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Planning and management of the health service by systems analysis methods

by

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The present paper deals with application of systems analysis to planning and management of health service. The main emphasis is laid on a problem of allocation of resources and expenditures among individual diseases and areas of activity (e.g. diagnostics, prophylaxis, safety and hygene, hospitalization, rehabilitation) that create a complex hierarchical structure.

Optimal allocation of resources in thematic, administrative, and regional aspects was also considered. The so called health level functional, which is a scalar function of recoveries rate, deaths averted etc., has been accepted as a goal function. The problem of weights (preferences) distribution in particular areas of activities has been considered.

1. Introduction

One of the important problems of contemporary health service is the creation of scientific basis for optimal planning and control of development of health service. The problem is of particular importance in Poland, where rapid growth of both industrialization and expenditures in health service calls for improving health efficiency by modernization and improving the quality of services and health system management.

The last problem is connected with the necessity of optimization of the process of allocation of resources and expenditures on particular areas of activities and organization of health service.

Proposals are often made to base the resources allocation not on intuition, but rather on economic accounts ballancing needs with effects and expenditures with needs.

Nobody is questionning to-day so generally formulated principles of management and planning of health service development. Since so far there are no satisfactory computational methods available the application of these methods is not always possible. The development of such methods requires previous theoretical analysis of the problem of control of health service and elaboration of a mathematical model of development. The systems analysis is the most adequate method for modelling purposes.

One of the main tasks of the present paper is to apply the systems analysis methods, to a model of health service in which the problem of allocation of resources has been exposed. The allocation is carried out in such a way that the maximum health level can be achieved. The level of health services is defined on the basis of the so called health level function that depends on recovery rate, avoidance of death etc. represented by individual health institutions. The concept of efficiency function of a health institution is introduced. That function defines the efficiency of recoveries related to expenditures in the given institutions. A problem of optimal allocation of resources yielding the maximum value of health level functional can be formulated and solved.

Formulas obtained in that way can be used for efficient computation of expenditures necessary in a given health programm.

Methods and results obtained can also be useful in solving problem of long-term planning and forecasting of health service development.

Results in optimization of complex development systems [1—7] were partly used in this paper.

2. Health system model and health level functional

Consider health system shown in the Fig. 1. It is composed of n institutions or particular areas of activity (clinics, hospitals, dispensaries, scientific research institutions etc.) A_i, $i=1, ..., n$. The system is financed by the government and obtains in the planning period T (e.g. 5 years) the given amount X zl. The management system (M.S.) carries out allocation of the fund X in the following aspects:

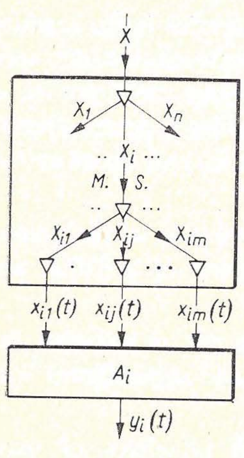

Fig. 1

(i) thematic (allocation of resources to particular areas of activity, e.g. diagnostics, prophylaxis, safety and hygene of work, hospitalization, rehabilitation) and disease cathegories (e.g. internal diseases, surgery etc.);

(ii) material or administrative (allocation of resources to wages, social expenditures, medicine, equipment, investments etc.);

(iii) regional (allocation to institutions situated in various regions of the country);

(iv) time (allocation to longer and shorter planning periods and current activity).

As a result the resources obtained by a particular health institution, A_i are partitioned into m parts and their intensity $x_{ij}(t)$, $j=1, ..., m$, varies in time t.

The activities of A_i also vary in time with the rate $y_i(t)$. This rate can be measured by the number of recoveries, the number of diseases diagnosed (in the case of diagnostics) and as a result — the deaths averted number, a number of medical examinations, interventions, services etc., all measured within a unit of time. In order to estimate the resulting health service activity it is necessary to take into account the total effect, that is

$$Y_i(x_{i1}, \dots, x_{im}) = \int_0^T w_i(t)\, y_i(t)\, dt, \quad i=1, \dots, n, \tag{1}$$

where $w_i(t)$, $i=1, 2, \dots, n$, are given weight functions indicating relative weights of recoveries in individual deseases and the public interest in obtaining quick results.

For this purpose, functions $w_i(t)$ are assumed monotonoously decreasing in time.

