RM-78-3

ANALYSIS AND FUTURE ESTIMATION OF MEDICAL DEMANDS USING A HEALTH CARE SIMULATION MODEL:
A Case Study of Japan

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Preface

The aim of the IIASA Modeling Health Care Systems Task is to build a National Health Care System model and apply it in collaboration with national research centers as an aid to Health Service planners. The modeling work is proceeding along the lines proposed in earlier papers by Venedictov and others. It involves the construction of linked submodels dealing with population, disease prevalence, resource need, resource supply, and resource allocation.

This paper describes an application of the IIASA health care model to the estimation of future medical demands. Since it usually takes a long time to plan health care delivery, it is important to estimate the future trends in advance. The concept of the IIASA health care model was tested using the actual routine statistical data of Japan and the model successfully predicted the future trends of medical demands under certain assumptions.

Some previous publications of the IIASA Modeling Health Care Systems Task are listed on the back page of this Memorandum.

Evgenii N. Shigan

Abstract

A method of building a universal health care model was proposed in RM-77-6 (Kaihara, et al., *An Approach to Building a Universal Health Care Model*). This method is based on the calculation of essential parameters of health care from ordinary statistics. The essential parameters proposed in the previous report were population structure, morbidity rate, recovery rate, death rate, patient registration rate and awareness rate.

The method was applied successfully to the analysis of medical demands at the national level of Japan. The results showed that in the past 15 years the awareness rate was the most important factor which contributed to the increase of the patients. But in the future, the model predicted that the change of population structure will be the main cause of the increase of the number of patients in Japan.

Analysis and Future Estimation of Medical Demands Using a Health Care Simulation Model: A Case Study of Japan

INTRODUCTION

In a Research Memorandum entitled "An Approach to Building a Universal Health Care Model: Morbidity Model of Degenerative Diseases" (RM-77-6), Kaihara, et al. defined the primary factors of a health care system and proposed that the analyses of these primary factors are useful in characterizing the health care system. The primary factors they proposed were population structure, morbidity rate (MR), recovery rate (RECOV), death rate (DR), patient registration rate (RPR), and awareness rate (AR).

This report describes one of the applications of this concept in analyzing the trends of medical demands using the Japanese data as an example. In Japan, the routine health statistics are available in some detail. The purpose of this report is, using these data, to calculate the trends of the primary factors and to estimate the future trends of medical demand in Japan up to the year 1990, on the basis of this calculation.

CONCEPT OF THE MODEL

The concept of the model used in this study is exactly the same as that shown in the previous study. Figure 1 shows the structure of this model. In addition to the primary factors shown in the previous report, some supplementary flows were introduced into the present model to make the calculation more reasonable, namely the inverse flow from latent unaware sick (US) to healthy persons (HP) and also from aware sick (AS) to healthy persons (HP). These flows represent the patients who get well without consulting physicians.

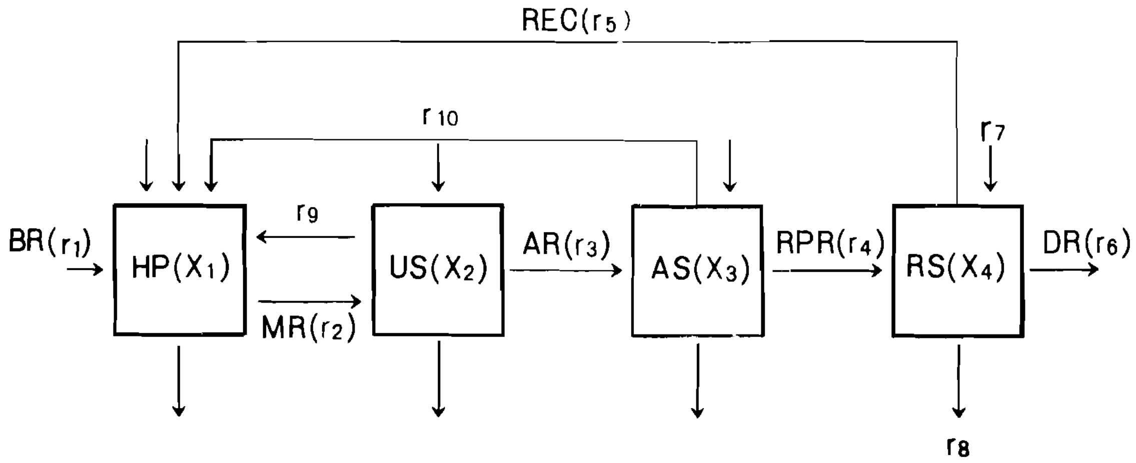

Figure 1. Structure of model.

