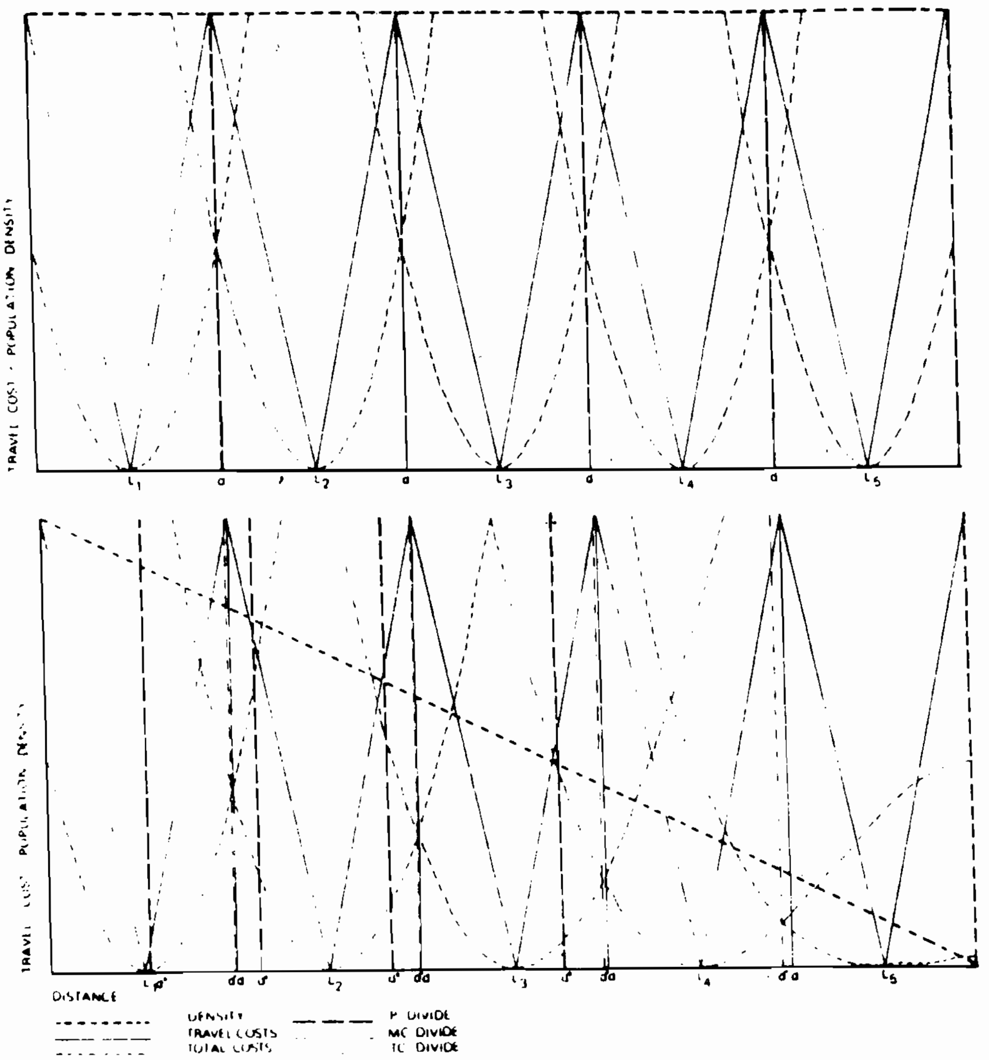


Figure 1. Urban districting

top half, an evenly populated city is partitioned into five equal-spaced sub-regions each served by an imaginary hospital (L_1 to L_5). Most important to notice is that the population P serviced by each facility is the same while the dividing line d between each sub-region is co-terminous with the points of maximum travel (MC) and the total distance (TC) of the contained population from each hospital. In the bottom half, a centre to periphery decline in density is depicted. Holding constant the locations, we note that (i) the population influenced by each centre decreases from left to right; (ii) the total distance of travel also declines because fewer people are travelling; and (iii) the intersections of the divides (d,d',d') under each criterion, MC,TC and P, become increasingly dislocated with distance from the centre.

Suppose now that the sizes of the hospitals in each sub-region are proportioned in the uneven case to the contained population. Under P districting (equal population) all facilities -measured, say, in terms of bed capacity- would be the same: under TC (equal total travel distance) and MC they would decline, the latter more rapidly by varying as the population density. Only in a uniformly populated region could the sizes associated with all three be the same.

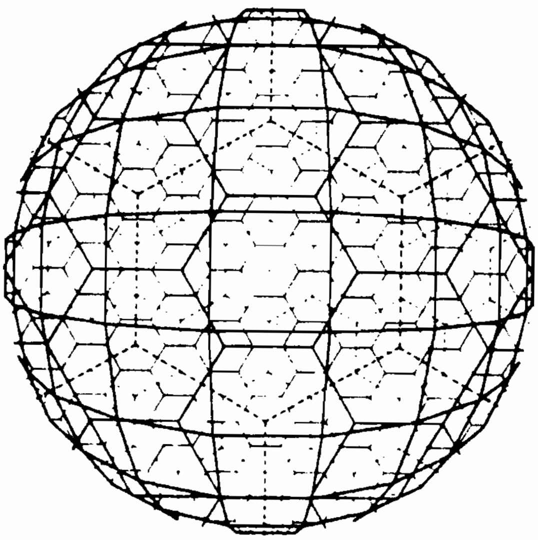
We can make a case for each type of districting: P-districted hospitals could perhaps be tailored to similar specifications in order to obtain the best returns to scale and other advantages of uniformity. The increased distance of travel at low densities, however, could be effective in reducing the consumption of services, so introducing a measure of spatial inequality. TC-districted hospitals, by contrast, take accessibility into account, but to a lesser degree than MC-districted hospitals for which, of course, the maximum distance to hospital is everywhere the same. Difficulties will be experienced with both of these types of organization, however, in providing an economic mix of services at very low densities.

Hierarchies and Transformations

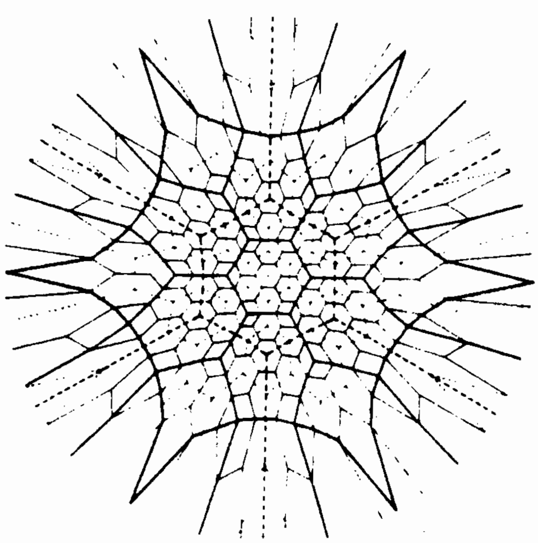
Unlike the simple example above the exact pattern of population densities varies not only between cities but also between times. Nevertheless, the recurrence of certain forms of mathematical urban density functions (Clark, 1951), not to mention the similarities in the structure and functioning of many urban services, reinforces the notion that the systems concerned have related forms which are capable of similar analysis. The suggestion is therefore that the spatial organization of hospital services in different cities at the same time or the same cities at different times may be regarded as transformations of one another that depend largely on the locational environment. Figure 2 offers one hypothetical instance of this idea. As is seen, the districting principle has been extended to the plane and then amplified to incorporate a five-tier hexagonal hierarchy of hospitals organized along well known lines (Christaller, 1960; Dietrich, 1977) for supplying services at varying intensity.

In the hierarchy there exists a centrally located hospital, which in addition to supplying high order services throughout the region, also subsumes the functions provided by layers lower in the hierarchy. Hospitals in lower layers are more numerous, but attract patients from more limited areas. At the lowest level, hospitals serve only the immediate locality, providing only those low order services which are in general demand and are used most frequently. Finally, some hospitals which border the region share services in an unspecified way with neighbouring regions: their sub-regions are truncated by the urban perimeter.

In (a) of figure 2 we recognise a form of MC districting assumed to overlay a uniformly populated region. This gives way in (b) to a form of P-districting by a transforming equation based on a function fitted to the 1971 distribution of population in London.



(a)



(b)

$$D(r) = 92.767 \exp(-\,0.00354\, r^2)$$

where D is the density in persons per hectare and r is the distance in kilometres from the city centre. The result is a net of different-sized curvilinear polygons which, as anticipated in figure 1 above, lose both the properties of MC and TC associated with the uniform case and become increasingly elongated with distance from the centre. A grid superimposed on (a) is there to show that (a) may also be regarded as the inverse of (b).

The procedure for obtaining a P-transform, if cities are radially symmetric, is to set equal the integral out to r of the density function in the region of interest to the integral over the uniform region and then to solve for r. Generally speaking,

$$\int_{R'} \rho \, d\rho \, d\theta = \int_{R} D(r) r \, dr \, d\theta$$

where R and R' are the region and image region respectively. For MC-districting, the solution is always the identity transformation.

APPLICATION TO LONDON

Stemming from this analysis an interesting question therefore is how the spatial organization of London hospitals has been influenced by the developing urban system and what transformations, if any, have taken place. Figure 3 provides the necessary background intended for testing this hypothesis by depicting the locations of acute hospitals at five times this century. The urban region at each time (defined in Mayhew, 1979) was partitioned into concentric rings 2.5kms in width. The number of beds and hospitals in each ring were totalled and proportioned, and then multiplied by N^t the total population, to provide the number of person equivalents. Ten linear regressions of the following form were then carried out:

$$Y_i^t = B_0^t + B_1^t X_i^t + u_i^t$$

where Y_i^t = the logarithm of the person-equivalent density of either beds or hospitals, ie. $Y_i^t = \log_e \frac{p_i^t \times N^t}{A_i}$ where A_i is the area

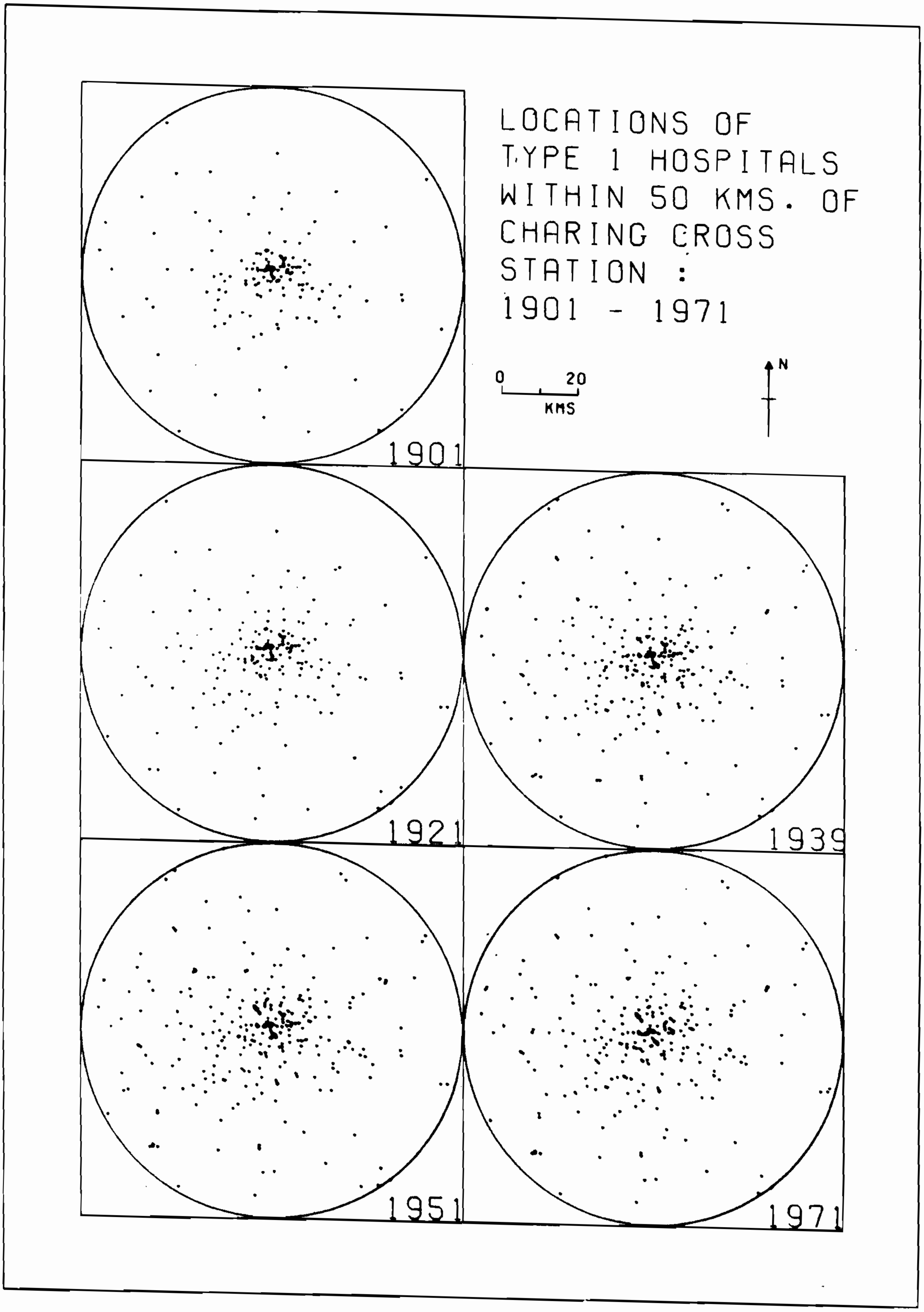


Figure 3. The locations of acute hospitals in London

of the ith ring; p_i^t is the proportion in the this ring at time t of hospitals or beds; and N^t is the urban population.

X_i^t = the logarithm of the actual population density estimated from the mid-point of the ith ring.

B_0^t, B_1^t = regression coefficients

u_i^t = the ith error term.

The results, which are all satisfactory from the statistical standpoint, are shown in table 1 (standard errors appear in brackets under the coefficients). The main interest lies in the comparison of the slopes (B_1's) estimated separately for bed and hospital densities. In particular, we note an apparent convergence to one in the values of each -hospitals from above and beds from below. For P districting, hospitals and beds 'map' exactly into the population density, so that graphically the result is a 45^0-line passing through the origin as figure 4 illustrates. For MC districting, hospital equivalents would plot horizontally.

DISCUSSION

From the diagram it is apparent that in peripheral areas the bed density in 1901 was much lower than the equivalent density of population while hospital density was higher. We would surmize therefore that relatively high travel costs ensured that hospital units at this time were closely packed relative to the population, but because of their limited bed capacities, they were able to offer only low order services. Historically, the hospitals concerned were chiefly of the 'cottage' type -a form of local hospital still popular in some rural areas. By 1971, however, bed and hospital slopes had converged almost to one, implying a change in districting from a type which on above grounds gave consideration to the ease of travel to another type less bound at low densities by the deterrent effects of distance. This transformation, which has been largely spontaneous, can be interpreted as the consequence, on the part of hospitals, to decentralize slower than the population, which in turn decentralized slower than beds. In short, it has resulted -mostly through the expansion of selected facilities- in much larger suburban hospitals and the gradual ecllipse of the cottage hospitals mentioned above.

The results from scatter diagrams showing the variation in mean hospital

Table 1.