It is worthwhile to observe, that y_i and than Y_i depend on x_{ij} and on stochastic factors ω. Since in the subsequent analysis we shall be interested in stochastically averaged characteristics (1) should be regarded as so called regression function, that is

$$Y_i(x_{i1}, \dots, x_{in}) = E\{Y_i(\omega) | x_{i1}, \dots, x_{im}\}$$

where E stands for mathematical expectation over the set of statistically similar processes.

As a further characteristic of the system a concept of health level should be introduce. This concept is already being used in relation to many existing health service systems intuitively. People say for instance, that the level of health service in a country is high, higher than that in the other countries. This implies that a functional (a scalar function) U can be attached to the expression "level of health services". This function U depends on vector

$$Y = (Y_1, Y_2, \dots, Y_n)$$

and represents the effects of activities of institutions A_i, $i=1, 2, \dots, n$, of health service system.

In order to compare systems characterized by different vectors say $Y^{(1)}$, $Y^{(2)}$, it is necessary to establish the ordering relations of components of vector Y. Priority relation P should be introduced, according to which $Y^{(1)}$ is better than $Y^{(2)}$ what can be written as $Y^{(1)} P\, Y^{(2)}$ or $Y^{(2)}$ is better than $Y^{(1)}$ ($Y^{(2)} P\, Y^{(1)}$), or these vectors are equivalent. The priority relation can be obtained by assuming the function U to satisfy inequality $U[Y^{(1)}] > U[Y^{(2)}]$ if and only if the relation $Y^{(1)}$ $P\, Y^{(2)}$ holds. The function U should be monotonically increasing and convex.

An example of such a function for $n=2$ is shown in Fig. 2. The hatched area below the curve U_0 corresponds to those $Y=\bar{Y}$ for which $YP\bar{Y}$; the area above the curve U_0, including the boundary, corresponds to those $\bar{Y}$, for which $\bar{Y}PY$.

It can be seen from Fig. 2 that substitution between two different forms of activities, say Y_1 and Y_2 is possible without change in health level. In other words, two countries characterized by vectors $Y^{(1)}$, $Y^{(2)}$, where $Y_1^{(1)} > Y_1^{(2)}$, $Y_2^{(1)} < Y_2^{(2)}$ and points $Y^{(1)}$, $Y^{(2)}$ are on the same curve $U=\text{const.}$, have the same health level.

The plot shown in Fig. 2 ilustrates a known fact, that in the public feeling it is not important whether higher health level is reached by an increase in the treatment efficiency Y_1 or by an increase in the prophylaxis efficiency Y_2. What is important is wheather the total amount of expenditures on the two areas of activity is used properly, that is wheather it yields the maximum level of health services $U(Y_1, Y_2)$ measured by a number of recoveries or a number of deaths averted. Ipsen [3] particularly points out the fact (see also [1] and [8]) that mortality is a product of the incidence and the case fatality and that public health (prophylaxis) and clinical therapy compete with one another for lowering mortality.

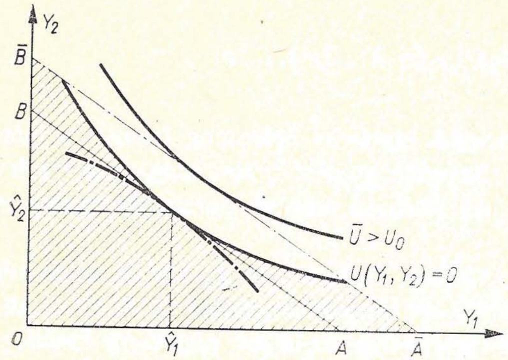

Fig. 2

The shape of function $U(Y_1, Y_2)$ suggests that it can be approximated by function

$$U = kY_1\, Y_2^{\gamma} \tag{2}$$

where k and γ are given positive numbers. Since

$$\gamma = \frac{dU}{U} : \frac{dY_2}{Y_2} \tag{3}$$

then an increase of the weight attached to the activity Y_2 results in the corresponding increase in coefficient γ.

In case of n areas of activity the health level function may assume the following form

$$U = k \prod_{i=1}^{n} Y_i^{\gamma_i} \tag{4}$$

where γ_i, k are given positive numbers.

It can be easily seen that (4) is a homogeneous function of order

$$\gamma = \sum_{i=1}^{n} \gamma_i$$

that is

$$U(cY) = c^{\gamma}\, U(Y).$$

When $\gamma > 1$ the so called "large scale" benefits or an increasing return is possible.