The population was separated into four age groups, namely under 14, 15-44, 45-64 and over 65, as described in Figure 2. This grouping was decided upon for the convenience of analysis of the trends in different age groups. By assuming the model as defined in Figure 2, the model can be expressed by a set of differential equations. The calculation, however, was performed on the basis of the following assumptions:

1. The primary rate factors and supplementary rates are functions of time. The changes of the level, namely number of healthy (HP), unaware sick (US), aware sick (AS), and patients (RS) are dependent on the changes of these rate parameters.
2. The changes of these rate parameters are sufficiently slow as to equilibrate the system when these changes occur, except that some strong external factors like policy changes affect the system.

On this assumption the set of differential equations can be regarded as a set of single order equations, and unknown parameters can be calculated from these equations, if a sufficient number of known parameters are present. All the available health statistics were incorporated to make the calculation of the primary factors possible.

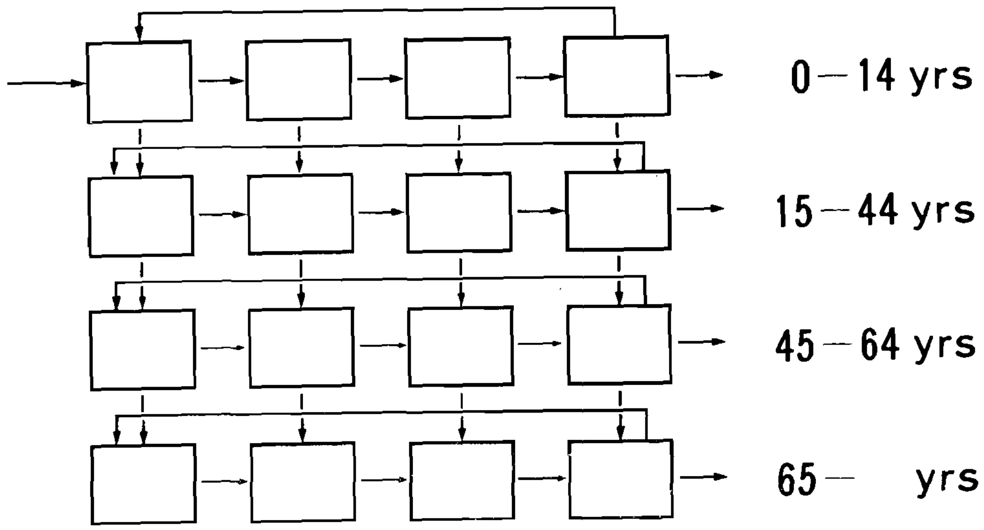

Figure 2

DATA AND COLLECTION

In Japan the statistical data in health care are reported in the "National Health Survey" and "Patient Survey." The government has been conducting national health surveys (Family Sickness Survey) and patient surveys since 1948 on a nation-wide scale by using a sampling method. In the national health survey about 27,000 households of 90,000 people in 420 areas are sampled and the incidences of diseases among the population are enumerated by the type of diseases, geographical area, occupation, and so on. Figure 3 shows one of the results of this survey, that is, the rate of prevalence of diseases by a self-supporting method. One of the characteristics of the prevalence rate is the constant increase of the rate from 30 per 1000 population or 3 percent to 11.3 percent in the last 15 years.

In the "Patient Survey" 773 hospitals (one tenth of the total hospitals), 684 general clinics (one thousandth of the total general clinics), and 297 dental clinics (one hundredth of the total dental clinics) are sampled and enumerated by the number of in- and out-patients who visit those facilities, by type of disease or injuries, sex, age, and by the method of paying the charge for treatment together with the length of hospitalization. The yearly charge of consultation rate to physicians, which is one of the results of this survey, is again constantly increasing during the past 15 years as shown in Figure 4.

