

The Use of Modern Information Technology in Medical and Health Institutions of Truskavets Resort

Mykola Odrekhivskyy^{[0000-0003-3165-4384]¹}, Volodymyr Pasichnyk^{[0000-0003-3007-2462]²},
Nataliia Kunanets^{[0000-0003-3007-2462]²} Antonii Rzhеuskyi^{[0000-0001-8711-4163]²}, Galyna Korz
^{[0000-0002-0296-7069]²} and Danylo Tabachyshyn^{[0000-0001-8626-9016]²}

¹ Department of Management and International Business, Lviv Polytechnic National University, Lviv, Ukraine
odr2002@ukr.net

² Information Systems and Networks Department, Lviv Polytechnic National University, Lviv Ukraine
vpasichnyk@gmail.com, antonii.v.rzheuskyi@lpnu.ua,
nek.lviv@gmail.com, gal.corzh@gmail.com,
tabachyshyn.danylo@gmail.com

Abstract. When organizing a national network of health centers, organization of market relations of health centers with the population, enterprises and organizations, there was a need to study this problem on a new basis, to develop scientifically justified terms for patients' stay in health, depending on the nature of the organism's susceptibility to a particular disease, resource and health conditions, health stages, patient age, and other metrics. All this leads to the application of individual approach to each patient, which is impossible without using of high technologies of healing, which are based on new high intelligent information systems. The methods and means of realization of information technology, which helps to increase the efficiency of the processes of rehabilitation in sanatorium-resort establishments, are presented. The given information technology contributes to the effective implementation of the health-improving processes of sanatorium-resort establishments in the city-resort of Truskavets. Testing of information technology is carried out at diagnosis and recovery by means of mineral water "Naftusya".

Keywords: Information Technology, Sanatorium-resort Establishments, Health Care System, Diagnosis and Recovery, Modeling, Mineral Water "Naftusya".

1 Introduction

The rapid development of information technologies, systematic recommendations, created the necessary prerequisites for the development of processes of intellectualization of decision-making processes in the medical field. Decision-making, in its turn, has come to be seen as a highly intellectual process that has led to the collaboration of specialists in various fields of knowledge (medicine, psychology, economics, informatics, law, etc.) to create intelligent decision support systems in management, and to enable the implementation of information management technologies, in particular technologies management of patients' healing processes.

Copyright © 2020 for this paper by its authors.

Use permitted under Creative Commons License Attribution 4.0 International (CC BY 4.0).

Information technologies can be effectively used in the health-improving process of sanatorium-resort institutions of Ukraine. This will improve the efficiency of the recreation, treatment and rehabilitation of patients, as they ensure the efficiency of the processes of collecting and processing statistical information, the study of individual characteristics of patients, diagnosing health conditions and diseases, predicting the course of diseases and determining algorithms for improving the health and wellness of patients, selection health resorts.

2 State of the Problem

The works of Eman Abukhousa, Jameela Al-Jaroodi, Sanja Lazarova-Molnar, Nader Mohamed[1], Inas S. Khayal1, Amro M. Farid[2] X. Zhong [3], Kiran Dewangan, Mina Mishra [4] are dedicated to application of information technologies in health care system. The use of information technology is one of the most promising areas of health care development today, in particular in the provision of health services in health resorts and resorts. Health information technologies are designed to facilitate the accumulation and processing of large amounts of information, provide early identification of medical problems and make effective decisions to address them in a non-medicated manner and generate recommendations for the prevention of recurrence.

The aim of the research is to analyze methods and tools for the implementation of information technology, which contributes to the improvement of the efficiency of the healing processes in spa resorts. When implemented in the practice of health institutions provide diagnosis of patients' health, primary and secondary diagnosis of diseases, analysis of health status, the choice of optimal methods of recovery, evaluation, analysis and prediction of the effectiveness of recovery, scientific and economic substantiation of recovery processes, accumulation and processing of medical data and knowledge about diseases, their possible course and formation of health complexes. Such information technology involves the creation of a referral system, in the database and knowledge of which physicians of many specialties, who act as experts, accumulate, and which provides the generation of recommendations that assist in the decision-making processes of physicians in difficult situations.