Time	Urban radius (kms)	Independent variable	B_0	B_1	R^2	Observations
1901	23.96	Hospitals	1.05 (0.36)	0.76 (0.10)	0.87	10
		Beds	-1.78 (0.49)	1.31 (0.13)	0.92	10
1921	30.09	Hospitals	1.19 (0.24)	0.72 (0.06)	0.92	12
		Beds	-1.30 (0.62)	1.23 (0.16)	0.83	12
1939	38.22	Hospitals	0.92 (0.19)	0.76 (0.06)	0.92	16
		Beds	-0.44 (0.36)	1.07 (0.11)	0.87	16
1951	40.84	Hospitals	0.74 (0.21)	0.79 (0.06)	0.91	16
		Beds	0.17 (0.21)	0.95 (0.07)	0.93	16
1971	47.61	Hospitals	0.37 (0.23)	0.89 (0.07)	0.89	19
		Beds	-0.07 (0.29)	1.01 0.09)	0.86	19

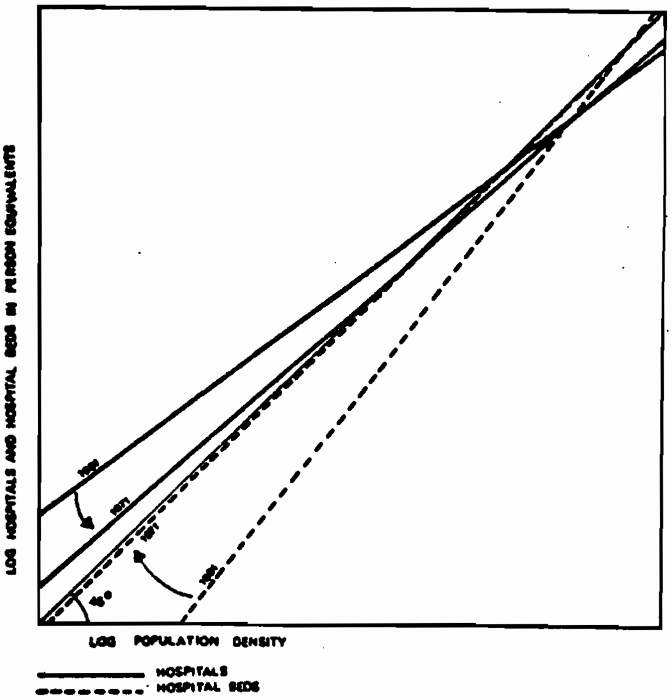


Figure 4.

size on distance from the city centre illustrate this change in another way. In 1901, for instance, a peak of about 360 beds is observed near the centre, but this declines rapidly to units averaging less than 20 beds at distances above 10kms. In 1971, after fifty years of adjustment, suburban facilities had been enlarged and developed to the extent that two new peaks -one at 15kms and another at 25kms- had emerged, partly offsetting the former attractiveness of the centre. This development is conveniently brought out in figure 2, the hypothetical transformation, in which layer two hospitals, next in importance after the central hospital, form two rings around the centre -one on the periphery and the other part-way between the centre and the periphery.

CONCLUSIONS

This paper has briefly introduced the author's research into urban hospital systems. The locational viewpoint has been advanced as the correct way for interpreting the spatial organization of urban hospital facilities. As such, it represents a departure from area-based planning by focusing attention on the hospitals themselves and the way in which they develop in time and space. Clearly, the evidence is that urban hospitals form part of a much wider system which itself is subject to change. It seems essential therefore that the interactions between one system and the other be taken fully into account in any future modelling of Health Care Systems in cities.

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THOUGHTS ON SYSTEMS ANALYSIS OF THE HEALTH CARE SYSTEM

P. Fleissner

As it is prevailing common activity in science, in the field of systems analysis usually, quantitative models are created, indicators defined, and functions empirically tested. The result of this process, THE MODEL, proudly is shown as a representative of social reality to the astonished public. But what type of reality is reflected in the models--or should one better characterize it by "created"?--especially in those of the health care system?

The usual approach of the modeler is the following: he takes the existing framework of the health care system, of specialists, specialities, drugs, organizations and decision makers for granted. Within this framework he (1) selects qualitatively predetermined variables, (2) he adds quantities to them and (3) associates some of the variables with each other in such a way as to bring down the degrees of freedom of the system of equations to zero. The system of equations, which produces a unique solution (this is the implicit goal of the modeler) on the basis of a linear or nonlinear network of relationships, describes one point in the space of variables--if static--or a set of points in the space of variables and time--if dynamic. The quality of the variables remains unchanged and unaffected by temporal changes (at least at the time the model describes). In short, the existing models do not allow for describing *qualitative* changes of the real system although one major goal of social policy and social reforms is to develop new organizational structures of changed quality which are superior in performance to the old structure. The shift from a treatment oriented health care system towards a preventive system could be used as an example. If this new quality "prevention" is not included into the model a priori, evidently no results on the level of prophylaxis could be expected as possible outcome. The usual models would continue to produce results of "optimal allocation" and would remain suboptimal.

From the above point of view this "purely" quantitative approach lacks the possibility of changing quality; the models are restricted to identical input and output qualities. This led to the GIGO-aphorism, (Garbage In - Garbage Out) as the property of usual systems analysis was called by its radical critics (Cole et al., 1973:8) One way to overcome this deficit can be seen in using a more adequate method. As a scientific language not only mathematics or mathematical logic could be used but also the scientific language of the social sciences as well. Sociology, economics, political, and historical science could be introduced in addition to quantitative models to create a better performance of systems analysis. At this conference Van Eimeren has called for such approaches in analyzing the real world. M. Field, for example, has offered a sociological approach to compare health care systems of different quality (Field 1976) at IIASA, V. Navarro analyzed the U.S. HCS from the point of view of political economics (Navarro 1977). Although these are valuable contributions for the understanding of the mechanism of the HCS, up to now these insights were not reflected in IIASA's modeling work.

In an interdisciplinary group of scientists in Austria we tried to apply the following approach: we combined quantitative and qualitative methods to analyze the HCS of Austria (Berger et al., 1978). The model building activity consumed only about 10 percent of the total research activity. It was found as a tool for bridging the gaps between the different disciplines and it helped to create a more intuitive understanding of the bottlenecks, available resources and possible effects of policy measures. It was no longer a tool which told the absolute truth on future development by computerized authority. The results of the model could be evaluated under the light of historical experience and the insights collected by social science.

With these qualitative considerations in mind I looked for a way to demonstrate the importance of the social, economic and political environment for the health status and the HCS to the model builders at IIASA. Because of my limited resources, it was not possible to review the very extended fields of social medicine and medical sociology, and I was therefore obliged to select some examples of linkages between health status and social and economic factors. I tried to stress the great impact of these factors on morbidity and mortality in terms of quantities and to feed the results into IIASA's framework.

1. MORBIDITY

Fields of importance had to be defined and the impact of social and economic factors was then determined quantitatively.

1. Chronic illnesses were chosen because of their high rate of occurrence, generating early retirement and premature death.
2. Sick leaves were taken into account because they cause losses in production besides the individual's negative effects of illness.
3. Hospital stays were included because of the high costs involved in inpatient care.

1.1 Chronic Illnesses

Finnish and US data were collected for analyzing chronic illnesses. The data for Finland 1964 and 1968 were analyzed in more detail. They included indicators of medical supply and family income (see Fleissner WP-79-29). A typical result can be seen in Figure 1.

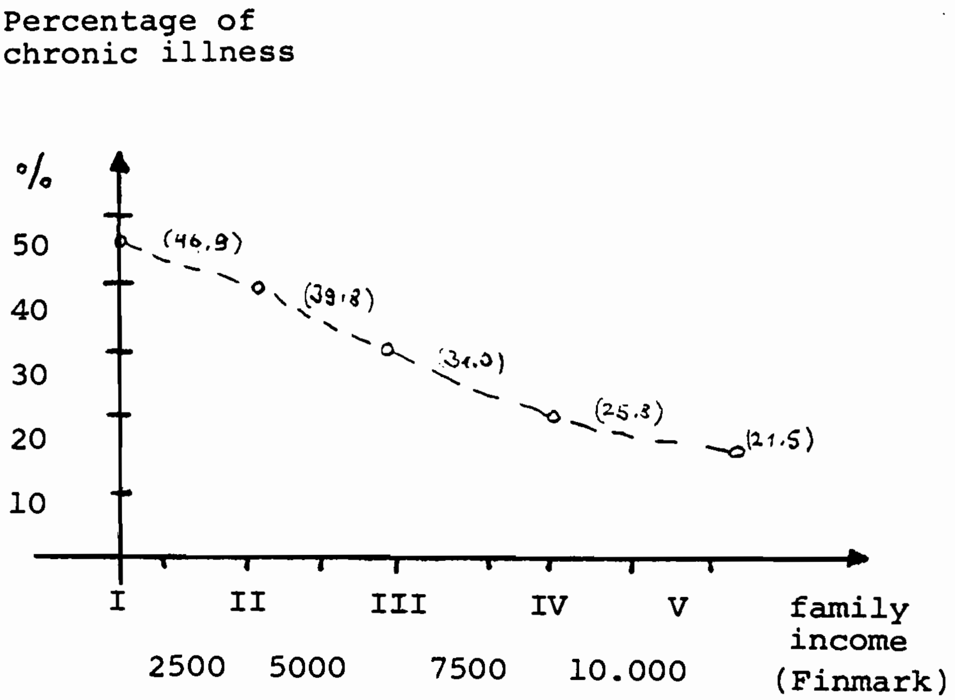

Figure 1. Rate of chronic illness and family income

The main impact on the variation of chronic illness comes from family income variation (± 12.5 percentage points), while different distances to the nearest doctor create an effect of ± 3 percentage points, different densities of doctors of less than ± 5 percentage points only. From the available data it cannot be decided if people are ill because they are poor or if they are poor because they are ill.

1.2 Sick Leaves

Because of availability, sick leave data were collected for Austria by type of occupation. The result is summarized in Table 1.

Austrian blue collar male workers show twice the per capita cases of sick leave per year than white collar male workers, but about the same duration per sick-leave case (see Fleissner WP 78-28). In Austria there is a loss of production by sick-leave of about 4% (1975). To compare sick-leave case and rates of hospitalization in different countries a collaboration between the scientists from the U.K., GDR, and Austria was started. The results of these efforts will be published this year at IIASA.

Table 1. Sick-leave cases per capita per year in Austria 1971.

Type of occupation	sex	
	male	female
Blue collar	1.0	0.9
White collar	0.5	0.7

Source: Fleissner (1977) p. 237

1.3 Hospital Stays

If one compares the total yearly hospital cases per capita for white and blue collar workers in Austria, one finds higher rates and duration of hospital stay for blue collar workers, (see Table 2).

Table 2. Annual hospital cases per capita and length of stay by type of occupation, Austria 1970.

Type of occupation	Hospital Cases per capita	Length of Stay
Blue collar	0.127	15.6
White collar	0.109	13.6

Source: Fleissner (1977) p. 245

From this result one could come to the conclusion that Austrian blue collar workers would enjoy adequate medical treatment by inpatient care: their hospitalization rates are higher than those of white collar workers, because of their higher risk at work.

But the picture becomes worse for blue collar workers if one takes into account the results of Table 3. In this table the average rates of hospitalization per sick-leave are listed.

Table 3. Hospital cases per capita and per 100 sick-leave cases by type of occupation and illness groups, Austria 1970.

Illness group	Type of Occupation: Blue collar	Type of Occupation: White collar	ratio Blue collar = 100
Cancer	100.0	121.1	121.1
Cardiovascular	24.1	33.7	139.8
Lung	8.8	9.6	109.1
Digestive Organs	18.0	25.0	138.9
Accidents	14.1	22.7	161.0
Spine and Joints	5.1	9.6	188.2
Infections Diseases	3.8	4.9	128.9
Neuroses and Psychoses	27.5	21.9	79.6
Others	22.8	36.0	157.9
Total	13.0	18.4	141.5

Source: Fleissner (1978) p. 105

For each illness category there is a higher rate of hospitalization for white collar employees than for blue collar employees with one important exception - blue collar workers have to go more frequently to hospital for psychoses or neuroses than white collar workers. The reason for these facts could be found in the filtering behavior of the general practitioners and specialists toward members of different social strata (Fleissner 1978:165).

2. MORTALITY

As a start in the investigation of the impact of economic factors on mortality, data on life expectancy of different countries were taken into account. In the literature one usually will find a static approach (Figure 2A) to analyze the impact of economic factors on life expectancy.

In a recent book (Preston, 1976, p. 67 ff) a "comparative statics" approach was used. Preston came to the conclusion that the growth of per capita income accounts for only 10 to 25% of the growth in life expectancy in this century. The comparative statics approach as used by Preston does not take into account the full amount of information available. It neglects the change over time of *individual* observations. It concentrates on cross-section analysis at different points of time (Figure 2B). Furthermore, Preston added *a priori* limit values to the data (e.g. a maximal life expectancy of 80 years).

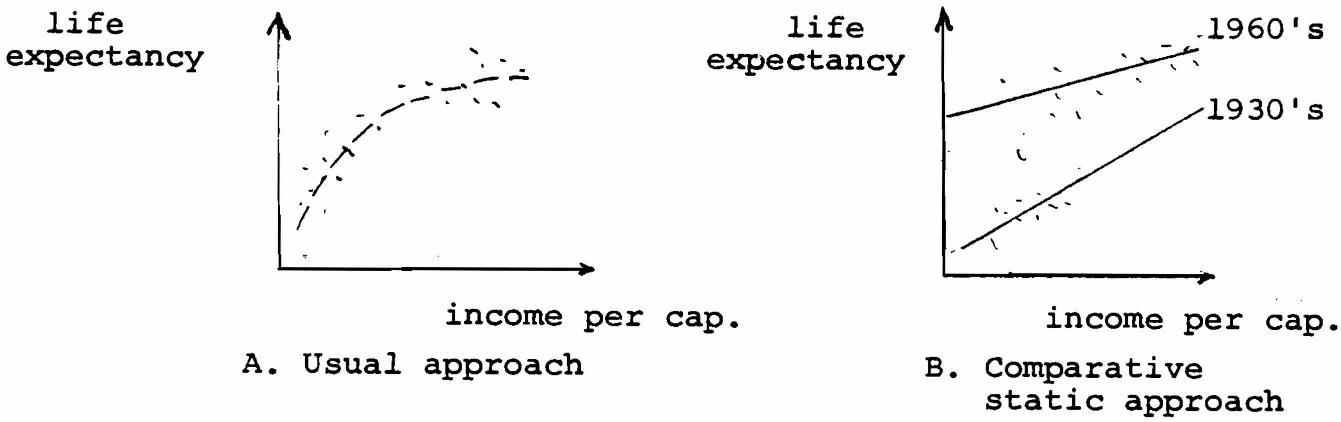

Figure 2. Static approaches

To overcome the above mentioned shortcomings in methodology, in a IIASA working paper (under preparation) I apply a dynamic approach to Preston's data in the following way. Each point of the life expectancy/income-plane was associated with a certain gradient of growth for the next years (Figure 3).

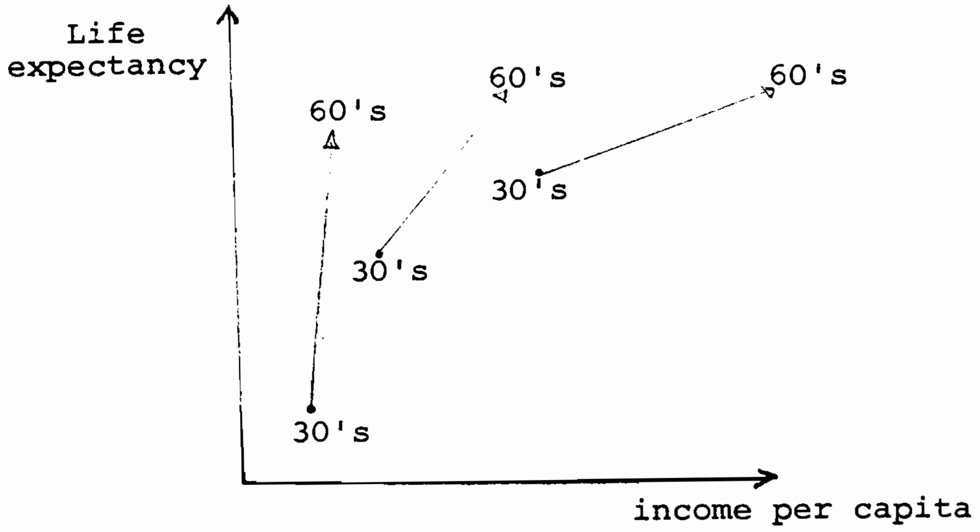

Figure 3. Static approach

By this method the income is no longer directly associated with the life expectancy, but the levels of income and the life expectancy are associated with their *growth* within a certain period of time. A "law of diminishing return on life expectancy" could be established as per capita income grows. Limit values are the results of the method used and need not to be indicated *a priori*.