In Japan, population census is also carried out every 5 years. The data were used as a basis for all the calculations. For the calculation of the model, the following values in the above statistics were used as input. Data from the population census were used for birth rate (BR) and also for the calculation rate from each age stratum (r_7 and r_8). The "rate of selecting medical care" in the "national health survey" was used for the calculation of the transitional rate from aware sick to healthy persons (r_{10}). The "patient survey" was used for the calculation of the number of patients (x_4) and the "prevalence rate" in the "national health survey" was used for the calculation of aware sick (x_3).

The patient registration rate (RPR or r_4) was estimated from the "number of first visit to physicians" in the "patient survey" with some adjustment in the process of simulation. The recovery rate (RECOV or r_5) was estimated from the data of the "period of illnesses" in the "national health survey" using the fact that the recovery rate is related to the inverse of the period of illness.

No statistical values are available at present for the morbidity rate (MR or r_2), the awareness rate (AR or r_3) nor unconscious recovery from illnesses (r_9). Since the number of healthy (HP or x_1) and the number of unaware sick (US or x_2) is not known, it is impossible to calculate the morbidity or awareness rates from these data either. However, if one of the above values is given, the other parameters can be calculated from the sets of equations. In this study, the morbidity rate (MR or r_2) was assumed to be constant for the past 15 years, and on this assumption other parameters were calculated. This assumption may not be justified in other countries, but in Japan, taking into consideration the change of the level of life, the sanitary conditions or nutrition, it is unlikely that the