3 The Main Part of the Research

The proposed information technology is implemented using a recommendation system, which should provide the definition of different physiological systems of the body, if necessary, differentiate them, generate and test the hypotheses of pathological conditions, predict the disease [5,6], determine and predict changes in the dynamics, recommend the type and scheme treatment or rehabilitation taking into account the indications and contraindications, other factors (age, severity of the condition, the degree of damage to various physiological systems, disconnection of pathological conditions, compatibility and cumulateness of medicines or wellness products, etc.), extrapolate the patient's condition based on the effect of treatment, adjust the treatment and health during the spa course. That is, the recommendation system has many tasks,

including: determining the state of the object; unbalance detection; finding out and eliminating their causes; predict the evolution of an entity's states, and more[7].

The following factors were taken into account when creating the proposed information technology:

- not all management goals can be expressed in quantitative terms, and some of the parameters that affect the management process cannot establish the exact, empirically determined, quantitative relationships;
- the process of achieving the goal is multi-step and the content of each step cannot be uniquely defined;
- an object evolves over time, its structure and functions change, which leads to the evolution of the control process itself;
- the elements that are part of the structure of the management object have an active nature and their behavior may be contrary to the management objectives;
- objects have a hierarchical structure, for each level of which may be its optimal solution;
- the elements of the system are united by a large number of different types and types of communications.

Information technology contributes to the effective implementation of the health-improving processes of sanatorium-resort establishments in the city-resort of Truskavets. This information technology is focused on the collection, processing and analysis of diagnostic information on urological and gastroenterological pathologies, diabetes and radiation diseases, conditions of patients, according to which they can be attributed to the risk groups of these diseases. Testing of information technology is carried out in the diagnosis and recovery with the help of mineral water "Naftusia" diabetic patients and persons at risk of this disease. Realization of information technologies of recovery occurs according to the scheme presented in Fig. 1.