CONCLUSION

The above examples were given to show the importance of social and economic factors on health status and mortality. An adequate HCS cannot be designed properly if one does not take into account these factors as well. Furthermore, it is not possible to understand economic and social processes by quantitative methods only. Qualitative oriented disciplines of social sciences should be introduced into IIASA's framework to support quantitative model building and to analyze qualitative changes of the health care and the whole social system more realistically.

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THE MODELING OF THE SAMPLING PROCEDURE FOR THE HUNGARIAN HOSPITAL MORBIDITY STUDIES

L. Greff, A. Krámli, and J. Soltész

INTRODUCTION

In Hungary there are about 200 inpatient facilities with 90 thousand beds for 10.5 million inhabitants - this means about 1.8 million inpatients in a year. Systematic statistics of the patient turnover were available, but they supplied only very poor data on the structure of the hospitalization. In order to complete these data a morbidity study was carried out in 1973 [see Csukás, Greff, Krámli and Ruda, 1975]. This study being finished, a continuous hospital morbidity study was started on the basis of the 10% sample.

The morbidity study of 1973 was based on a selective representative sample: the patients with birthdays on the 4, 8, 10, 14, 18, 20, 24, 28, 30 and 22nd from the departments of great turnover and everybody with even birthdays from the other departments were included into the sample. So the expected sample ratios were 32.6 % and 49.3 %. This sampling method was justified by testing the distribution of the birthdays and their independence of the other data of the patients.

Another advantage of this sampling procedure is, that once a case of a hospitalized patient is included into the sample then so are his further hospitalizations. This circumstance provides an opportunity for the "statistical follow-up" e.g. for the investigation of the complications of a frequent disease.

1. THE STATISTICAL ANALYSIS OF THE RANDOM IDENTIFICATION CODE

A 13 digit identification code containing the birth data and sex was used for the statistical follow-up. The effectiveness of this identification code was investigated by theoretical means applying the classical occupancy model [see Békéssy, 1963] and the results obtained were checked experimentally, too. Although the 13 digit identification code has about $3 \cdot 10^7$ possible values and the sample size is only $5 \cdot 10^5$, the expected number of the different persons having the same code is not negligible.

1.1. Theoretical Considerations

We assumed that the data used for identification [except for the age and the sex] are independent random variables. The age and the sex are dependent, because women of reproducing age represent one fifth of all inpatients. The probability distributions of these random variables [including the joint age-sex distribution too] were estimated by the relative frequencies. Thus using the independence the probabilities $p_1, \ldots, p_n$ [n is about $3 \cdot 10^7$] of each possible code value can be determined. Let N and k_i be the sample size and the number of codes belonging to exactly i different persons respectively. Then

$$Ek_i = \frac{\left(Np_1\right)^i}{i!} e^{-Np_1} + \ldots + \frac{\left(Np_n\right)^i}{i!} e^{-Np_n}$$

$$D^2k_i = Ek_i - \frac{\left(Np_1\right)^{2i}}{\left(i!\right)^2} e^{-2Np_1} - \ldots - \frac{\left(Np_n\right)^{2i}}{\left(i!\right)^2} e^{-2Np_n} .$$

1.2. The Experiment

Our assumption on the independence of the random variables constituting the identification code was checked by chi-square test. In addition we carried out a computer experiment on a subsample consisting of 57920 cases of 47333 persons. An 11 digit part of the identification code was selected as a "new identification code" and two hospitalization cases were assumed to belong to different persons if their 13 digit codes were different. The numbers $k_2, k_3, \ldots$ characterizing the coincidences were determined by sorting the sample. The results are summarized in Table 1.

Table 1. Numbers characterizing the coincidences of the 11 digit identification codes.

theoretical mean	empirical value
$k_2 = 5600$	5586
$k_3 = 2530$	2579
$k_4 = 1220$	1187
$k_5 = 632$	695
$k_6 = 347$	382
$k_7 = 201$	207

Remark: the planned general 11 digit identification code will contain the birth data and the sex.

2. THE STATISTICAL ANALYSIS OF THE SAMPLE TUNING

The sampling procedure based on birthdays has been used in the 10 % morbidity studies from 1974. The specialists planning the health care system require exactly 10 % sample from each department. This claim can be satisfied by including 4 days per month and omitting certain days in a year according to each department. A probabilistic analysis shows that 4 days per month almost surely provide at least 10 % sample ratio for every department, from which by omission a 10 % sample can be obtained with suitable accuracy. However, this sampling procedure causes some difficulties in the estimation of the multiple hospitalizations.

A natural way to estimate the multiple hospitalization would be the use of the largest subsample based on the common birthdays.

The following artificial example shows the defectivity of this method in the case when the rehospitalizations within departments are very different. Let the departments A and B have 100 and 200 cases respectively. Let us assume that every person in A is exactly twice hospitalized, while every person in B is only once hospitalized; further on the subsample contains 100 cases from A and 100 cases from B.

Thus the estimated multiple hospitalization ratio [i.e. the probability of the event that a person is at least twice hospitalized] will be $\frac{50}{150} = \frac{1}{3}$ instead of the real $\frac{50}{250} = \frac{1}{5}$.

Probabilistic calculations based on the central limit theorem show that such enormous differences between the subsample and the 10 % sample can occur only with probability close to zero.

Table 2 shows the 95 % quantiles of the relative errors for different departments.

Table 2. The 95 % quantiles of the relative errors.

Department	Relative Error [$\bar{e}_i$]
Internal medicine	0.010
Rheumatology	0.060
Surgery	0.013
Traumatology	0.029
Orthopedics	0.047
Urology	0.039
Ophthalmology	0.031
Otolaryngology	0.021
Dentistry	0.085
Gynaecology	0.008
Pediatrics	0.015
Contagious ward	0.026
Neurology	0.029
Onkoradiology	0.060
Dermatology	0.043
Intensive therapeutics	0.148
Pulmonology	0.025
Psychiatry	0.031
Long-term after treatment	0.086
Sanatoria	0.031

The exact meaning of e_i can be explained as follows. Let us assume that the total sample is sorted according to the birthdays. Let M and r_i be the sample size and the empirical decile of the hospitalization cases treated in the i-th department respectively. Then

$$P\left(\frac{M}{10} - e_i \frac{M}{10} < r_i < \frac{M}{10} + e_i \frac{M}{10}\right) = 0.95$$

Remark: The above considerations concern an ideal situation, they do not take into account the indiscipline in the data supply.

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A SURVEY OF HEALTH CARE MODELS TO EVALUATE SCREENING PROGRAMS IN JAPAN

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Noboru Kawamura

INTRODUCTION

Since we reported the health care modeling activities here at IIASA in 1977, the importance of the area has gradually been accepted in our country and many researchers have joined in the research of this field. Although most of the studies were originated from research institutes or universities, the results of the studies are also taken into considerations in various ways in administrative levels, when the central or local governments make up plans of their health care delivery.

The purpose of this report is to review the health care modeling activities in Japan with emphasis on the evaluation of health screening programs.

Health Care Planning and Health Care Modeling Research

In Japan, as we reported at the previous conference,[1] many statistics are accumulated every year from several sources such as The Bureau of Information and Statistics, Ministry of Health and Welfare, health insurance bodies, hospital information network which covers national hospitals or various private non-profit organizations. These statistics are published every year, and probably Japan is one of the countries where health statistics are most abundant. However, the utilization of these health statistics for health planning is not so advanced and the plans are still in the hands of human experiences. Many people agree that advanced techniques must be developed and health care modeling is one of such techniques. But at the moment these studies are mainly performed at universities and research institutes and so far no models have been implemented officially in the real settings.

In this meaning, the models presented in this report are still at the stage of research. However, the models were developed with administrators in the research team, so we believe that the results has given some influence to the planning of the screening activities of the centeral as well as local government of Japan.

Health Screening

In 1951, cerebrovascular diseases became the top leading cause of deaths in Japan, taking place of the position of tuberculosis which had been the first leading cause of death for a long time. Since 1953, the cerebro-vascular diseases, malignant neoplasms, and heart diseases have been respectively occupying the first, second and third rank among the leading causes of death in Japan. These three diseases are generally called degenerative diseases. On the contrast to the decrease in the death rates of tuberculosis and other infectious diseases, the death rates of the degenerative diseases among the total death rates have been on the increasing trend.

In this connection, the screening of these degenerative diseases has become one the biggest concerns of the health planners. The success in decreasing the number of tuberculosis in the past gave them hope that these degenerative diseases might also be overcome in future by extended health screening programs. On these considerations, studies were performed to analyze the factors related to decrease of tuberculosis in the past and also similar methods were applied to evaluate the health screening of degenerative diseases. In the following section, three models representing these studies are presented.

Trend of Tuberculosis and its Control Program

If it is possible to estimate the future epidemiological trends of tuberculosis and to select the tuberculosis control programs on the base of the evaluation of past programs, it will be helpful for planners of tuberculosis control. Endo and Aoki (2) approached to this end by simulation model. The model they used is shown in Fig. 1 . The population was divided into 6 groups, that is, i) non-infected, ii) BCG-protected, iii) infected within 5 years, iv) infected before 5 years plus inactive and healed cases, v) active cases with cavity, vi) active cases without cavity. The various parameters used in the model were estimated from the available data such as the results of nation-wide tuberculosis prevalence surveys and their follow-up studies and vital statistics in Japan.

The main assumptions in estimating parameters were as follows. The infection rates of various age group decrease exponentially. This was verified in the past data and it was also found that this decrease was paralel to the decrease of bacillary excreters. Protection rate of BCG was assumed to be 50 %. The incidence rate of active cases from the group infected within 5 years was estimated as 2.4 times more than that of the group infected before 5 years, which was 2.5 to 3 %.

The initial situation was set at 1958. The output which the model generated was compared with the results of tubeculosis prevalence surveys in 1963 and 1968 and they agreed well with each other. Calculations were then extended up to 2013 to estimate the future trends of tuberculosis. The initial prevalence of active cases was 3 millions in 1958 and it decreased to 2 millions in 1963 and 1.5 millions in 1968. (Fig. 2) Course A shows the trend when the TBC control programs remains the same level in future. As shown in Fig. 2 , the rate of reduction gradually levels off and the number of active cases reaches below 1,000,000 in 1988. Course A' shows the trend, when the incidence rate of active cases from the group infected before 5 years decreases at the rate of 10 % every five years, owing to the improvement of socio-economic conditions and medical care. In this condition, it was estimated that prevalence of active cases reaches to the level of 1,000,000 in 1978.

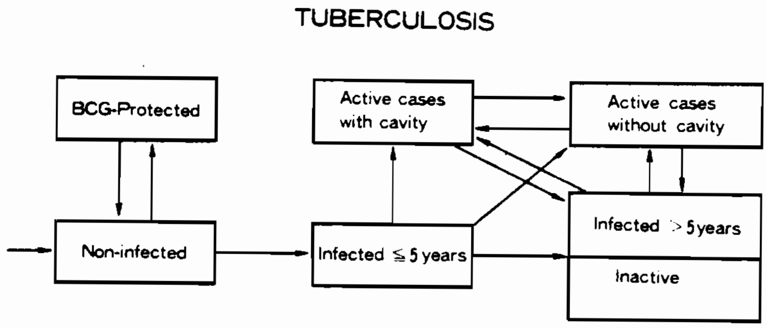


Fig. 1 Model of tuberculosis

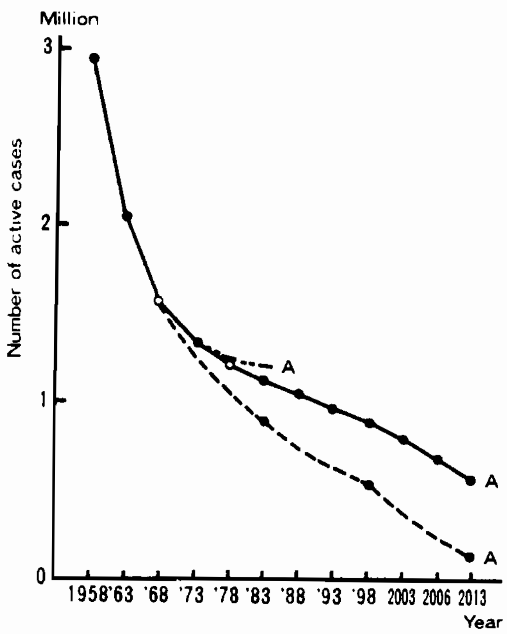


Fig. 2 The number of active cases estimated from the model
A: incidence rate is fixed at the value of 1968
B: incidence of active cases of the group infected before 5 years decrease at the rate of 10 % every 5 year.
A": care of tuberculosis patients was fixed at the rate of 1963

These results may suggest that the past tuberculosis control programs contributed to the reduction of the cases with sputa positives, leading to the reduction of risk of infection. High rate of BCG vaccination accelerated this trend. However, they could give little effect on the decrease of incidence of active cases in the subgroup infected before 5 years, which occupied 36 % of the population in 1968. This fact was considered to be the reason for the level off of the decreasing trend. (Fig. 3)

The model was also used for the evaluation of anti-tuberculosis programs. Potential protection of BCG was estimated under two conditions. In schedule B', BCG vaccination was completely stopped in 1958 to 1978 and protective power of BCG at 1958 was set to 0. The trends of prevalence is shown in Fig. 4 , that is, BCG vaccination saved total 4,170,000 persons year of active case for these 20 years. If the protective power of BCG is assumed to be 80 %, which was obtained from BMRC studies, the more effect of BCG can be expected as shown in B". Potential protection of chemoprophylaxis to the subgroup infected before 5 years was estimated, because majority of active cases will be derived from this group in future. Schedule 1 has the conditions that incidence rate in tuberculin strong positives is 3 times higher than that in the other type of tuberculin positive and that the protection power of chemoprophylaxis is 50 %. The result is shown in Fig 5 , and a great amount of reduction can be expected.

From these studies it may be able to conclude that anti-tuberculosis programs in future should be pointed to the reduction of the number of the subgroup infected before 5 years and also to the treatment of active tuberculosis cases.

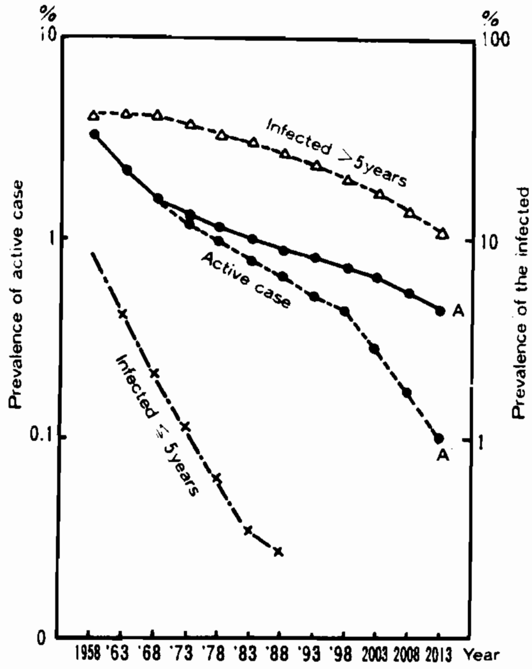


Fig. 3 Prevalence of active cases and classification

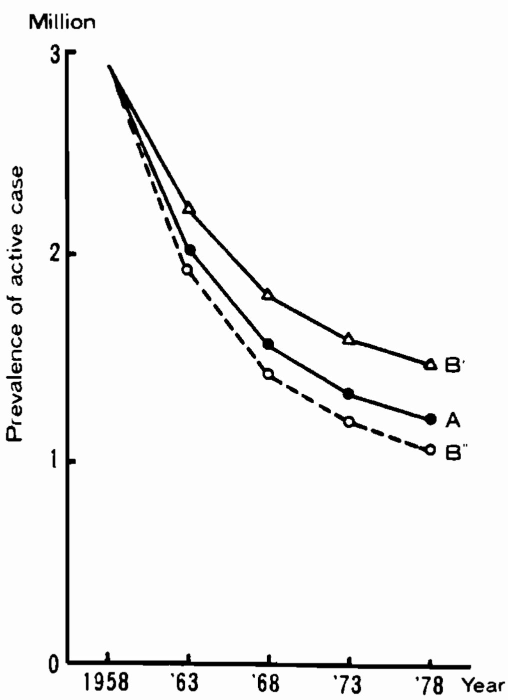


Fig. 4 Estimation of potential protection of BCG
A: the present control programs will continue in the future
B': BCG vaccination was stopped and protected power of BCG is 0 in 1958 to 1978
B": protective power of BCG is 80%

Screening of Gastric Cancer

Fukutomi et al (4) developed a model to evaluate the effect of screening in decreasing the death from gastric cancer. Their assumption was that by detecting early stage of gastric cancer, the rate of cure increases leading to the save of lives. The model they used is shown in Fig.6 .