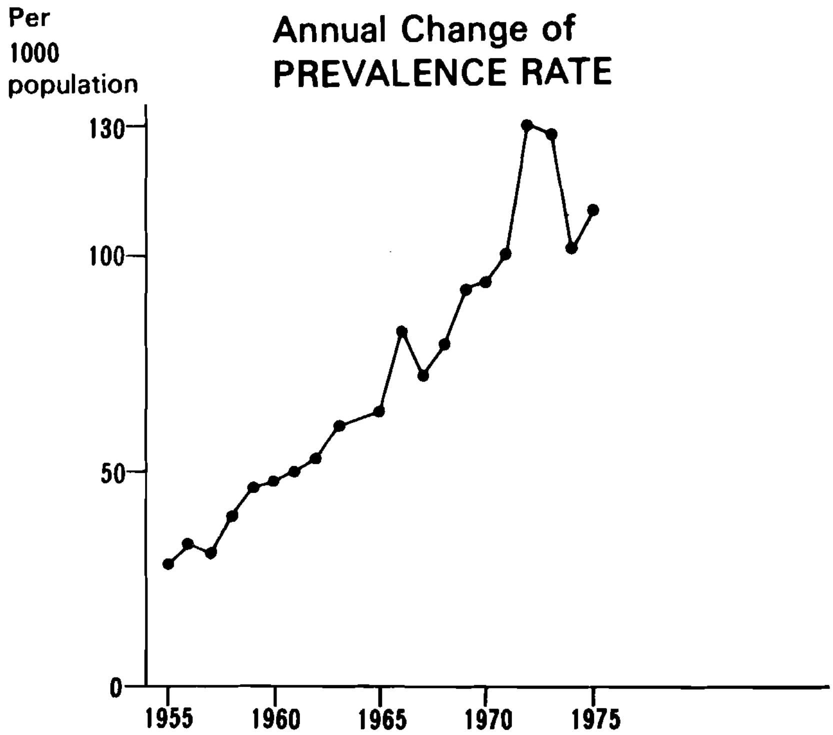

Figure 3

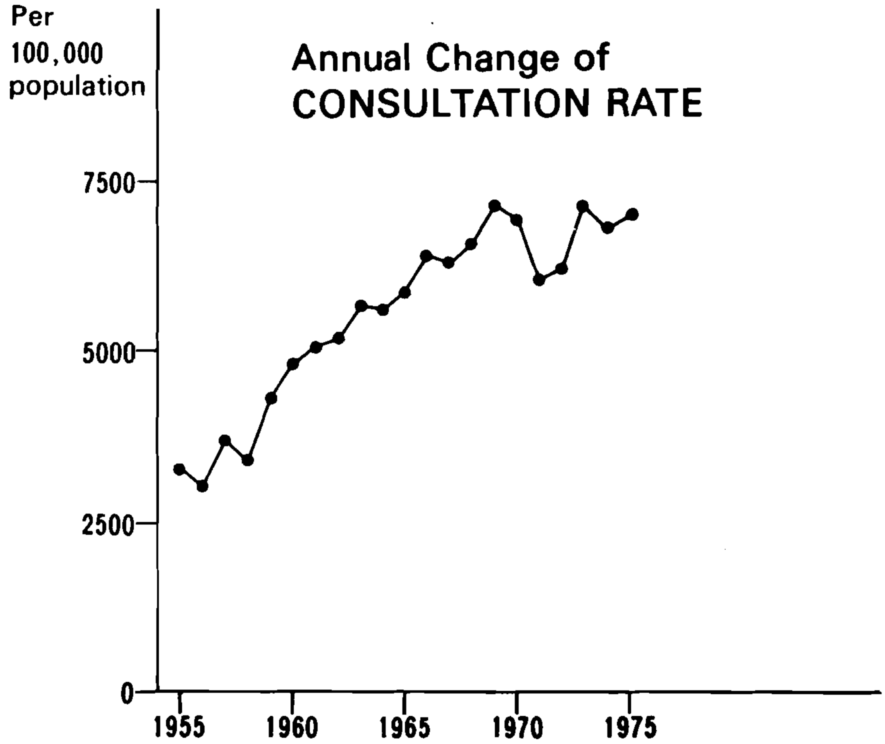

Figure 4

morbidity rate has changed during the last 15 years. After discussion with various public health experts we came to the conclusion that at least in Japan this assumption is well justified.

The calculation was performed for each year assuming that the system is in equilibrium within a year. After all the parameters were obtained for each year, the total model was run for the past 15 years, using the DYNAMO program.

RESULTS OF CALCULATION

Figure 5 shows the calculated results of essential factors in Japan in the last 15 years, and, as can be noticed from this graph, the awareness rate gradually increases over the past 15 years. There was also the gradual decrease of the recovery rate (RECOV). The patient registration rate (RPR) gradually increased until the middle of 1960 and then decreased again. This might have been caused by the relative shortage of supplies of medical care.

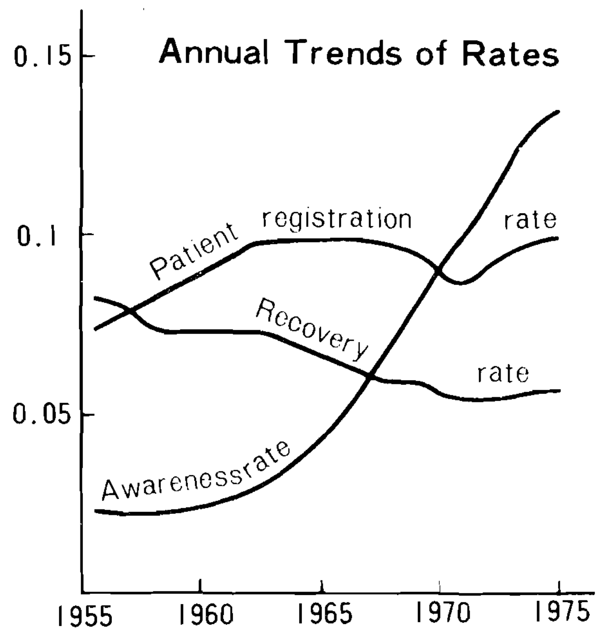

Figure 5

Other variables, calculated with the above rate, fitted to the real change within a reasonable range (Figure 6). The solid line shows the real change in the number of patients over the past 15 years and the dotted line shows the results calculated by this model. The agreement of both values was satisfactory.