The identification problem of health level function is rather difficult. In a statistical (experimental) way these parameters can be determined on the basis of the formula

$$\gamma_i = \frac{\Delta U}{U} : \frac{\Delta Y_i}{Y_i}, \quad i = 1, \ldots, n,$$

by examining estimates of increases in health level $\Delta U/U$ due to the changes in activity $\Delta Y_i/Y_i$. This, however, requires that estimates are being made by neutral and competent experts.

Among other functions, that may be taken into account (as the approximation of health level function $U(Y)$), the so called constant elasticity of substitution function (C.E.S. function) is worthwhile mentionning. That function has the following form:

$$U=k\left[\sum_{i=1}^{n} Y_i^{-\gamma}\,\delta_i\right]^{-\rho/\nu} \tag{5}$$

where $\sum_{i=1}^{n} \delta_i=1$, $\delta_i>0$, $\nu\in[-1, 0]$, $\gamma>0$, $k>0$.

The limit of (5) for $\nu\to 0$ is equal (4) where $\gamma_i=\delta_i$, $i=1, \ldots,$ while for $\nu=-1$ and $\rho=1$, U it is a linear function of Y_i.

3. Optimization of expenditures and resources allocation

When the function $U(Y)$ is known, the problem of financial expenditures and resources X (such as medicine, equipment etc.) allocation in such a way that ensures maximum value of health level function can be considered. We shall consider two cases.

The first one is concerned with the situation in which a weight or price p_i, $i=1, 2, \ldots$ $\ldots, n$, can be attached to each form of activity Y_i. The central budget X is used for "purchase" of appropriate amount of activity Y_i in such a way, that

$$\sum_{i=1}^{n} p_i\, Y_i\leqslant X. \tag{6}$$

Now, we are faced with a problem of finding positive values $Y_i=\hat{Y}_i$, $i=1, 2, \ldots, n$, that maximize function $U(Y)$ of type (4) or (5). It can be shown [4] that the optimal strategy $Y=\hat{Y}$, for which

$$\hat{U}=\max_{\sum_{i=1}^{n} p_i Y_i\leqslant X}\left\{k\left[\sum_{i=1}^{n} Y_i^{-\vartheta}\,\delta_i\right]^{-\gamma/\vartheta}\right\}=k\left[\sum_{i=1}^{n} \hat{Y}_i^{-\vartheta}\,\delta_i\right]^{-\gamma/\vartheta} \tag{7}$$

is expressed by the following formula

$$\hat{Y}_i=(\delta_i/p_i)\,X,\quad i=1, 2, \ldots, n, \tag{8}$$

where

$$\hat{U}=KX^{\gamma},\ K=k\left[\sum_{i=1}^{n}\left(\frac{\delta_i}{p_i}\right)^{-\vartheta}\delta_i\right]^{-\gamma/\vartheta}.$$

The optimization problem (7) has a simple geometrical interpretation in Fig. 2. The optimal policy $(\hat{Y}_1, \hat{Y}_2)$ corresponds to the tangent point of the curve $U(Y)=U_0$

and the straight line AB having the equation $X=p_1Y_1+p_2Y_2$. If the resources X allocated to health development were increased to the value $\bar{X}$, the new optimal strategy would result from a tangent line ($\bar{A}\bar{B}$) to a new health level function $\bar{U}>U_0$.

It should be noticed, that by (8) one can determine the optimal expenditures on activity areas and deceases that form a complex, hierarchical, multilevel structure as shown in Fig. 3. The amount of expenditures $p_i\ Y_i=X_i$ that are allocated of the level I can be partitioned into m subgoals of level II according to the following formula:

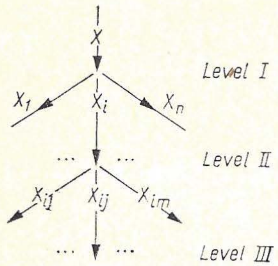

Fig. 3

$$\hat{x}_{ij}=p_{ij}\ \hat{Y}_{ij}=\delta_{ij}\ X_i, \quad j=1, \ldots, m, \text{ etc.}$$

The process can be used for determining expenditures in individual areas of activity in a system having the hierarchical structure. Examples of such structures are met not only at health service institutions, but at faculties, divisions and departments of Clinics of Medical Academies etc. as well.