They classified gastric cancer into three stages, namely latent early stage cancer, non-detected progressed stage cancer and detected inoperable caner. They estimated from the literature the rate of death after treatment as 0.01 per year for early stage cancer and 0.3 for progressed stage cancer. Since the incidence rate of gastric cancer (r_0 and r_2) was not known, they assumed four levels for the rates namely at level I 0.0003 for r_0 and 0.0006 for r_2, at level II 0.0006 and 0.0012; at level III 0.0012 and 0.0024 and at level IV 0.0024 and 0.0048. All other transition rates were estimated from the past studies in literatures. The rate of screening was assumed as 20 %.

The results were expressed as the number of deaths in the cohort group of 100,000 males with age between 50 and 69 in 5 years, and they were shown in Fig. 7 . The percent of reduction in number of deaths and other parameters was almost identical in all four levels of incidence rates. The per cent reduction in the number of death in 5 years was about 10 %, the reduction in the number of undetected early stage cancer was about 24 % and the reduction in the number of progressed stage cancer was about 8 %.

These results may be discussed from various aspects in relation to the policy of screening. Some may argue that 10 % reduction of death by screening is very low, but some may argue that it is important to save a single life. Whichever the arguements are these results form the base for the evaluation of screening.

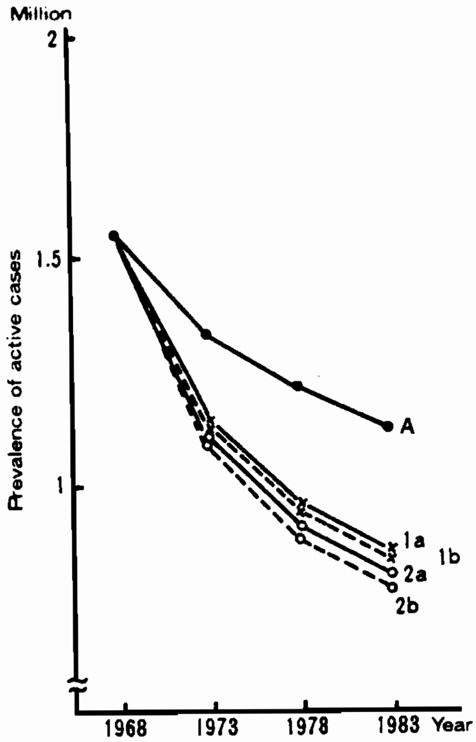


Fig. 5 Estimation of potential protection of chemoprophylaxis
A: the present control programs will continue in the future
1(2): supposing that incidence rate among tuberculin strong positives is 3 times (5 times) higher than that among the other type of positive reactors and protective power of chemoprophylaxis is 50 %.
a) chemoprophylaxis against the group infected before 5 years
b) chemoprophylaxis against both groups

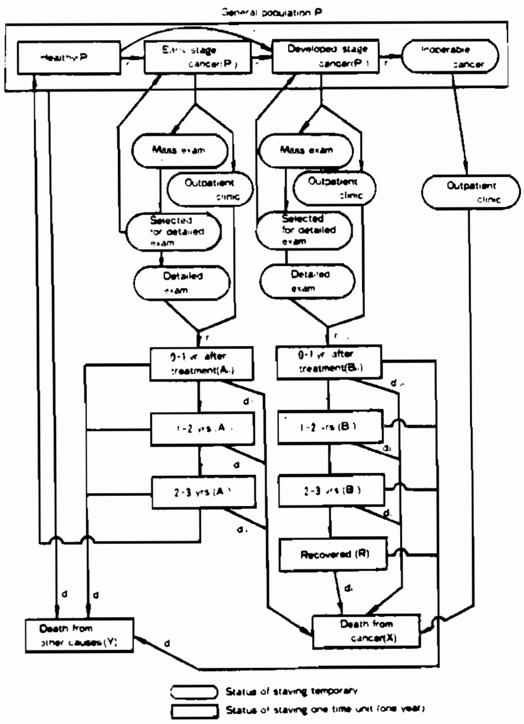


Fig. 6 Model of screening of gastric cancer

Cerebro-vascular Accidents

In the previous model, the effect of screening was shown as the reduction of death, but this was not related to cost to reduce the deaths. Yanagawa et al[5] analyzed the effect of sc reening in relation to cost using the screening of cerebro-vascular accidents as a model. The model he used is shown in Fig.8 .

The basic concept of the model is the same as previous model, except that they classified the population into three groups, namely high risk A group, high risk B group and healthy group. Each group was assumed to have different rate of transition to cerebro-vascular accidents and this rate could be reduced if hypertension was detected before accidents and treated. Patients who suffered from cerebro-vascular accidents were assumed to receive treatments for the following years for the sequela as well as for prevention of the recurrence of accidents. Transition rates were estimated from the past studies and main estimations were as follows. Incidence rates were estimated as 0.0005 for health group age 40 - 49 0.0015 for age 50-59 and 0.006 for age 60-69. The ratio of incidence rates among healthy, high risk A and high risk B was estimated 1 to 3 to 9. The incidence rates of high risk goups with detected hypertension were one half of non-detected groups. Fatal rate of accident was 0.3. The coverage of screening was set as 20 % of population.

The result was calculated in the cohort group of 100,000 males of various age groups. The number of death and accidents with screening and without screening in age group 50 to 59 is shown in Fig. 9 . The reduction rate of death was about 20 % after 5 years and 17 % after 10 years. The reduction of accidents was 24 % after 5 years and 14 % after 10 years.

The effect of screening in different age groups was also analyzed and the results are shown in Fig.10 . In this analysis, it

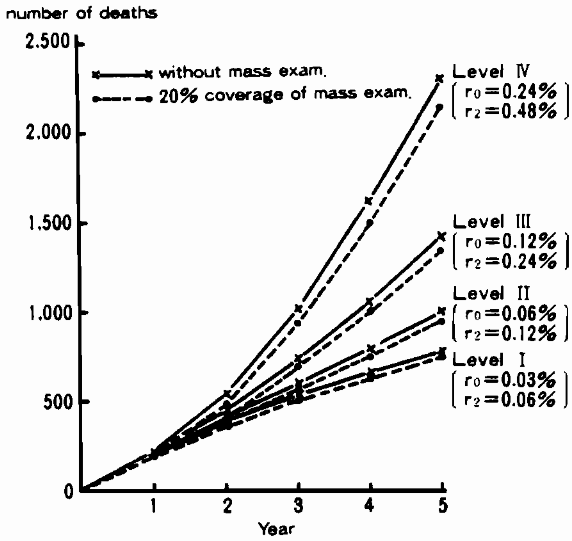


Fig. 7 Cumulative number of deaths from gastric cancer

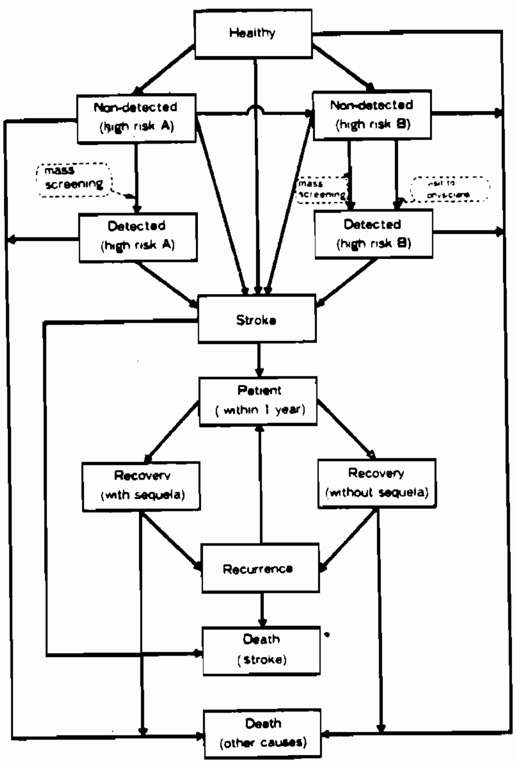


Fig. 8 Model of screening of cerebro-vascular accidents

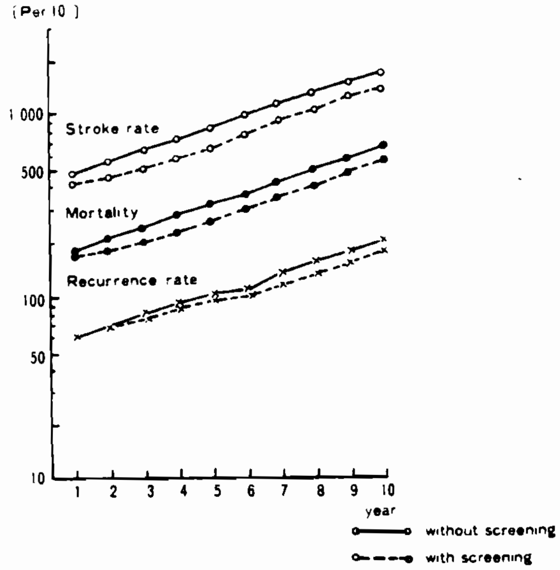
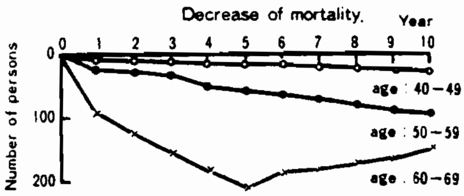


Fig. 9 Incidence rate, death rate and recurrence rate of cerebrovascular accidents with and without screening



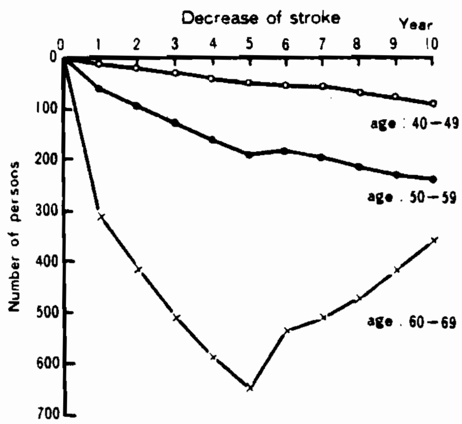


Fig. 10 Difference of effect of screening in each age group

was assumed that the screening was continued for 5 years and then it was stopped to see the remaining effect of screening for another 5 years. As shown in this figure, the effect of screening is prominent in older age group, but this effect disappeared rapidly soon after the screening was stopped.

On the base of this results, cost effect analysis was performed. Table 1 shows that the reduction of one death costs ¥ 19,750,000 (US$ 100,000) in age 40 to 49 group, ¥ 5,740,000 (US$ 30,000) for age 50 to 59 and ¥ 980,000 (US$ 5,000) for age 60 to 69 group. The details of the costs are shown in Table 2 . The cost of prevention was increased about 50 % by screening. The cost to discover hypertension was increased 871 % but this increase did not contribute much to the increase of total cost because the unit price was not so high. The cost of treatment was reduced due to the reduced number of accidents, but the total cost was the increase by 22.5 % in age group of 50 to 59.

Conclusion

In this report, we described three models related to the area of health screening. Although the effect of health screening is accepted by everybody, it is still controvertial whether the present type of screening can be given to the whole population by public sector. The present model may give part of answers to these quenstions.

In addition to cost of screening, there still remain many problems to be studied, for instance, long term effect of radiation when screening by x-ray is used, social and psychological effect of false positive and negative cases, adequacy of fascilities to follow-up the detected cases and so on. The models presented here do not answer these questions, but theoretically these can be included in the model. We believe that the studies of health care modeling should be more promoted in future.

Table 1 Cost to reduce one cerebrovascular death by screening program

Age	Decrease of death	Cost to decrease 1 death [10^3 Yen]
40-49	52	19,750
50-59	193	5,740
60-69	769	980

Table 2 Classification of cost in screening of cerebrovascular accidents

Age : 60—69

		No Screening	20% Screening	Difference
No. of persons with mass screening		—	51.053	+51.053
No. of Voluntary		4.337	2.451	— 1.886
No. of boundary hypertention		—	51.715	+51.715
Detected hypertention		101.793	140.832	+39.039
Stroke (Including Recurrence)		14.578	12.064	— 2.514
No. of stroke within 1 year		8.917	7.632	— 1.285
Recovered (with sequela)		18.807	18.190	— 617
Recovered (without sequela)		28.210	27.284	— 926
Cost (Million yen)	Discovery	21.7	165.5	+ 143.8(+ 663%)
	Prevention	3.053.8	4.380.1	+1.326.3(+43.4%)
	Treatment Care	9.566.8	8.848.3	— 718.5(— 7.5%)
	TOTAL	12.642.3	13.393.9	+ 751.6(+ 5.7%)

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EPIDEMETRIC MODEL OF TUBERCULOSIS

Josef Radkovský +)

SYNOPSIS

A "consensus" model of tuberculosis from the workshop on model methodology for health planning (Cornell University, Ithaca, New York, January 1968) was computerized by the author in Fortran IV for 16 five-year age groups after the 5-year intervals. The results of the simulation are presented in 16 epidemiological groups by age and sex. The previous alternative of cohort analysis is also available with the author.

The simulation can be done with or without interference with BCG vaccination and/or with the infection by atypical Mycobacteria. The impact of treatment can be shown by changes of some coefficients used in the formulas. The model is based on the estimation of the infection risk and at this stage has no feedback for epidemiological impact for health activities. It is meant mainly for epidemiological studies of tuberculosis statistics in the past and for planning of Tuberculosis control for the next 5 to 15 years, for which the infection risk could be reasonably estimated. The planning period is usually 5 years and after each period the calculation could be repeated with

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some corrections for new observed data.

The computer programme was tested for data from Czechoslovakia and Ceylon.

INTRODUCTION

This version of the model is an alternative to the previous one for analysis of the tuberculosis problem in cohorts, mimeographed under the title "Epidemiological Surveillance of Tuberculosis" (Indian Council of Medical Research, New Delhi, January 1968).

The cohort method gives an answer to the development of tuberculosis for both epidemiological and cost-benefit analysis of the tuberculosis problem. Unfortunately this method needs an estimate of the infection risk for a life-time period or the feedback relation influencing tuberculosis by the given tuberculosis control. The estimate of the risk or the relation should be valid for the whole period of about 80 years without changes. The doubts about this assumption and the need for health planning, usually in 5 years periods, call for a system where the data are usually presented. In most countries the valuable data are available only for the last few years, during which the observed and simulated data could be compared. In Ceylon e.g. data for the period 1960 - 1970 are available and estimates could be calculated for the period 1970- 1980, which is sufficient for the purpose of planning of the national tuberculosis control programme.

For testing and tuning of the computer programme the author used some data from analysis of tuberculosis infection in Czechoslovakia (Radkovský 1967) and Ceylon (Krzysko et al. 1970), from the above paper (Radkovský 1968) and the transfer rates for development of tuberculosis from infection (Sutherland and Švandová, 1971).

MODEL OF TUBERCULOSIS

1. Incidence and prevalence of infection

The analysis of the prevalence of tuberculin allergy in the population enables to estimate the infection risk for a limited period of time preceding the survey. If the survey could be repeated, possibly after 5- or 10-years periods, the age and sex components of the risk could be derived (Radkovský 1967, Stýblo etc. 1969).

Using the estimated infection risk for a given period of time, the following epidemiological groups can be calculated for 5-year age groups and after 5-year intervals:

(1) $TI_i = TQ_{i-1}\ (1 - Q5_i)$ incidence of infected in last five years, where

$Q5_i = Q_{5i-5}\ Q_{5i-4}\ Q_{5i-3}\ Q_{5i-2}\ Q_{5i-1}$ means a chance of escaping infection in the last five years for age group i = 1, 2, ..., 16;

$Q_i = 1 - RI_t\ CI_i$ is calculated for age (i) from the infection risk (Ri) in the last five years, e.g. for the year 1970 from years 1965, 1966, ..., 1969:

$Q_0 = 1 - RI_{65} CI_0$, $Q_1 = 1 - RI_{66}\ CI_1$, ... $Q_4 = RI_{69}\ CI_4$

$Q_5 = 1 - RI_{65} CI_5$, etc. The coefficient (CI) stands for the age component of the infection risk.