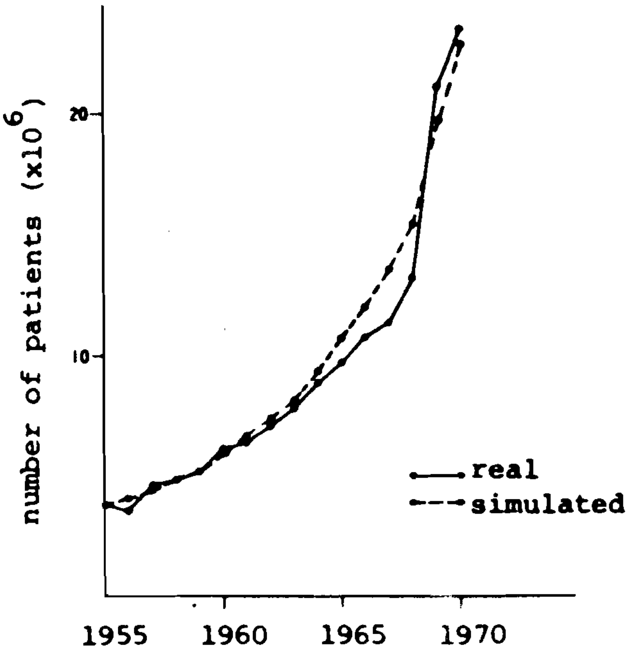

Figure 6

ANALYSIS OF THE TRENDS IN MEDICAL DEMANDS USING THE RESULTS OBTAINED FROM THE MODEL

Analysis of Past Data

The results of the calculation were used for the further analysis of the mechanism of the increased number of patients in the year. As shown in the previous section the number of patients has increased very rapidly in Japan. However, the mechanism for this increase has never been clearly analyzed. The most impressive trend of medical demand in the past years is represented by the increase of the prevalence and consultation rates, which is proportional to the number of patients.

The analysis was performed to see which primary factors contributed most to the past increase in number of patients. The model was run first on the assumption that only the change of population structure had occured but that no other parameters had changed. The result is shown as the base line of Figure 7. Later one parameter, namely the change of awareness rate (r_3), was introduced. The results are shown as the dotted line. Still later the recovery rate (r_5) was included. The solid line shows the result when both parameter changes were included. It is interesting to note that the change in population structure did not contribute much to the increase in medical demands in the past years. On the contrary, the change of the awareness rate was most remarkably reflected by the increase in the number of patients. Accordingly, this was considered to be the main factor which caused the increase in medical demands. This result can be summarized as follows: the increase in the number of patients in the past years was caused mainly be the increase in the awareness rate when the unaware sick became informed of their illnesses.

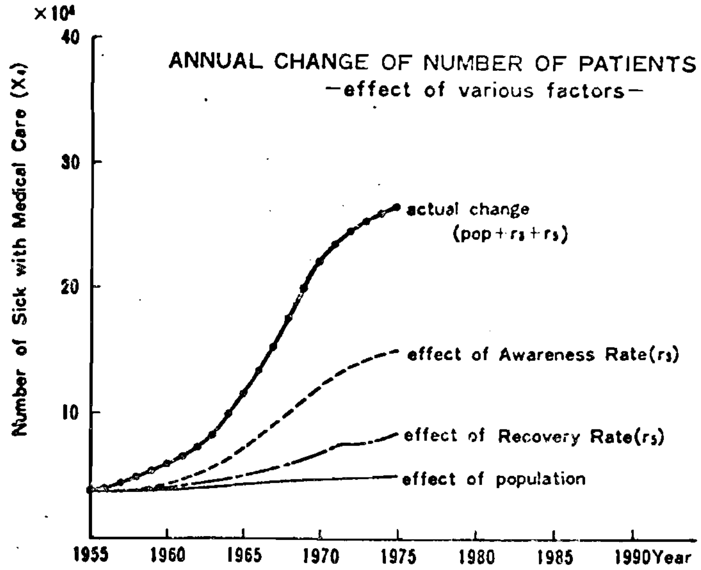

Figure 7

<u>Future Estimation of the Number of Patients</u>

On the basis of this model, the future trends of the number of patients were estimated (Figure 8). The factors having influence on the medical demand were again introduced one by one. The base line shows the future trends of the number of patients, when only the population structure was changed. The dotted line represents the change when population plus recovery rate or awareness rate changes are included respectively. The solid line shows the trends when all the factors are included. In contrast to the analysis of past trends, marked differences were noticed, namely the changes of population structure has a great effect on the future increase of the number of patients, and the increase of the awareness rate is no longer a strong factor. The reason for this difference can be well demonstrated when we break