However it should be pointed out, that the model formulated in which the weights or prices p_i are assumed, to be known is not suitable for health development planning systems in countries like Poland. First of all, the problem of "purchase" of health activities seems to be controversial in such systems, and furthermore the prices p_i that should be attached to such forms of activities as diagnostics, prophylaxis, safety and hygene of work, etc. are not known. Prices (or rather weights) that are attached to particular forms of activity should follow from the model itself rather. The efficiency of work of a particular health service institutions play an essential role here. We shall approach now a problem of resources allocation with the prices unknown. It is now neccessary to make health level function dependent on expenditures $x_{ij}(t)$, $i=1, \ldots, n$, $j=1, \ldots, m$, that is — to determine the so called production function of a health service institution. The efficiency function of the institution A_i (in which for simplicity in notation the subscript i will be droped) can be expressed in the following form

$$y(t)=\int_0^t k(t-\tau)\prod_{j=1}^{m} x_j^{\alpha_j}(\tau)\, n(\tau)\, d\tau, \tag{9}$$

$$\sum_{j=1}^{m} \alpha_j=\alpha<1,$$

where α_j — given positive numbers, $n(\tau)$ — intensity of patients admitance to A_i, $k(t)$ — given continuous function, such that $k(t)=0$ for $t<0$. A typical shape of function $k(t)$ is shown in Fig. 4. If the functions $x_j(\tau)$ were constant for $j=1, \ldots, m$, the corresponding process $y(t)$ would have time lag T_0 within which no effects (recoveries) would appear at the system output. This is due to large inertia of therapeutic and rehabilitational activity. Before a recovery is reached, a time-consuming treatment and examinations must be applied. The efficiency function (9) contains also the so called "saturation" nonlinearity ($0<\alpha_j<1$ for $j=1, \ldots, m$). This effect corresponds to a situation in which increase in expenditures on therapeutics does not cause proportionnal increase in effects because of limited space of institutions, limited number of specialists etc.

These limitation frequently have more restrictive character that is

$$\underline{x}_j \leqslant x_j(t) \leqslant \bar{x}_j, \quad j=1, \ldots, m,$$

where $\underline{x}_j$, $\bar{x}_j$ — given positive numbers. The upper bound $\bar{x}_j$ is due to saturation in investment, employment, equipment, etc. while the lower bound $\underline{x}_j$ is determined by the minimum wages and other cathegories of current expenditures.

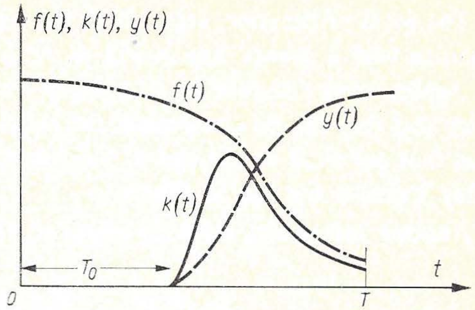

Fig. 4

Now we can determine optimal policy of financing A_i activity in the planning period T which is represented by m variables x_j, $j=1, \ldots, m$. The purpose is to achieve maximum value of health effect, that is, maximum value of the functional

$$Y=\int_0^T y(t)\, w(t)\, d\tau \tag{10}$$

(where $w(t)$ — given weight function), under the assumption that the expenditures are limited, that is

$$\int_0^T x_j(\tau)\, d\tau \leqslant X_j, \quad j=1, \ldots, m. \tag{11}$$

The weight-function can be assumed in the following form

$$w(t)=(1+\varepsilon)^{-t}$$

where ε — the so called discount rate. In that way our interest in fast health results is emphasized.

In the discount calculus, which is being used in investment processes optimization, ε is usually taken as 0.1. In health service, the value of discount rate was not yet determined. Due to the importance of fast results of diagnostic and prophylactic examinations, in case of cancer, considerably higher discount rate should be used.

It should be pointed out, that the optimization problem formulated falls into the cathegory of problems of the calculus of variations.