$TQ_i = TQ_{i-1}\ Q5_i$ is prevalence of non infected in age group (i) and successive 5-year periods.

The data for starting time t = 0 can be taken from observed data obtained in the survey or can be simulated by the constant infection risk in the past.

(2) $TR_i = (1 - TQ_i)\ (1 - Q5_i)$ means the incidence of repeated infection and

$TO_i = (1 - TQ_i)\ Q5_i$ the prevalence of old infection, i.e. infected not later than five years age.

$TP_i = TO_{i-1}+TR_{i-1}+TIi/2$ means the prevalence of infected subjects in age group (i).

2. Atypical infection and BCG vaccination

The interference of the infection with atypical strains of Mycobacteria with tuberculosis infection could influence the development of the disease in a similar manner as the BCG vaccination. We are interested in groups of persons who are primary infected by atypical and secondary infected by Mycobacteria tuberculosis. For the estimates of such groups we have to calculate all groups of atypical infections:

$A = (1 - RA)^5$ presents a chance of escaping infection in the last five years, if we asume a constant risk of atypical infection (RA)

$AQ_i = AQ_{i-1}\, A$ is the prevalence of non infected subjects by atypical Mycobacteria in the age group (i)

(16) $AP_i = 1 - AQ_i$ the prevalence of infected subjects in age group (i)

$AI_i = AQ_{i-1}\,(1-A)$ the incidence of infected in age group (i)

Now we calculated the secondary tuberculosis infection in age group (i):

$STAI_i = (AP_{i-1}+ AI_i/2)\, TI_i$ incidence of secondary TB infection in the last 5 years

$STAR_i = (AP_{i-1}+ AI_i/2)\, TR_i$ incidence of repeated secondary TB infection

(15) $STAP_i = STAP_{i-1}+STAI_i$ prevalence of secondary TB infection

The interference of tuberculosis infection with BCG vaccination is calculated with actual figures of vaccinated persons in age group (i), i.e. BCG_i. The effectiveness of the vaccination (VEF) could decrease during life-time, e.g. by 1 % per year. Then the loss of effectiveness would be VEFL = 0.05 in five years and after this period BCG_i will be **reduced** to

(13) $BCG_i = BCG_{i-1}\ (1 - VEFL)$.

The effective vaccination coverage for age group (i) would be

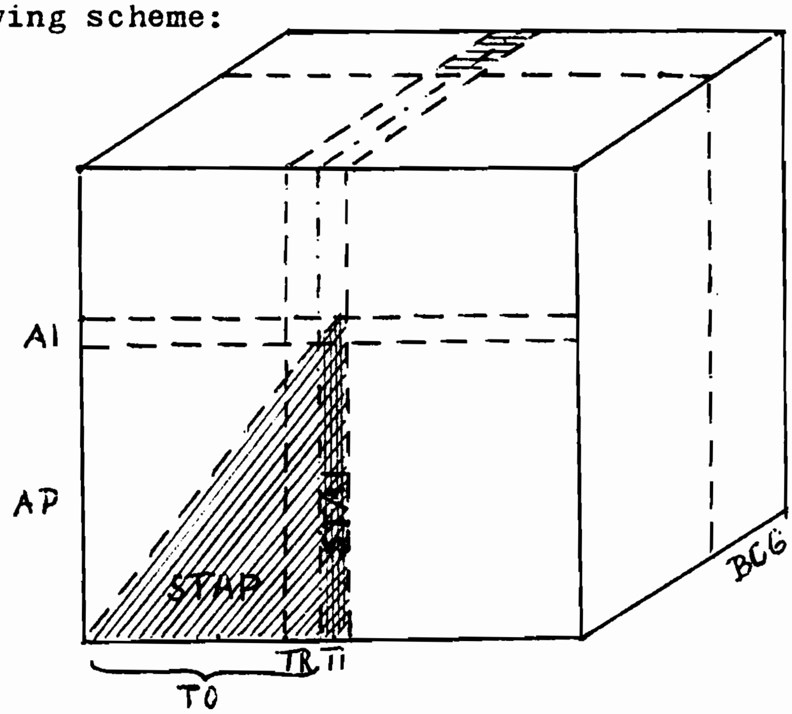
(14) $EVC_i = BCG_i\ VEF$.

Without interference with atypical Mycobacteria or BCG vaccination we use for the development of tuberculosis the above formulas for the risk groups of newly and repeated infected persons TI and TR. With the interference we have to replace them by the "vaccinated" groups TIV and TRV:

$$TIV_i = (1 - STAI_i\ AEF)\ (1 - EVC_i)\ TI_i$$

$$TRV_i = (1 - STAR_i\ AEF)\ (1 - EVC_i)\ TR_i$$

where the coefficient AEF means reduction of the risk of developing tuberculosis in persons previously infected by atypical Mycobacteria. The combination of these three factors can be clarified by the following scheme:



3. Pulmonary tuberculosis

Among the infected persons some develop signs of disease, which can be diagnosed by X-ray as lesions (XB) or suspected cases of tuberculosis (XA). The relation between the number of tuberculin positive subjects and the number of X-ray findings in some surveys gives the coefficients CXB and CXA by age and sex for these two epidemiological groups XB and XA. These coefficients can be used as approximate estimates for development of X-ray lesions from infected persons $TP_i = TO_{i-1}+TR_{i-1}+Ti_i/2$.

(4) $XB_i = TP_i \; CXB_i$

(5) $XA_i = TP_i \; CXA_i$

Both these groups or at least the latter have a higher risk of developing tuberculosis, which could be classified by bacteriological examination as excreating bacilli. If we could estimate or assume coefficients for development of tuberculosis from the above groups - CTI from the new infections, CTR from reinfections in last five years and CTO from old infections - then we could write the formula for the incidence of new cases of pulmonary tuberculosis

(6) $PI_i = (Ti_i \; CTI + TR_i \; CTR + TO_{i-1} \; CTO + XA_i CX) \; CP_i$

CP_i is the age component of the risk to develop tuberculosis by age, as it is known, that most infections occur in the first age groups, but only few cases which can be identified by microscopy are developing in these age groups.

The incidence of relapses of pulmonary tuberculosis (PR) is calculated on the basis of the relation between (PR) and the incidence of new cases five years age, which gives the coefficients CPR. It was found by analysis of age curves that the interval between two modes of PI and PR is about 5 years:

(7) $PR_i - PI_{i-1} \; CPR.$

The <u>prevalence of pulmonary tuberculosis</u> comprises new and recurrent cases which last for a period of natural healing without treatment (on the average e.g. 3 years). If a portion (CTT) is treated by chemotherapy with reduced duration of diseases CHT

(8) $PP_i = (PI_i + PR_i)\ (NAT - (NAT - CHT)\ CTT)$

The portion of deaths caused by pulmonary tuberculosis is the product of the prevalence of pulmonary tuberculosis and the death rate CDP

(9) $DP_i = PP_i\ CDP$

4. <u>Extrapulmonary tuberculosis</u>

The <u>incidence of extrapulmonary tuberculosis</u> (EP) comprises new infections with the risk of developing tuberculosis meningitis (CMG) and the product of the incidence of new cases 5-10 years earlier and the risk (CEPI)

(11) $EP_i = TI_i\ CMG + \bar{PI}_{i-1}\ CEPI$

The pool of earlier cases is neglected in the formula assuming that the risk to develop extrapulmonary tuberculosis from pulmonary cases decreases with time after onset of the primary disease. This portion could be corrected by adding $POOL_{i-2}$ CEPP.

<u>Deaths from extrapulmonary tuberculosis</u> occur in new infected persons with a transfer rate DMG and in the prevalence of extrapulmonary cases with transfer rate CDE

$DE_i = TI_i\ DMG + (EP_i - TI_i\ CMG)\ CDE$

(12) $DE_i = TI_i\ (DMG - CMG\ CDE) + EP_i\ CDE$

We may need to use in the above formulas or for some other purposes the sum of all cases still living at the time (i), regardless of the bacteriological activity. This group has a higher risk to develop recurrent cases or extrapulmonary tuberculosis. As the incidence and death rates are calculated per year, we have to multiply them by five:

$$(10) \quad POOL_i = POOL_{i-1}+5(PI_i+TI_i\ CMG) - 5\ (DP_i+ DE_i)$$

Finally we have to correct the number of old infections by subtracting the number of deaths

$$(3) \quad TO_i = TO_{i-1} + TI_i + TR_{i-1} - TR_i - 5\ (DP_i + DE_i).$$

All transfer rates are given in fractions of a unit and the results are calculated in rates per 100 000.

- - -

In the above formulas 4, 5, 6, 10, 11 and 12 the epidemiological groups TI, TR and TO are substituted for the "vaccinated" groups TIV, TRV and TOV, if the interference of tuberculosis infection with BCG vaccination and/or with infection by atypical Mycobacteria is to be clarified. The comparison of figures with and without interference is included in the programme and helps not only in the study of the epidemiology of tuberculosis under different epidemiological conditions, but also in the evaluation of the tuberculosis control programme.

Computer programme in FORTRAN IV for calculation of the epidemetric model of tuberculosis is available with the author.

EPIDEMETRIC MODEL OF TUBERCULOSIS. Coefficients (transfer rates) Annex

Ceylon:

.0350 .1300	R RA
1960 10 1960	IEAR LI IEARB
.033 .032 .0305 .029 .0275 .026 .0245 .023 .0215 .02	RI(I)
.04 .43 .40 .29 .16 .07 .03 .0 .0 .0 .0 .0 .0 .0 .0 .0 .04 .47 .45 .04 .47 .50	BCG(I)
.38 .152 .00015 .001 .111 .010 .006 .250	CTI CTR CTO CX CDP, CMG DMG CDE
3.0 1.0 1.0 0.0 .75 .05 .60	ANAT CNAT CHT CCHT VEF VEFL AEF
.0125 .0142 .0165 .0190 .0220 .0255 .0300 .0345 .0410 .0500 .0580 .0640 .0710 .0780 .0860 .0950	CXB(I)
0.10 0.25 0.50 0.90 1.o 1.o 1.o 1.o 1.o 1.o 1.o 1.o 1.o 1.o 1.o 1.o	CP(I)
.420 .008 .130 .004	CPR CPRP CEPI CEPP } MALES
1.5 1.o 1.o 1.o 1.o 1.o 1.o 1.o 1.o 1.o 1.o 1.o 1.02 1.08 1.18 1.27 1.36 1.43 1.47 1.50	CI(I)
.004 .0055 .0077 .010 .0122 .018 .030 .041 .044 .053 .070 .085 .093 .102 .110 .120	CXA(I)
.350 .006 .340 .008	CPR CPRP CEPI CEPP } FEMALES
1.5 1.0 1.0 1.0 1.0 1.o 1.o 1.o 1.o 1.o 1.o 1.o 1.o 1.o 1.o 1.o 1.o 1.o 1.o 1.o	CI(I)
.004 .0055 .0077 .020 .019 .019 .019 .022 .03 .035 .037 .0375 .037 .036 .0355 .035	CXA(I)

Czechoslovakia:

.10 .0	R RA	
1910 70 1950	IEAR LI IEARB	
.099 .098 .095 .093 .094 .098 .105 .110 .108 .106 .103 .100 .097 .094 .092 .090 .087 .084 .082 .080 .0775 .0754 .0712 .0657 .0585 .0517 .0466 .0430 .0389 .0368 .0355 .0326 .0294 .0268 .0229 .0209 .0185 .0164 .0145 .0128 .0114 .0100 .0089 .0078 .0070 .0062 .0055 .0049 .0043 .0038 .0034 .0030 .0027 .0023 .0021 .0019 .0017 .0015 .0013 .0012 .0011 .0010 .0009 .0009 .0008 .0008 .0007 .0007 .0007 .0006	RI(I)	
.324 .752 .7 .399 .094 0 0 0 0 0 0 0 0 0	BCGM	1950
.911 .848 .837	BCGR	1955
.976 .915 .87		1960
.985 .98 .92		1965
.985 .99 .985		1970
.985 .99 .995		1975
.985 .99 .995		1980

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INTERACTIONS AMONG HEALTH CARE SUBSYSTEMS AND THE NEED FOR AN EXTENDED INFORMATION SUPPLY

E. Shigan

INTRODUCTION

One of the main elements of systems analysis is the investigation of the relationship of different structural components within a system. Without knowledge of the interaction between internal and external subsystems, it is impossible to describe the behavior of a system.

The Health Care System (HCS) is a prime example of a system whose strategical problems may be examined with the help of systems models. In the past, however, these models have not included information regarding the interconnections between the *subsystems* of the HCS.

1. QUALITATIVE ASPECTS

There are four types of interactions between HC subsystems. These can be categorized by the substance that is transferred between the two subsystems. For example, *information* may be passed between subsystems through the use of letters and telephone calls. *Material* such as techniques, money and goods may be exchanged. *Specific medical* commodities such as drugs and laboratory tests as well as patients can be routed between the subsystems and, of course, a *combination* of two or three of the above items must be considered.

It is also helpful to define the different hierarchical levels of the HCS: the medical establishment itself, and the district, regional, national, and global levels of the HCS. The horizontal level includes all the facilities within the same hierarchical level such as a hospital or a maternity home within a city. The vertical level of the HCS incorporates district-level or regional-level hospitals (Figure 1).

Further classifications of the interractions among HC subsystems include official, unofficial, direct, and feed-back interactions. *Official* interconnections are held together by legislation, instruction, or legal contract while *unofficial* links include the less formal, word-of-mouth contact. The so-called *direct* interactions include, for example, the transfer of patients from one medical establishment to another, according to the sequence of the treatment, and the *feed-back* relations are a reaction due to some direct influence such as payment or health status.

One of the most important qualitative aspect of the interactions between subsystems is the *substitutional effect*. By understanding the effect on the system as a whole when one activity in a subsystem has been substituted for another, the decision maker is able to form better opinions regarding the allocation of resources. There are many possible substitutional effects in the HCS (Figure 2). Without the investigation of the substitution effect and its utilization in the managerial process, duplications of activity in different subsystems can exist. For example, in order to economize, laboratory tests should be made in the outpatient Polyclinic and the results of these tests should be adequate for patients in hospital.

If there exists a large *duplication effect* it will lead to an unreasonable increase of resources in the HCS. But taking into account the limited national resources such a "strategy" of increasing resources in one sector will lead to the decrease of resources in other sectors of the national system as a whole.