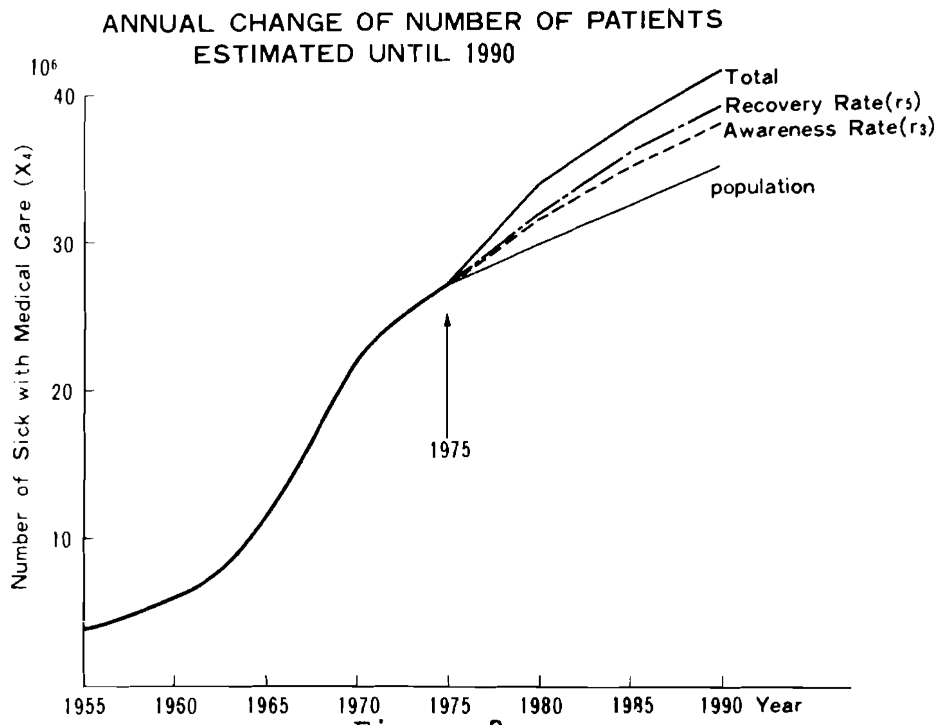

Figure 8

down the data into four age groups. Figure 9 shows the number of patients in each age group in the future. In the age group 0-14 and 15-44 the increase in the number of patients has already been saturated and the change of factors has almost no effect on the future trends of the number of patients. In contrast to this, the change of the aged group is very remarkable. In this group, the increase in the number of patients continues mainly due to the population structure, or the increased number of aged people. And the changes of the awareness and recovery rates have not such great effects.

In the age group 45-64 the effect of the recovery rate is manifest. This means that the more adult diseases are found in this group of people, the more the medical demand will increase. This is related to the health screening of healthy people, which is not discussed in this paper.

The influence on the future trends of medical care may be summarized in order of importance as follows. The increase in the number of patients in the future will be caused by: 1) the aging of the population; 2) the decrease of the recovery rate in the 45-64 age group; and 3) the increase in the awareness rate.