It can be shown [4], that the optimal policy $x_j(\tau)=\hat{x}_j(\tau)$, $j=1, \ldots, m$, for which the functional $Y(x_1, \ldots, x_m)$ attains the maximum $\hat{Y}$, is expressed by the formula

$$\hat{x}_j(\tau)=f(\tau)\,\frac{X_j}{F}, \quad j=1, \ldots, m \tag{12}$$

where

$$f(\tau)=n(t)\int_{\tau}^{T} k(t-\tau)\,w(t)\,dt,\ F=\int_{0}^{T} f(\tau)\,d\tau.$$

The form of function $f(t)$, which is proportional to the optimal strategy $x_j(\tau)$, is shown with a dashed line in Fig. 4. As follows from the Fig. 4 the expenditures on health service should be distributed over the planning periode $[0, T]$ in such a way that they should compensate the inertiality of the efficiency function. Expenditures that are close to the end of the planning period (for $t\approx T$) can not considerably increase the health effects.

Another interesting result is obtained when optimal policy (12) is set in (10):

$$\hat{Y}=(Y(\hat{x}_1, \ldots, \hat{x}_m)=F^{1-\alpha}\prod_{j=1}^{m} X_j^{\alpha_j}. \tag{13}$$

If the total expenditures on a given health activity are limited, that is if

$$\sum_{j=1}^{m} X_j\leqslant X,\ X_j\geqslant 0,\ j=1, \ldots, m. \tag{14}$$

the problem of optimum allocation of X among m areas of activities can be formulated. It consists in maximization of function

$$F^{1-\alpha}\prod_{j=1}^{m} X_j^{\alpha_j}$$

subject to the constraints (14). It can be seen that the present problem is similar to (7) (with $\vartheta\to 0$) and the solution becomes:

$$X_j=\hat{X}_j=(\alpha_j/\alpha)\,X,\ j=1, \ldots, m, \tag{15}$$

where

$$\alpha=\sum_{j=1}^{m}\alpha_j,$$

and the following relation holds:

$$\hat{Y}(\hat{x}_1, \ldots, \hat{x}_m)=KX^{\alpha} \tag{16}$$

where

$$K=F^{1-\alpha}\prod_{j=1}^{m}(\alpha_j/\alpha)^{\alpha_j}.$$

Now, there is one more problem to be solved, namely a problem of resources allocation in regional aspect. Assume that there are n health service institutions, each characterized by the efficiency function (13)

$$Y_i=F_i^{1-\alpha}\prod_{j=1}^{m} X_{ij}^{\alpha_j},\ i=1, \ldots, n, \tag{17}$$

where F_i, α_j — given numbers. Assume also that the total amount of resources in j-th area of activity is limited, that is

$$\sum_{i=1}^{n} X_{ij} \leqslant X_j,\ j=1, \ldots, m, \tag{18}$$

$$X_{ij} \geqslant 0,\ i=1, \ldots, n,\ j=1, \ldots, m. \tag{19}$$

The optimal policies $X_{ij}=\hat{X}_{ij}$, $i=1, \ldots, n$, $j=1, \ldots, m$, that maximize function

$$Y(X_{ij})=\sum_{i=1}^{n} Y_i \tag{20}$$

have the following form [6]

$$\hat{X}_{ij}=(F_i/F)\,X_j,\ i=1, \ldots, n,\ j=1, \ldots, m, \tag{21}$$

and

$$F=\sum_{i=1}^{n} F_i .$$

The following relation also holds

$$\hat{Y}=Y(\hat{X}_{ij})=F^{1-\alpha}\prod_{j=1}^{m} X_j^{\alpha_j}. \tag{22}$$

The formula (22) describes an important property of aggregation of characteristics (17). Applying the above formulae it is possible to express the efficiency function of complex health service systems in a simple form of type (22).

When the function (9) is known, it is possible as can be seen from formulas (12), (15), (21) to allocate resources in thematic, time, regional and material aspects. The formulae (13) and (16) can be used for determination of relations between expenditures on individual areas of activity and their effects in the following form

$$Y_i=K_i\, X_i^{\alpha_i},\ i=1, \ldots, n. \tag{23}$$

where K_i — given positive coefficients.

Now we can turn back to the problem of maximizing health level function $U(Y)$, which can be formulated in a form that does not involve prices p_i, $i=1, 2, \ldots, n$. To do this we shall substitute expression (23) to (4) (formula for $U(Y)$) to get

$$U(Y)=\bar{U}(X)=k\prod_{i=1}^{n}[K_i\, X_i^{\alpha_i}]^{\gamma_i}=\bar{K}\prod_{i=1}^{n} X_i^{\alpha_i\gamma_i}, \tag{24}$$

K=const.