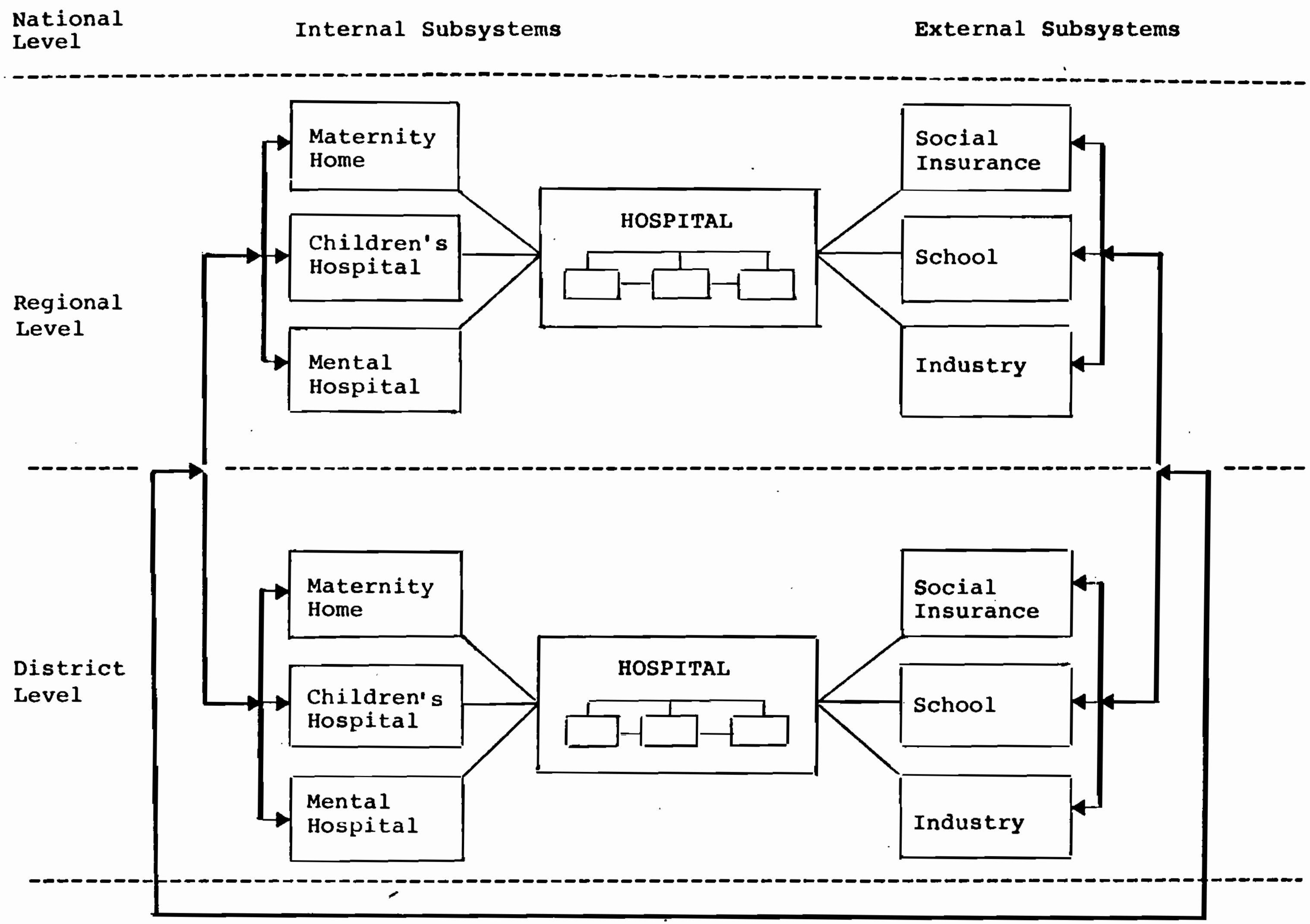

Figure 1. Interractions between internal and external HC subsystems.

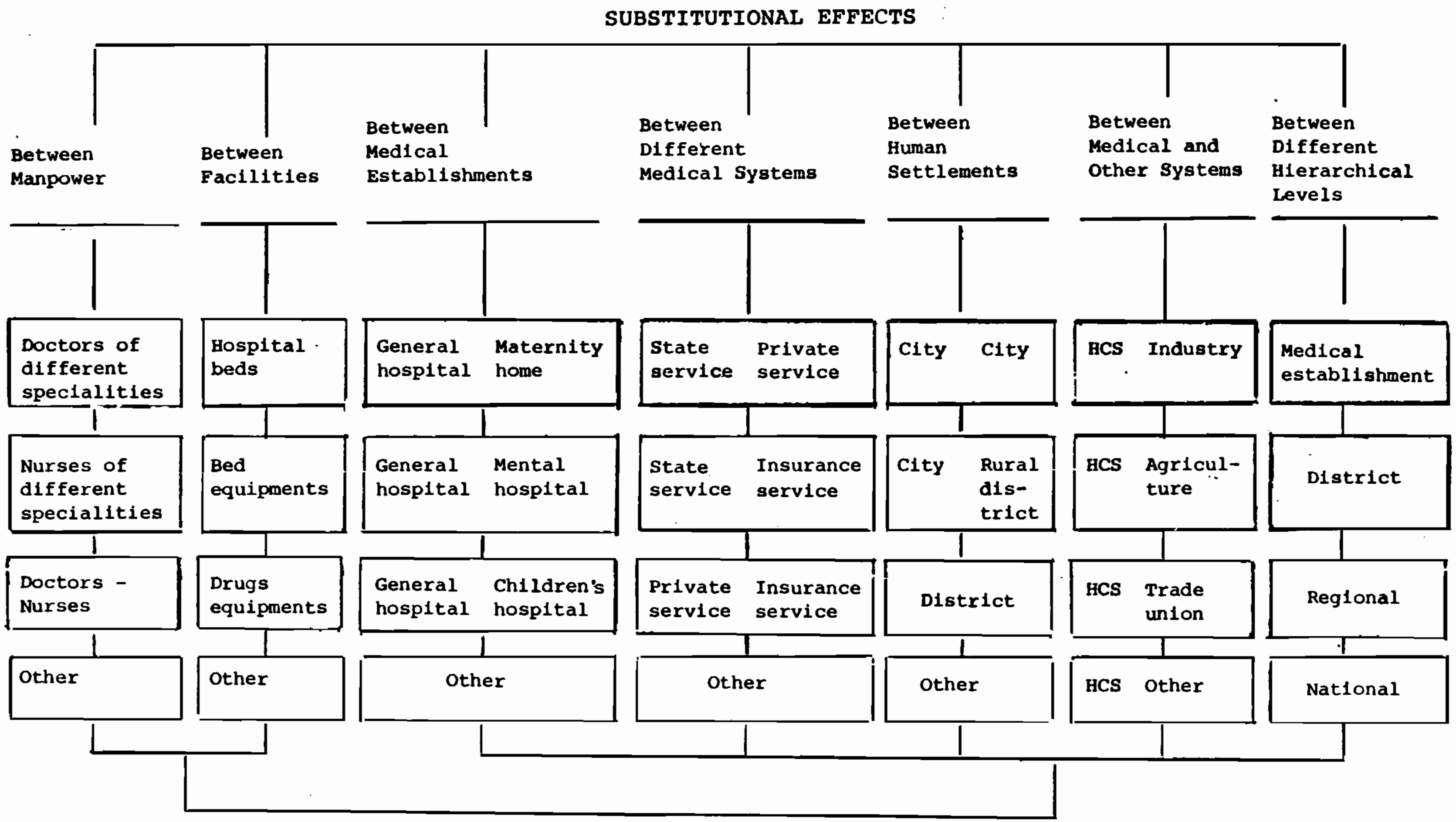

Figure 2. Substitutional effect in the HCS.

2. QUANTITATIVE ASPECTS

In spite of the existence of logical differences between the interactions of the structural elements of the HCS, quantitative methods of analysis can help to estimate and compare these interrelations which is very important for the modeling process.

There is a number of quantitative techniques, from simple to complex, which could be used in a numerical analysis of these internal and external subsystem interrelations.

- The development of different, simple indices is one such technique. For example, the relation between the Polyclinic and the Hospital could be described by a set of simple rates such as the percentage of the population hospitalized or the coefficient of correspondence between Polyclinic and Hospital diagnoses.
- Another example is the correlation and regression analysis within pair and partial rates. For example, the interrelation between the Polyclinic and the Hospital could be measured by a rate in order to indicate the average number of outpatient visits per capita that will change in the Polyclinic if the percentage of hospitalized cases decreases.
- The interaction among subsystems and their parameters could be estimated by different mathematical models. For modeling these interrelations it is important to have some detailed information about subsystems and their interraction. Depending on the goals, especially investigating relations, the supply of the information model could be static or dynamic, statistical or deterministic.

In order to use quantitative rates or equations in describing the interrelation between the subsystems and the substitutional effect in the model building process, it is necessary to look at their stability. The *stability effect* should be studied from two points of view: the stability interrelation rate in time and in space (from one region to another). The investigation of the substitution rates during several years will help to estimate the stability of these rates. If the substitution rate is constant over time, or is changing on the constant coefficient, it means that this rate could be used to build up a dynamic model.

It is also important to study the substitution rates for different cities, regions and countries. If the substitution rates are different among the districts, it means that the mathematical model developed for one locality will not apply to other districts or will need serious corrections.

Taking into account all the above quantitative aspects one can suggest the following steps for the investigation of interractions among different HC subsystems (Figure 3).

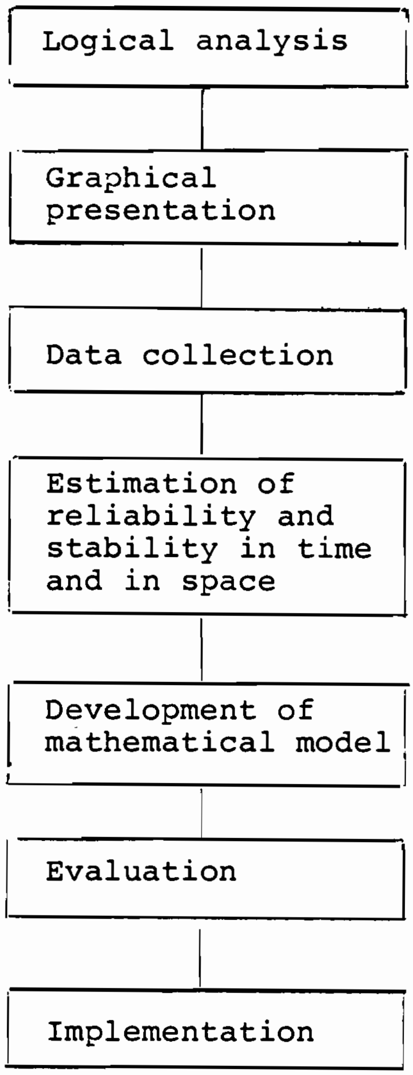

Figure 3. Flow-chart of the investigation of subsystem interractions.

As a result of the quantitative analysis of interrelations among different internal and external subsystems a number of mathematical indices of varying complexity can be created, which would be useful in the decision-making process. Some of these indices could be presented as a set of graphics, tables, or monograms. Even such simple means would help the decision maker to better understand the behavior and interraction of subsystems. More complicated mathematical models describing the network subsystem interactions could also be used as one of the submodels of the whole HCS model.

3. INFORMATION ABOUT SUBSYSTEM INTERACTION

One of the main obstacles in investigating the interconnection of HC subsystems is lack of information. A paradox exists. On the one hand there is a great deal of information in the HCS about each subsystem, but on the other hand it is difficult to find data concerning the *interaction* of these subsystems. Even in cases where the interrelation is formal and known there is little quantitative data about these relations in time and in space. When it becomes clear that many health care problems are intersectional and interdisciplinary and that for their solution a system analysis methodology should be used, it will then be necessary to revise the information supply system.

From my point of view, it is time to create such a *strategic* information supply as part of the existing information system. This strategic data should include mainly long-term information about trends of each functional block of the HCS and its interrelation (Figure 4). This strategic information should come from four sources:

1. "Routine" statistics about the HCS
2. Official reports/environmental systems
3. Interrelations among HC subsystems taken from the current revisions of completed research investigations
4. Specially organized new investigations

Routine statistics about HC and external systems can be obtained from a number of official reports, including

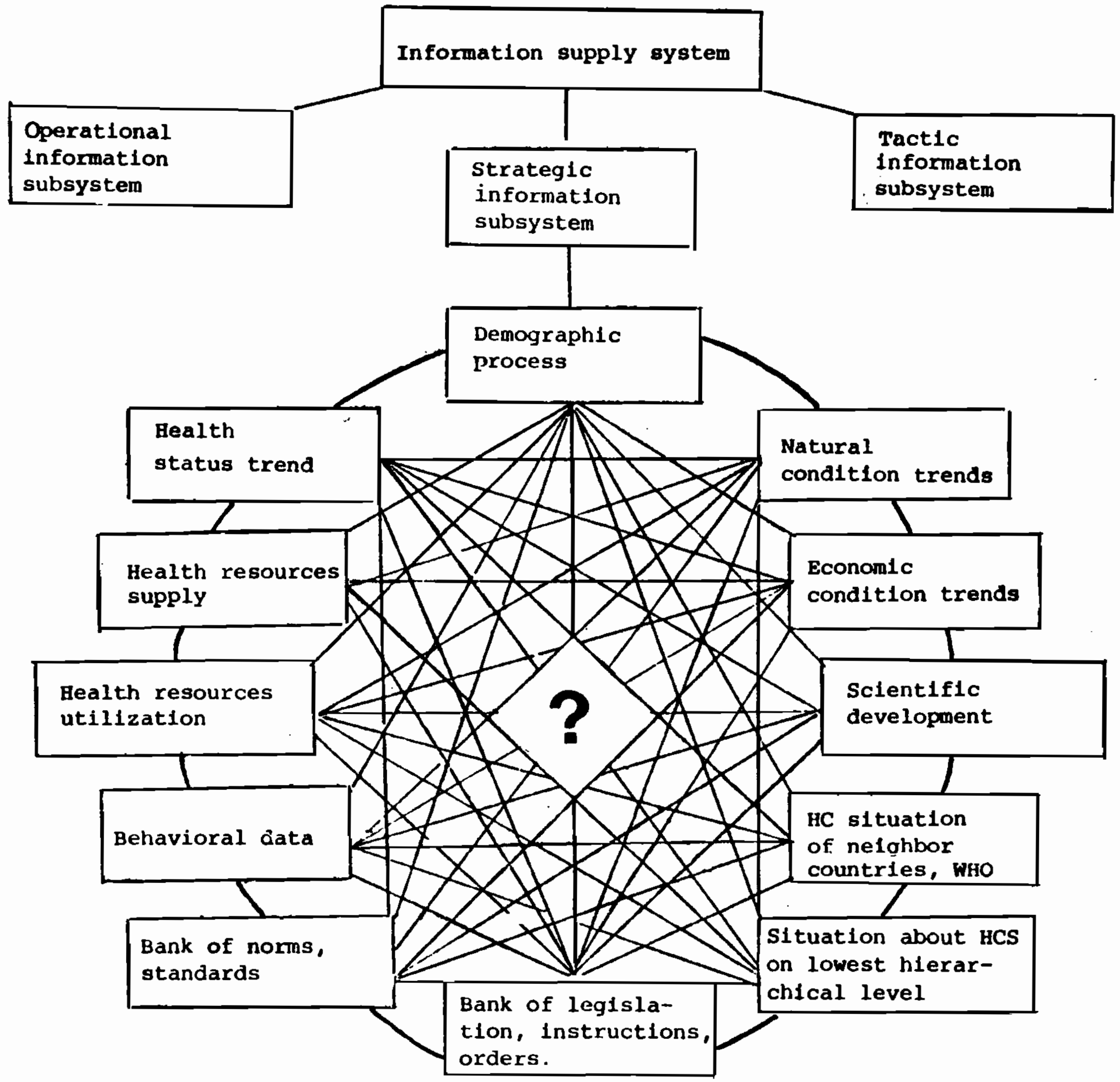

Figure 4. Block-scheme of subsystem interraction information.

different independent tables for each subsystem. These tables contain quantitative data about different variables and parameters describing the corresponding subsystem. With the help of these official periodic reports it is possible to estimate statistical tendency rates in time and their difference from place to place. Information about the interrelation among different subsystems, however, could be only partly taken from routine statistical channels. More detailed information about the interrelation among different subsystems could be collected from finished research reports dealing with some specific subsystems and their interactions. This should be done by big hospitals, research institutions, etc.

There is no question that subsystem interaction information should be added to the existing list of key words in the subject index of current literature on HC. For example

- Interrelation
    - between
        - hospital and emergency unit
        - hospital and maternity home
        - hospital and polyclinic
    - modeling, etc.

or

- Substitutional effect
    - horizontal
    - vertical
    - within medical establishment
    - within health care system

An important source of strategic information would have to come from special comprehensive studies. Information would have to be gathered about individual health status, health care service, behavior aspects and the interrelation of all these with the natural and socio-economic conditions of the area being studied. A beginning could be made at the level of the HCS--the individual's health in relationship to the medical establishment. This information could be taken from dynamic comprehensive investigations: linkage record studies. When these investigations encompass different regions within a country, geographical differences become an important consideration. It is clear that there should be additional questions asked about interractions with external systems.

Periodic studies, describing the interraction of different subsystems and their changes in time and in space should be conducted. A number of such studies, oriented to the investigation of interrelations between different subsystems together with permanent linkage record studies in representative clusters, current revision of finished research studies, and "routine" statistics will give the opportunity to create a family of systems models.