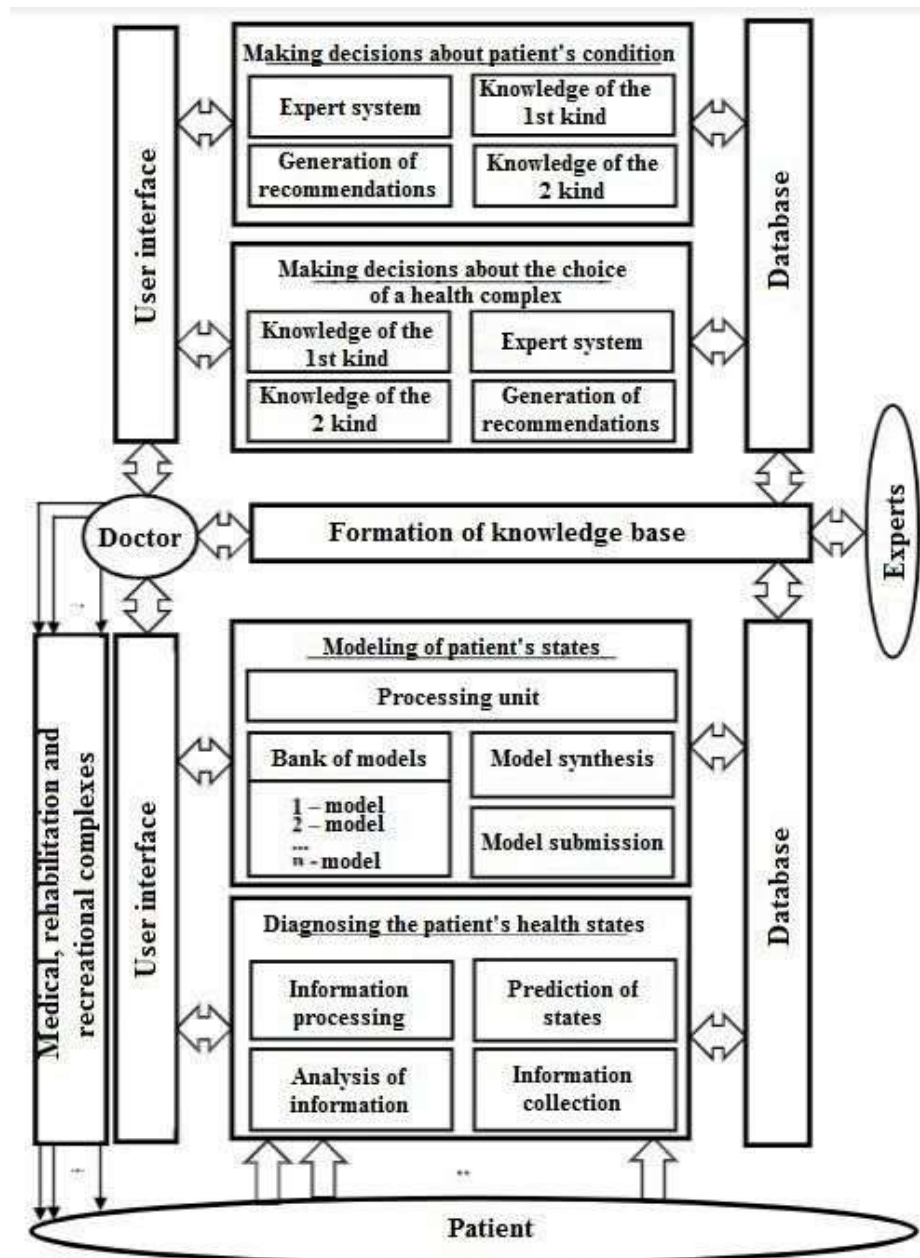


Fig. 1. Scheme of implementation of information technology for patient improvement

The collection of diagnostic information is based on the results of laboratory, instrumental, radiological, radio-indicator and electrophysiological studies. The collected information about the patients' health status is recorded in the appropriate

examination cards, with further formation in the computer memory of formalized medical history frames and their accumulation in the database (electronic archive of medical histories).

From the survey map, where the medical parameters under study are located in the order in which the doctors examine the patients, the specific values of the medical signs are recorded in a formalized medical history. Information on medical features, such as their affiliation with a particular classification group or diagnosis, determines the health status of patients, that is, their pathological, healthy or pre-pathological condition (intermediate between health and disease). When entering the values of medical signs in the pathological range is supplementing the signs of the patient's condition, otherwise extrapolation of the patient's condition and the choice of the optimal method of recovery.

Situation supplemented by the situation is recorded in an electronic medical history, which also collects data from formalized medical history and all information generated by the object system and used to solve various tasks in the medical-diagnostic process.

Disease diagnosis is made by activating diagnostic rules that include signs or different combinations of signs, sometimes even contradictory ones, in order to be diagnosed in different situations. It also includes data that does not provide basic information but which can increase the accuracy of the diagnosis.

In the diagnostic rules, the sequence of situational structures reflecting the clinic, biochemistry and pathophysiology of the disease is presented in the form of "and - or" graphs. Any of the defined conditions is a node of the pathology tree. Extensive areas of therapy, such as kidney, liver, gastrointestinal, cardiovascular, and endocrine systems can be selected to construct this tree. Within each of these sectors, subclasses are distinguished on the basis of the pathogenetic mechanism.

For example, the kidney injury subclasses are kidney failure, kidney inflammation, kidney stone disease, nephrosis, and kidney infarction, similarly can be divided into subclasses of endocrine glands, such as the pancreas, as discussed below. These subclasses are further divided into more specific diagnoses by type, type, severity, phase, severity, and so on.

In the process of diagnosis, we propose to use computer simulation of the inference procedure, that is, the conclusions are attributed to qualitative estimates, such as the truth of the diagnosed condition (true, quasi-true, false), differentiation of severity (light, medium, heavy, etc.). The diagnostic process can be expressed as a growing pyramidal network, the configuration of which may change during operation. This change is based on causation, so the pathological process can be represented in the form of a causal network, the nodes of which are pathological states, and the arcs determine the time relations, the nature of the relationships, the cause-to-effect relationship and the weight of these ties. This makes it possible to support decision-making about patients' health conditions and treatment methods based on recommendations generated by the expert system.