Assuming, that the total expenditures are X and that they should be splitted into $X_i=\hat{X}_i$, $i=1, \ldots, n$, in such a way that $\bar{U}(X)$ assumes its maximum value subject to

$$\sum_{i=1}^{n} X_i \leqslant X,\ X_i \geqslant 0,\ i=1, \ldots, n.$$

we obtain

$$\hat{X}_i = \frac{\alpha_i \gamma_i}{\sum_{i=1}^{n} \alpha_i \gamma_i} X, \; i=1, \ldots, n. \tag{25}$$

We get also

$$\bar{U}(\hat{X}) = \bar{K} \prod_{i=1}^{n} \left[\frac{\alpha_i \gamma_i}{\sum_{i=1}^{n} \alpha_i \gamma_i} \right]^{\alpha_i \gamma_i} X^{\kappa} \tag{26}$$

where

$$\kappa = \sum_{i=1}^{n} \alpha_i \gamma_i .$$

It should be pointed out, that strategies (25) depend not only on preference expressed by the values of coefficients γ_i, but on the efficiences of health institutions expressed by α_i as well. In other words, the bighest expenditures on the particular areas of activities receive these institutions that deal with the preferred areas of activities (diseases) and that have greatest efficiency. This principle coincides with expenditures policy suggested by R. Grosse [2].

4. Discussion of results

As mentioned before, the determination *ex ante* of preference coefficients γ_i and the efficiency coefficients α_i for particular areas of activity and institutions may prove to be difficult. It is however possible to determine these quantities or their products α_i, γ_i, $i=1, 2, \ldots, n$, *ex post* on the basis of statistical data concerning means allocated to individual areas of activity in the past.

Of course, it will be reasonable to assume that allocation of resources in the past have been carried on in the optimal manner according to expression (25).

It should be pointed out, that further system parameters, e.g. F_i, α_i in formulaae (15) and (21), can be determined by means of that identification method. Refering to Fig. 2 and coming back to the results of Chapt. 3 we can discuss the geometrical interpretation.

The curve $U(Y_1, Y_2)$ may be regarded as "demand" curve for health services. The point $\hat{Y}_1$, $\hat{Y}_2$ is tangent to another curve marked with a dashed line, which represents "supply" of health effects which are possible to be realized by health institutions having resources X at their diposal. The straight line $p_1 Y_1 + p_2 Y_2 = X$ represents linear function separating convex sets one of which is above the curve $U(Y_1, Y_2) = \text{const.}$ and the other below this curve. The existence of such a line — or in general case — a linear functional follows from a known theorem on separation of convex sets [5].

It should be noted that the "demand" curve for services is generally nonstationary in time. It changes with progress in science and with introduction of new medicines and methods of therapy, and with arising threats following from industrialization, environment polution, etc. This process results in change of preferences, that is in the change of values of γ_i in health level function $U(Y)$. The model does not take into account these processes as well as those following from epidemic diseases. There exists however a possibility of relating function $\bar{U}(X)$ to the so called epidemic models.

Of a particular interest are the models which were developed by Lotka [9]. The morbidity $\dot{Y}_i(t)$ in these models is proportional to the product of a number of ill persons $Y_i(t)$ and a number of persons susceptible for a disease $[N-Y_i(t)]$:

$$\dot{Y}_i(t)=cY_i(t)\,[N-Y_i(t)]$$

where N — total number of members of population considered, $c=\text{const}$.

The solution of that equation with an initial value $Y_i(0)=y_0$ is the so called logistic curve, while $\dot{Y}_i(t)$ changes along the "bell shaped" curve shown in Fig. 5.