With this information on the interaction of HC subsystems on the one hand and the family of HCS models on the other hand, the decision maker will become well armed to make conscientious and constructive decisions for the HCS (Figure 5).

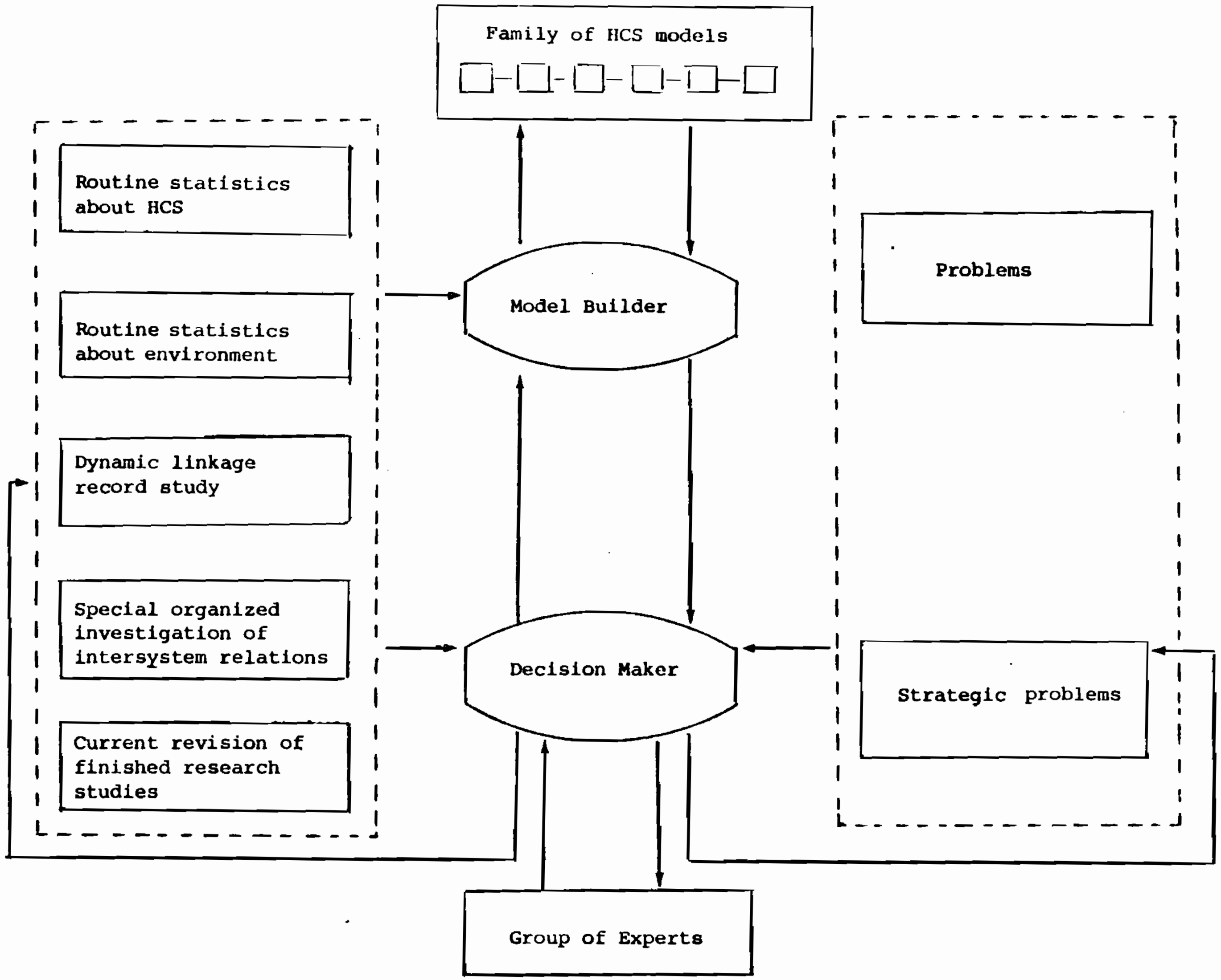

Figure 5. Decision-making process in solving strategic problems.

MODEL FOR SHORT-TERM PROGNOSIS OF THE NEED OF GROWTH OF MEDICAL PERSONNEL (PHYSICIANS,STOMATOLOGISTS AND PHARMACEUTISTS) AND STUDENTS' ADMISSION TO HIGHER MEDICAL EDUCATIONAL INSTITUTIONS

Eng. Zenov, S.Bačev, El.Petkova

The need of personnel with higher medical education (PHME) in Bulgaria is determined in the form of norms.The norms, used in the elaboration of current and perspective plans are developed as results from complex scientific investigations.They reflect the need of medical personnel of the society ,refracted through the national possibilities of their provision.The tendency for a more complete provision of medical attendance of the population has an effect on the constant growth of the number of personnel with higher medical education.When the growth for the compensation of the natural elimination,due to retirement and death is added to that necessary growth, the need of new personnel with HME is seen to be considerable. Under the conditions of our country,the only source of new personnel with HME appeared to be the higer medical educational institutions.

The proposed model is elaborated with a view to the prognostication of the growth of personnel with HME as well as the role of the higer medical educational institutions for its realization:

1. Optimal provision of the population with PHME;
2. Maintenance of optimal structure according to sex of PHME;
3. Guaranteeing of normal work of the higer medical educational institutions;
4. Consideration given to the expected dynamics of personnel

potential with the operative labour laws and regulations;

5.Credit given to formed age and sex structure of PHME as a decisive factor in the elimination of the perssonel by natural causes;

6.Difference in the training terms of the different medical specialities 6physcians - 6 years,stomatologists - 5 years,and pharmaceutists - 4 years);

7.The graduating students appeared to be the only source of RHME;

8.Our country exports personnel for developing countries being also an element in the personnel balance.

The model is based on the scientific regularities,presented with mean statistical indices (data for 1977).

A separete model is elaborated for each medical speciality.Each model comprises two submodels - one for males and females.The need of new personnel and students admission according to calendar years are prognosticated with the model.

The ratio males to females, reflecting the specificity of each medical speciality,is treated as input information for the model, revealing the labour policy and the solution of certain social problems.The latter is with a character of a norm.

The information about the necessary number of medical specialistis appears also as input information for the model.It is also with the character of a norm.The personnel norm is presented as a control figure for the end of the planned period in the perspective plans for the development of the country and balance commitment of personnel potential.The option that the growth should be regular is advanced. Therefore, the annual number of PHME is obtained via the interpolation between the last known reported figure and the control figure for the end of the period.

The rest of the values have a statistical character and are calculated either as a mean for a certain year or as a permanent trend if a dynamics is present in their development.

The model is presented with the following equations:

$$Q_i = Q_i^M + Q_i^F$$

or

$$Q_i = \begin{cases} Q_i^M = \dfrac{N_{i+k}^M - (H_{i+k}^M - O_{i+k}^M - I_{i+k}^M).(100 + R_1^M + R_2^M)}{R_3^M} \\ Q_i^F = \dfrac{N_{i+k}^F - (H_{i+k}^F - O_{i+k}^F - I_{i+k}^F).(100 + R_1^F + R_2^F)}{R_3^F} \end{cases} \quad (1)$$

where :

- Q_i - is the number of students that should be admitted to the higer educational institutions during the year i,
- M - index for male subjects,
- F - index for female subjects,
- i - calendar year,
- k - term of training in the higer medical educational institutions,
- H_{i+k} - available PHME at the begining of i+k year,
- N_{i+k} - planned need of PHME during i+k year,
- O_{i+k} - natural elimination due to retirement or death at the begining of i+k year,
- I_{i+k} - number of PHME, working outside the country during i+k year,
- R_1 - per cent of working pensioners out of all working at present PHME,
- R_2 - per cent of PHME holding more than one office,
- R_3 - per cent of graduating students out of the admitted to the higer medical educational institutions.

The numerators of the submodels presented (1) reflect the necessary new PHWE according to years whereas the total fraction - the necessary number of students that should be admitted in order to meet the needs.

The model is solved via yearly steps.

The information about the model parameters is collected as follows:

1. Planned need (N_{i+k}) - an element of personnel balance of the plan for social-economic development of the country;

2. The number of the available PHME (H_{i+k}) is obtained as planned data on the base of data from the National card-index of the personnel with higher medical education, distributed according to age and sex;

3. The natural elimination due to retirement and death (O_{i+k}) is calculated as a product of two vectors according to the formula:

$$O^M_{i+k} = / \; H^M_{i+k} \; / \; . \; / \; P^M \; /$$

(2)

$$O^F_{i+k} = / \; H^F_{i+k} / \; . \; / \; P^F \; /$$

where the PHME distribution of males according to age is presented by:

$$H^M_{i+k} = (h^M_{i+k,20}, h^M_{i+k,21}, \ldots, h^M_{i+k,n})$$

The PHME distribution of females according to age is presented by:

$$H^F_{i+k} = (h^F_{i+k,20}, h^F_{i+k,21}, \ldots, h^F_{i+k,m})$$

The indices for mortality rate according to age and sex are presented by:

$$P^M = (P^M_{20}, P^M_{21}, \ldots, P^M_n \;)$$

$$P^F = (P^F_{20}; P^F_{21}, \ldots, P^F_n)$$

where n is retirement age.

It is admitted that $P^M_n = P^F_n = 1$.

4.The prognosis for PHME,expected to work abroad (I_{i+k}) is elaborated with the aid of a dynamic linear model on the base of retrospective information for the dynamic of the process.The data obtained are subjected to assessment.

5.The relative share of the pensioners among all working (R_1) is calculated on the base of the data for 1977.During the last few years,this index has shown no tendency for a dynamic change in our country.It is admitted also not to change in the future 10-15 years.

Essential are the differences in the index of males and females and according to medical specialities,that is the reason they are separately calculated for each model.

6.The relative share of jobs,held by one person (R_2) is a planned index.It is calculated on the base of planned data.No dynamics is observed as with the previous index but there is a difference between males and females as well as according to medical specialities (it is not common,among the pharmaceutists,to hold more than one job).No changes are expected in labour legislation,thus among that the index will maintain its value during the next several years.

7.The relative share of the graduating students out of the admitted ones (R_3).Due to the above mentioned considerations it is calculated according to specialities and sex of the admitted students.

The prognosis for the need of new medical personnel and ad-

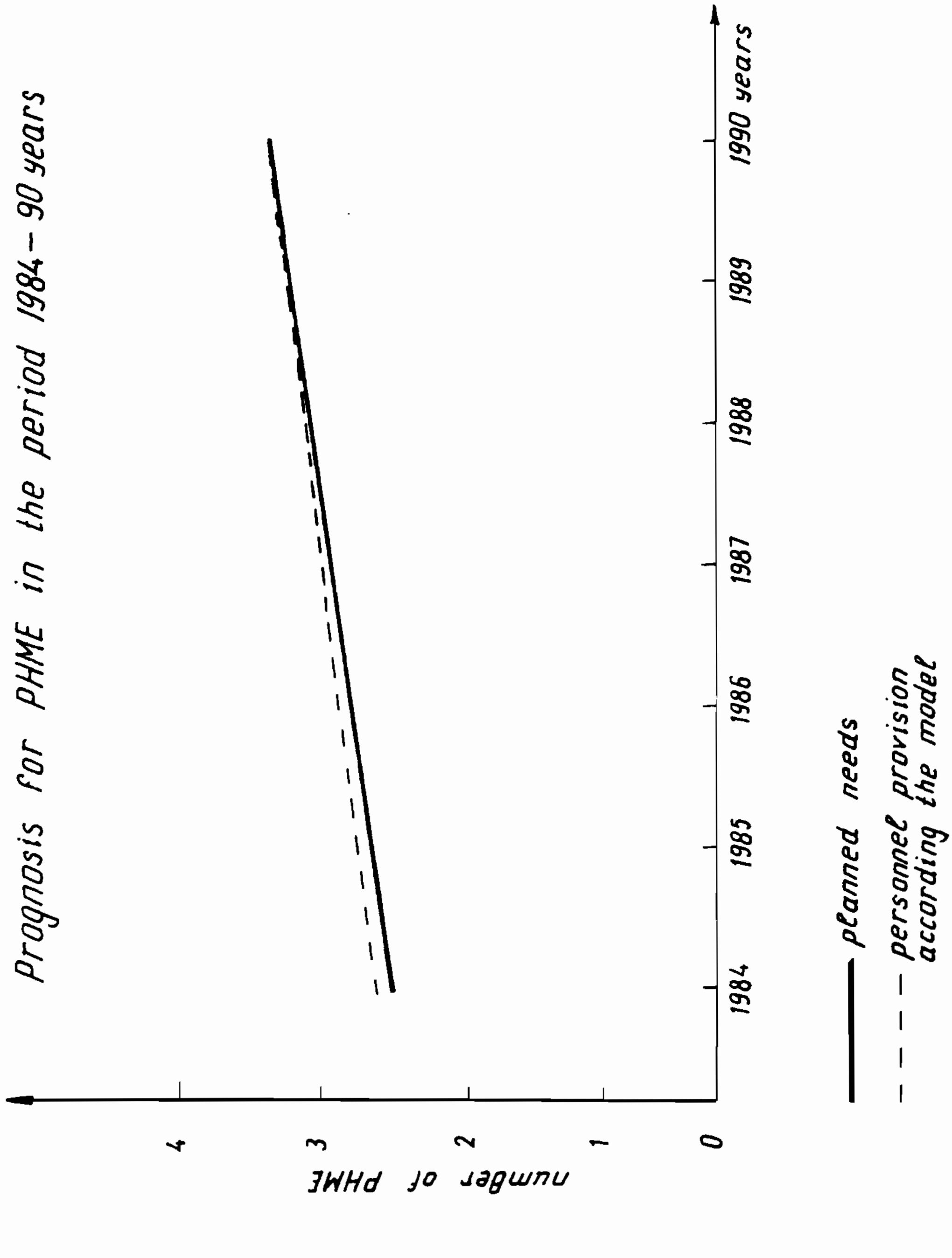
Prognosis for PHME in the period 1984 - 90 years
number of PHME
0
1
2
3
4
1984
1985
1986
1987
1988
1989
1990 years
planned needs
personnel provision according the model

fig.1

mission of students for their provision according to specialities is obtained via the parameters, assosiated with the respective specialities, being set in the indicated models (submodels)(1).

The prognoses obtained reflect, both the annually emerging needs and the annual admission of the students. The prognostic values are subjected to considerable fluctuations (dispersion). Based on the flexibility of the public health system and the possibilities of meeting certain needs via holding two jobs and penssioners' work, a mean need and admission annually are proposed to be calculated. That, to a great extent, corresponds to the nature of educational system. The considerations indicated necessitate the elaborated prognosis to be derived as linear regressions or to be averaged in order to calculate the planned admission of the students annually.

The personnel problem arising with the averaging processes are negligible for the public health system as shown on fig.1.

The model was put into practice for the needs of planning of students' admission to the higer medical educational institutions in Bulgaria up to 1985. The results obtained completely satisfy the plan practice.

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STRATEGIC HEALTH PLANNING IN CHANGING ECONOMIC ENVIRONMENT

A. S. Härö

1. IDEAS PENETRATE SLOWLY

It seems that theories, ideas and even technological innovations which should influence the behaviour of bigger organizations are sometimes taken into use relatively slowly. Obviously this is a safety measure because the changes must not be so violent or frequent as to destroy continuity and ready comprehension of the main objectives of the organization. A relevant example is the relative slow adoption of "systems approach" in the health field. It seems that many systems applications which require primarily analytic skills and are suited in minor problems have been fully accepted at least in principle long time ago. But now when the time is ripe for solutions concerning really big problems the progress is slow, the climate is cold, and it is difficult to find examples to be followed. This statement is especially oriented to programme-budgeting, social accounting and modern management, which all can be labelled as "systems approaches".

2. PROBLEMS OF PRESENT HEALTH POLICY

Each health service system has his own specific policy problems, but on the other hand if we are concentrating to "health related strategies" the main features do not at present differ very markedly. We are obviously moving to a direction where the environmental aspects are very important goals as well as health behaviour or life-styles. Sanitation,prevention, health education etc. were in the past often labelled as "hygienic" activities and it is not without reason to say that we all are now moving to a "neohygienic" epoch. Another typical aspect in the published goal statements of most countries is the stress laid on "humanistic" aspects e.g. to the closeness, to alternative ways of care etc. Generally speaking the problems are to be seen with the eyes of the consumers,not from the point of view of the producers. Maybe the third main policy line is the active interest in primary care and in all extramural ways of providing services.