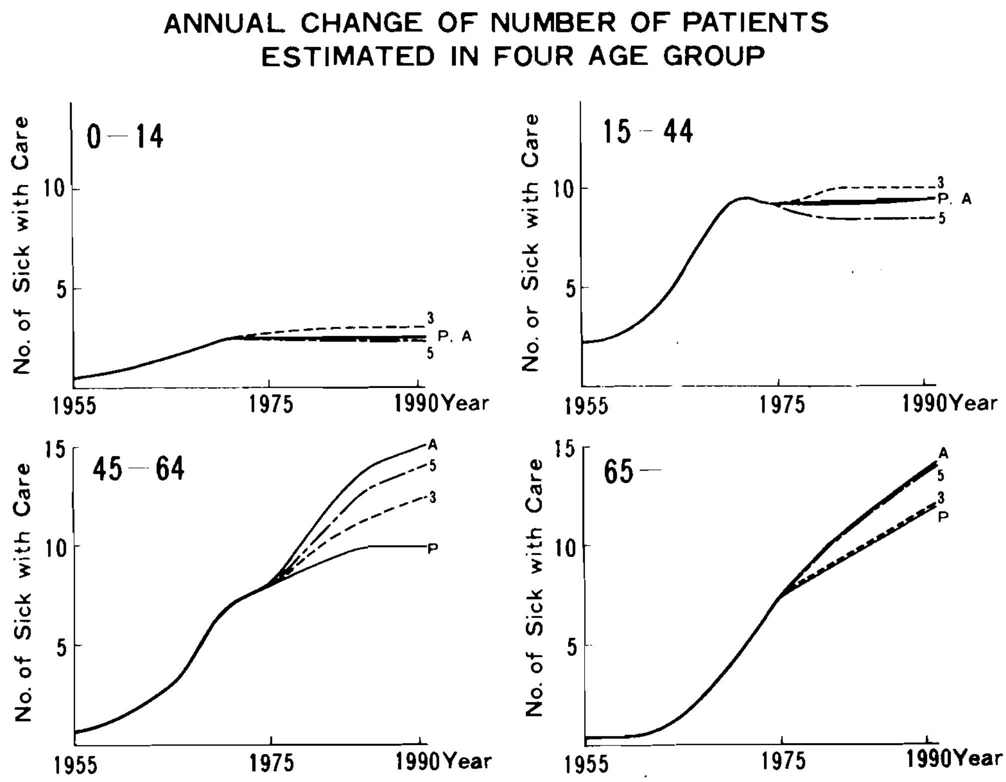

Figure 9

Figure 10 shows a summary of the computer output estimation of the number of healthy, unaware sick or latent needs for medical care, aware sick without treatment, and the number of patients. The number of latent needs is decreasing but the number of patients increases. The number of healthy does not change greatly.

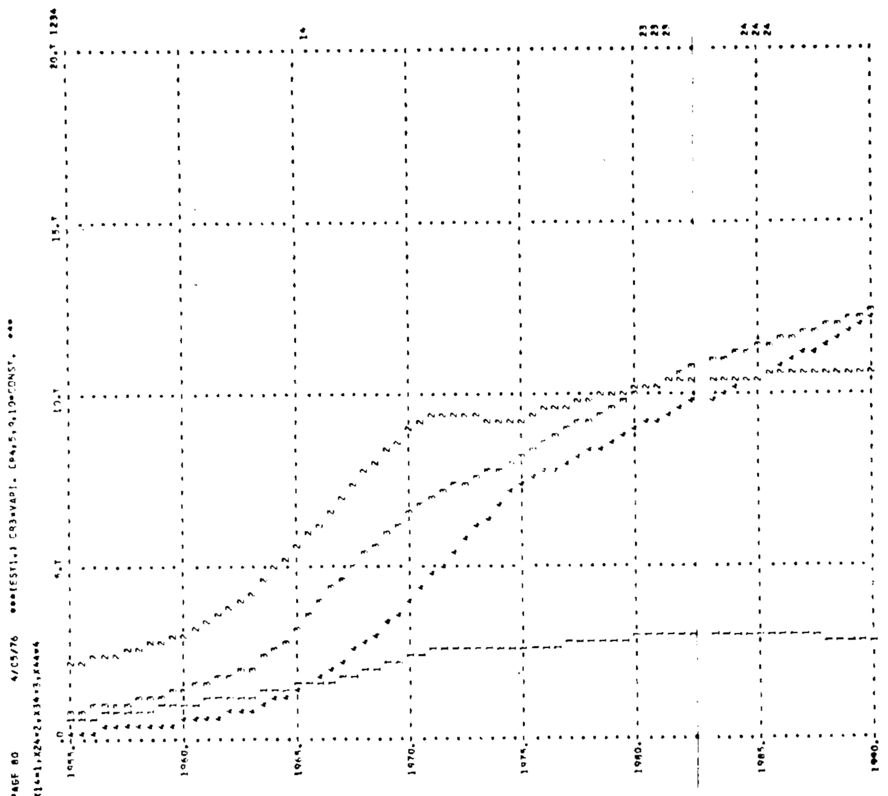

Figure 10

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