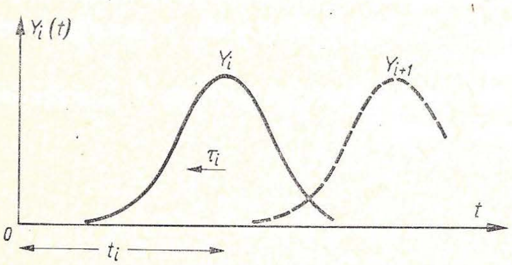

Fig. 5

Parameters of that curve can be described in terms of the so called moments

$$\mu_i^{(k)}=\int_0^\infty Y_i^k(t)\,dt,\; k=0,1,2, \tag{27}$$

where $\mu_i^{(0)}$ determines the area of the curve, $t_i=\mu_i^{(1)}/\mu_i^{(0)}$ — the time of maximum intensity, $\tau_i=\frac{1}{\mu^{(0)}}(\mu^{(2)}-t_i^2)^2$ determines the actual duration periode of the epidemic $T_i\approx 2\tau_i$. Assuming that the parameters $\mu_i^{(0)}$, t^i, τ_i, $i=1, \ldots, n$, are known (or can be estimated) the coefficients γ_i can be made dependent on time, as follows

$$\gamma_i(t)=\mu_i^{(0)}\exp\left[-\frac{(t-t_i)^2}{2\tau_i^2}\right],\quad i=1, \ldots, n. \tag{28}$$

It should be noted that efficiencies of health institutions may also change in time. In particular the parameters α_i, $i=1, \ldots, n$, (see formula (23)) that determine efficiency of health institutions change in time. Those changes may be due to the fact that both equipment and specialists grow older in physical and moral sense.

Changes of parameters $\alpha_i(t)$ and $\gamma_i(t)$ are in general slow, comparing to short planning periods and in one year planning they may be neglected. They should however be taken into account in long-range planning, as for example in a plan that ranges up to year 2000.

Assuming that the institution efficiency, in a given area of activity expressed by function $\alpha_i(t)$, $i=1, \ldots, n$, may be described by formulae of the type (28) and setting $\alpha_i(t)$ and $\gamma_i(t)$ to formula (25) we can estimate demand for expenditures and specialists in long-range planning. Changes in total resources $X(t)$, depending on growth in national income, should also be taken into account.

When the model is applied to the long-range planning and forecasting purposes, it is necessary to formulate areas of future activities and preferences in terms of parameters α_i, γ_i, $i=1, ..., n$. These data may be determined on the basis of reports formulated by groups of experts. Thus possibilities exist in formulation of the general problems expressed in descriptive language in the systems analysis language. It is now easy to proceed in solving problems of ballancing expenditures and development demands determining forecasts of health service development in both qualitative and quantitative aspects.

It should be noted that the model discussed is a macromodel in which economy of expenditures and its health effects has been exposed. There is a whole class of methods allowing more efficient modelling and optimization of simple processes of health service organization, data processing, management, etc.

Finally it should be noted, that solution of basic problems from the domain of health service development planning at the national level can not be done separately from the whole social and economical life of the country. In other words, in order to estimate expenditures in health, the health effects, etc., a complex model of development [5] should be considered.

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Planowanie i zarządzanie służbą zdrowia metodami analizy systemowej

Praca dotyczy zastosowania analizy systemowej do potrzeb planowania i zarządzania służbą zdrowia. Rozważono zwłaszcza problem optymalnego podziału zasobów i nakładów na poszczególne jednostki chorobowe i dziedziny działalności (np. diagnostykę, profilaktykę, bezpieczeństwo i higienę pracy, szpitalnictwo, rehabilitację), które tworzą złożoną strukturę hierarchiczną. Roz-

ważono też optymalny podział zasobów w aspekcie tematycznym, administracyjnym, czasowym i regionalnym. Jako funkję celu przyjęto tzw. funkcjonał poziomu zdrowotnego, który jest skalarną funkcją wektora intensywności wyzdrowień, uniknięcia zgonu itp. Rozpatrzono problem kształtowania się wag w określonej populacji ludzkiej lub preferencji w stosunku do poszczególnych dziedzin działalności.

Планирование и управление в секторе здравохранения при использовании методов системного анализа

Работа касается применения системного анализа для нужд планирования и управления сектора здравохранения. В особенности рассмотрена задача оптимального раздела ресурсов и затрат по отдельным заболеваниям и областям деятельности (например, диагностики, профилактики, охраны и гигены труда, больничного дела, реабилитации), которые образуют сложную иерархическую структуру. Рассмотрен также оптимальный раздел ресурсов в тематическом, админисстративном, временном и региональном аспектах. В качестве функции цели принят так называемый функционал уровня здоровья, который является скалярной функцией вектора интенсивности выздоровливаний, избежания смертных исходов и т.п. Рассмотрен вопрос формирования весов для определенного слоя населения или предпочтений в отношении отдельных областей деятельности.