This type of policy statements, if materialized, require much more effective management than health service systems in which the focus of interest are primarely well equipped isolated institutions like hospitals, sanatoria, mental institutions etc. These will remain important, but in addition the society requires services and programmes which can be managed only as "systems". A more effective style of management is accordingly a must.

3. SPECIFIC HEALTH SYSTEMS CHARACTERISTICS

It is not uncommon that management experts are describing health services as the last of "Cottage Industries" and consequently judge its management most backward. But actually the health services are really a "complex social dynamic functional system" as repeatedly described in e.g. IIASA publications (2). Some attention should be devoted to such characteristics which hardly at all are relevant in industrial type of management which obviously is seen as the standard of effective managerial style. I will borrow directly the list of characteristics presented in a recent study of European Public Health Committee (Buchstaller & al) concerning modern methods of management applied in health institutions.

2.5. Specific systems characteristics

Systems characteristics with special importance for organisational and managerial ventures in the health field are :

a. The object to which the service is rendered is a person or a group of persons, and the item to be serviced cannot be separated from its owner.

b. The service is an intimate part of the individual's life. It deeply affects if even for a short time the total experience of the patient and his family.

c. The field is "anxiety-driven". Assurance is often more important to the patient than definitive medical care. Any sudden changes will therefore be resisted as much by the public as by the professionals.

d. Severe manipulations of organisational structures will lead to chaos in the system and to disappointment on the part of health service planners.

e. The systems (most of them) have to be "emergency-ready" : accidents and unforeseen illnesses may occur at any geographic sites during each of the 168 hours of the week. This feature prohibits too much centralisation. Forced attempts to restructure the organisation can only result in a reduction of response.

f. The system is labour-intensive. Most of the services are rendered directly by health personnel and cannot be substituted by equipment or facilities.

Thus we have a combination of a labour-intensive, professionally-dominated and anxiety-driven system, operating in an infinite number of combinations and places, a system difficult to supervise in detail from a distance, i.e. by a central authority.

If one adds that all health services combine different techniques, methods and skills in order to achieve a number of goals difficult to express in exact terms and quite often partly conflicting, the real meaning of the word complex becomes more clear. One complication is the fact that there is no generally accepted scale of priorities which could serve as basis in the ranking of numerous different objectives. Technological innovations are taken into use in shortest possible time which means that the system is dynamic. It is also dynamic in the sense that the direct pressures coming from the environment must be taken into account.

This presentation is not intended to be more than a few glances at most obvious characteristics. I am convinced that we health administrators have not devoted enough attention to the complexity of our service systems; accordingly we do not fully understand their "anatomy" and especially their "physiology". It is hardly reason to expect that we are ready to adopt new managerial attitudes and apply new techniques in such a situation. The professsionally qualified employees do not fully co-operate if the leadership is based only on traditional managerial values and methods and the same is obviously true concerning the new ones. As a conclusion it can be said that health services are one of the most complicated areas for management. There is no reason to wonder why new techniques and technologies in management are adopted slowly.

4. INTERNATIONAL TENDENCIES

In the health field the international co-operation is active and there are areas in which the medical services have very little national features. New diagnostic procedures, drugs and other methodological innovations are taken into use in shortest possible time. But there are exceptions. WHO has for about 10 years strongly advocated "modern management" to member countries but without any marked success. European region of WHO had a working group in this field but the report has not made any greater impact at least in my country [4].

In World Health Assemblies of WHO into which the nations are sending usually their top administrators, the Director General has year after year advocated e.g. programme budgeting as "a golden opportunity to all countries" in order to achieve the health related goals. WHO has organized its own ($ 250 mill.) budget according to the most modern principles, and has published manuals of "country health programming" in order to infect the national authorities. The progress has been slow, no industrialized country has applied this programming procedure and at least in my part of the world programme budgeting has been applied only at a very general level. To speak about programmes in this connection is hardly justified at all.

Very much the same conclusions are presented in the previously mentioned study of European Public Health Committee [1].

5. NEW BUDGETING AND ACCOUNTING SYSTEMS

The tendency of previous discussion is to advocate the adoption of new "systems management oriented" budgeting and accounting procedures.

First some words <u>why</u> they are needed. One of the reasons is the specific characteristics of service system. It is easier and more meaningful to construct a flexible planning-budgeting system than reshape the whole service system. Health organizations tend to be composed of more or less autonomous special units, departments, professional groups etc. Some autonomy is obviously needed but, at the same time, a chance and necessity to top management for defining priorities and securing more value for money. To some extent the subsystems can be directed by education, training, professional authority etc., but practically speaking this will not be successful without some amount of centralized authority in investment policy, vacancies, volumes of activities etc. It means in other words: a purposeful budgetary policy which balances the professional tendencies towards separation and concentration.

Another related aspect is the interconnection to planning which is really a meaningful activity only in circumstances where programmes and their objectives are spelled out and alternative strategies can be considered. Programmed budgeting means also that there exists some information of the volume of different activities. It introduces the opportunity to take care that the inputs and outputs can be evaluated or at least the management can form impressions of the results.

There is of course one valid axiomatic argument in all financial problems - the possibility to limit expenditures. Who is winning and who is loosing is not allways clear in health related problems but in any case a system which is oriented to know where the money goes, is in principle interesting to all groups involved.

Some special words about accounting systems are justified. They have traditionally existed everywhere but usually have been constructed completely different aspects in mind than the objectives of the programmes or the goals of the organization. Modern accounting is no more only financial book keeping but a much more broad activity which to a marked extent is overlapping with activities usually labelled statistics or information services. Accounting is a relevant part of information system,serving the top management among others in strategic considerations.

6. WHY WE DO NOT HAVE SUCH SYSTEMS

Some of the reasons have been mentioned more or less directly. One important reason is the fact that the way of thinking which is often labelled as "systems philosophy" and which is the essence in the management by systems is not a common property. Systems-oriented managers and administrators are at present exceptions in the health field - of course such an statement is based on subjective impressions. The present generation of top management has been educated before the systems were incorporated to any of the normal topics. There is a tendency to select the top management from the medical profession and modern managerial methods are not their strong side. Competent professional managers can easily find much more profitable vacancies in other sectors of economic life.

There is reason to repeat that health services are from the management point of view a problem case. This system contains elements and structures which need special attention and care. Some kind of management team is the normal solution. However the calibre of the individuals should be very high and the balance of disciplines and backgrounds must be carefully controlled.

Another obstacle is the fact that health services, in spite of their relatively great size as an organization or "system", have usually not closely linked to such ministries or other political powers which have the authority to legal actions e.g. modifying legislation or reorganizing formal administration. It is more the rule than exception that modern management has difficulties with outdated clauses concerning small details and meaningless lines of responsibility. Organizational and legislative innovations have the tendency to be complicated and time consuming excercises even if the goals are clear and agreed. It is also a truism that all components of modern management are mutually interacting. Small changes e.g. in budgeting are very harmful in accounting and vice versa.

Very typically the few countries which have published their health plans until the year 2000 have incorporated new budgeting and accounting systems to their long term goals, more as continuous processes than as defineable objectives.

7. CAN SOMETHING BE DONE

A holistic picture of this complex area of innovative actions is not always very clear. To understand the functions of service system as well as the goals of health politics is as such a difficult area for studies and training. In any case in this field something must be done both nationally and internationally. The basic attitudes are definitely positive which is reflected e.g. in the active interest in long term goal statements which are under editing in my country and if we are correctly informed in numerous other countries too.

The essence of programme budgeting is not very clear and the wording means different things to different actors. Expectations are maybe sometimes set too high. A consequence of this might be the reason of a move away from quantitative approaches in favour of qualitative variety, well illustrated in scenario approach. This is true in corporate planning and it is also reflected e.g. in the recent government actions in Finland. The office of prime minister has e.g. actively distributed to higher administrative authorities text books on how to write scenarios [5].

How to formulate meaningful programmes and seeing these as systems is something in which one could think that IIASA has a role to play. The same can be said about the budgeting systems but especially the accounting should interest IIASA. In principle it is an information system - specially oriented and satisfying defineable needs. Education and training is the normal answer to this kind of problem areas. To develop such systems should probably not be regarded either a profession or a career in its own right. The essence is a developmental activity which should be an invaluable stage in the career development of promising men and women who already have some relevant experience in the functioning of health service system and who can guide the process in their next more responsible appointment. This area is closely related to research and intermediaries between research and practice are the expected results of training.

I have included a "map" of activities which at least are closely related with systems approaches. The list is not exhaustive but especially in the field of systems we must keep in mind the holistic comprehension which is the essence of systems way of thinking. When introducing either modelling or management by systems we must keep in mind the whole field, not only minor segments isolated in their natural interconnections.

FIGURE 1 The systems approach.

Systems Theory			
	Systems philosophy	Systems management	Systems analysis
Viewpoint	Conceptual	Pragmatic	Optimizing
Method	Cogitative	Synthesis	Modeling
Organization subsystem	Strategic	Coordinative	Operating
Task	Integration of the organization with the environment	Integration of operations through design and emphasis of interrelationships	Achievement of goals and efficient utilization of resources

8. CONCLUSIVE REMARKS

I think that IIASA has taken a very correct step when indicating in this programme its interest in economic applications of systems sciences. This is a difficult field but on the other hand something where investments are paying back both directly in money and especially indirectly as better services to those who are in need.

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COLLABORATION IN HEALTH CARE SYSTEMS MODELLING BETWEEN IIASA AND WHO

Norman T. J. Bailey

1. WHO's PROGRAMME

The World Health Organization now contains just over 150 Member States. Its overall programme is designed to meet the aspirations of these States in the health field by virtue of a wide range of collaborative activities. There are a number of overlapping and high priority undertakings with such titles as Country Health Programming, Primary Health Care, Health for All by the Year 2000, Technical Collaboration with Developing Countries, etc. It has been agreed by the World Health Assembly that the major emphasis of WHO's overall programme shall be on meeting the requirements of developing countries, of which the total number is now over 100.

WHO itself consists of a Headquarters in Geneva, together with six semi-automonous regions, each having its own regional office. Requests for technical collaboration of all kinds should go in the first instance to the relevant regional office, and may then be transmitted to headquarters if necessary. In addition to medical, epidemiological and public health topics, there are naturally requirements for collaborative support in statistics and allied quantitative areas. These now cover a wide range, including applied mathematics, modelling, operational research, systems analysis and medical informatics. A good deal of this support is provided by the Health Statistical Methodology Unit, within the Health Statistics Division at headquarters, but an increasing degree of activity is now building up in the regional offices themselves, especially of course in the regions for Europe and the Americas.

As the demand for WHO's collaboration in statistics and allied areas increases, it is envisaged that this will be met in two ways. First, by direct participation of the relevant WHO staff, wherever they may be located. Since those staff will be severely restricted in numbers it will be necessary for them to concentrate on a small number of high priority problems which are not readily handled elsewhere. Secondly, one can foresee the provision of suitably qualified and experienced external consultants. The latter may well necessitate the development of an appropriate informational subsystem to facilitate efficient management. It may also be promoted through the establishment of a world-wide network of appropriate WHO Collaborating Centres, involving selected university departments and other research institutions.

2. WHO's NEEDS IN HEALTH CARE SYSTEMS MODELLING

WHO's needs in the area of health care systems modelling are essentially to be able to provide, promote or develop those forms of HCS modelling that are immediately relevant to the requests from countries for collaboration. Many such requests are expected to come, and indeed are already coming, from developing countries. They arise out of the countries' own perceived problems and priorities. Typically these start from major difficulties in disease control programmes, the provision of health care delivery systems (especially in relation to primary health care), the optimal allocation of scarce resources, the management of health manpower (including both medical, paramedical and 'traditional' forms), etc.

It will of course be appreciated that all this involves not only the health sector itself, but also interrelated sectors covering agriculture, industry, the environment, economics, education, and so on. And this inevitably entails collaboration, not only with national health institutions, but also with a variety of other institutions and agencies, both national and international.

In the face of such diverse, complex and interacting subsystems, special efforts are required to understand the mechanisms that operate and to explore the consequences of alternative strategy-choices available to decision-makers. Those considerations apply at many different levels, and certainly include the whole range from rather specific technically-oriented situations dealing with epidemiological details to broad planning activities concerned with general policy.

It is indisputable that these difficult matters, occupying a substantial part of WHO's activities and responsibilities, could be materially facilitated by improved and increased support from a variety of methodological approaches in the general area of operational research and systems analysis. While WHO staff already exist to promote and apply any special procedures required, much detailed technical research may be needed to forge the kind of instruments that can be immediately used by practical decision-makers at the country level. WHO does not itself have the kind of resources needed for the research explorations that must be undertaken for effective methodologies to be produced, particularly for developing country applications.

3. IIASA's ROLE IN HEALTH CARE SYSTEMS MODELLING

Having briefly looked at WHO's programme and special needs, it is appropriate to comment on IIASA's role in HCS modelling, not necessarily as a whole but as it stands in relation to WHO's own work. The question of future collaboration between IIASA and WHO will then be taken up in Section 4 below.

The present status of HCS modelling at IIASA has been admirably reviewed in the recent report by Shigan, Hughes & Kitsul (1979). It is clear that the work undertaken so far involves both generalised theoretical research on the principal components and interactions of all HCS, and the practical testing of certain models on the national or regional statistics of an appreciable number of countries in Europe and elsewhere, especially in Japan and Canada. All of the countries involved in the development of these practical investigations are of course developed countries which support IIASA through their National Member Organizations. A fundamental question therefore arises as to whether this HCS modelling work can also be expeditiously applied to the developing countries for which WHO has special concern. If the structure of the IIASA models are as universal as they are claimed to be, there should be no insuperable obstacles to adapting the general insights obtained by IIASA to Third World requirements. On the other hand, this generality has yet to be established. However, even if new models are needed, the general approach of systems analysis and systems modelling could still be used with advantage to provide a better and more rational treatment of the search for optimal strategies.

Since WHO is itself unable to mount any great systems research effort, it is of considerably importance to maintain close liaison with a research institutions like IIASA which has the benefit of large numbers of research staff, who make substantial contributions to applied systems analysis in specific fields while actually at IIASA and usually continue to do so, sometimes on an intermittent basis, after returning home. Any successful practical validation of HCS modelling carried out by IIASA provides a prima facie case for further modification and development by WHO in connexion with the latter's own programme.

4. FUTURE COLLABORATION BETWEEN IIASA AND WHO

If full advantage is to be taken of IIASA's research work on HCS modelling, steps must be taken to incorporate the fruits of research in the actual decision-making procedures at the country level. So far as the developed countries mentioned above in Section 3 are concerned, this empirical validation is already being pursued by IIASA itself. This also involves collaboration with certain regional offices of WHO, especially the Regional Office for Europe in Copenhagen. Further ties might also be developed with the American Regional Office in Washington in respect of work in Canada and the USA, and with the West Pacific Regional Office in Manila because of the work going on in Japan. Increased collaboration between IIASA and the latter two WHO Regional Offices would automatically enhance the likelihood of health systems applications being made in the developing countries of those regions.

The possibility of applications being made in the three other regions of WHO can at present best be explored through WHO headquarters, where requests for collaboration with all countries in statistical and allied subjects will be received on an increasing scale.

It may be expected that one or two developing countries with appropriate institutions may apply for membership of IIASA before long. This would greatly accelerate IIASA's contribution to the solution of many systems problems at present affecting Third World countries in an acute form, especially in the area of primary health care which received world-wide recognition by the International Conference held at Alma Ata, USSR, in September 1978.

In the meantime, a positive start could be made by IIASA by holding a series of conferences on the health problems of developing countries, with a view to establishing (a) which approaches, already available in developed countries, could be applied directly with only minor modifications, and (b) what new methodologies need to be worked out. In fact, the first of such efforts has already been planned for July 1979 with the title "Low-Cost Health Delivery Systems in Developing Countries". The results of this meeting should be extremely useful, not only for their intrinsic value regarding the subject matter, but as a basis for further planning to meet some of the needs of developing countries.

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