The decision on the patient's health status in general, or any body, is made on the basis of simulation results, which is used to study structures, functions and processes at different levels of living organism organization: atomic-molecular, subcellular, cell-tissue, organ- systemic, organismal, biocenotic. To carry out these studies, we propose

to use: functional models that reproduce a certain relationship between known and unknown quantities; models represented by a system of many-unknown equations, which requires their study of computer hardware and related software; optimization-type models represented by systems of equations or inequalities for unknown quantities, the aim of which is to find the solution that would give the optimal value of a given indicator; simulation models used for analyzing biosystems as complex systems, characterized by accurate reproduction of a biological process or phenomenon, require special calculations by computer technology; systems and complexes of interdependent models of the above types. That is, mathematical models are proposed for the study of complex physiological processes, the study of the interaction of organism systems in normal and pathology, in the study of epidemic processes, in clinical immunology, pharmacokinetics, for the calculation of clinically relevant indicators in the processing of signals and images, for the description of the diagnosis and imaging. and prediction, which is usually done using differential calculus, elements of linear algebra, and theory of random processes. In order to evaluate and predict patients' states to make optimal decisions about these conditions and to manage them through the use of decision support systems, we propose to use models based on mathematical methods of Markov process theory.

The evaluation of the truth of the diagnosis is dynamic, it is formed in the process of working of the model of diagnosis, it is used in the calculation of the transitive force of causation, the reliability of the predicted pathological conditions or the probability of their hypotheses. This helps doctors find out the causes and effects of illnesses, as moving up and down a tree of conclusions to identify the cause-and-effect chains based on the transitive nature of cause-and-effect relationships.

The analysis of the states in dynamics can be performed using the following groups of qualitative linguistic assessments:

- a) "bad", "unsatisfactory", "satisfactory", "good", "very good";
- b) "substantially below normal", "below normal", "normal", "above normal", "substantially above normal";
- c) "improvement", "no change", "deterioration" and others.

Analyzing the rate of change of these states is due to the intensity of transitions from state to state, and with the help of linguistic variables, "insignificant", "significant", "sharp" and others. It is advisable to draw conclusions about these assessments in the presence of a diagnosis of disease information at certain points in time (for example: at the beginning, middle and end of the healing or treatment period), formed on the basis of ratios of different gradations of a large number of features. That is, at a high level, in terms of abstraction, at the linguistic level, and with the use of appropriate mathematical modeling tools.

In our view, the most promising way to model the states of treatment objects is an approach based on the generalized representation of this object as some information-associative network model. In this case, the behavior of the treatment object can be described by the spatial-temporal distribution of its discrete states. The condition description is a linguistic variable that indicates the elemental properties of the object under study. Some element of this object at a fixed point (or interval) of time may be

represented by a status word in this case. Given the integrity of the treatment objects and the appropriateness of their behavior, one can represent one or another of their internal relationships and interactions by assigning associative calculus to a corresponding set of concepts that express the condition. In this way, the doctor is able to describe the structure and behavior of the treatment object at a conceptual level, listing the properties and structure of the object, giving causal relationships between its elements. Such a representation can be automatically formalized and transformed into a machine image of some mathematical model - deterministic or stochastic.

The implementation of this approach, when the conceptual representation of an object is recognized as a Markov chain of states, allows to use the theory of Markov chains by means of constructing on the basis of qualitative estimates of the states of the corresponding quantitative indicators of the change of these states in dynamics for the analysis of medical systems. This can solve the problem of evaluating the effectiveness of the healing effect of natural factors of healing, such as Naftus mineral water, taking into account the holistic and differentiated response of body systems. It is proposed to implement a comprehensive approach to the organization of computational experiment, which would include expert assessments and modeling of the dynamics of biological processes.

To achieve this, we proceeded from the following prerequisites:

- a living organism is a complex hierarchical structure;
- the therapeutic effect of mineral waters or other natural healing factors is considered as an external influence factor;
- the living organism to such influence responds to the reactions of organs and systems of different levels of its organization. This includes mechanisms of regulation that seek to bring the system to a state of dynamic equilibrium, which corresponds to the level of therapeutic action of a health factor.

The therapeutic effect of any health factor is complex in nature and causes changes at the level of biophysical, biochemical, physiological and other processes, the mathematical description of which on a classical basis is quite complex. Given the fact that the development of biological processes in many cases has a boundary character, all the diversity of processes can be described as a set of states, the transitions between which are random [8].

Thus, the modeling of biological processes in the healing action of natural health factors, it is advisable to start by solving the following tasks: development of an adequate mathematical model of the dynamic properties of the therapeutic effect of health factors; development of an informational model of dynamics of action of health factors. This approach was used by us in modeling the state of the endocrine system of the organism, which in this case it is advisable to present in the form of a four-level hierarchical structure (Fig. 2) [9, 10]. The element of the first level of the hierarchy here is the central nervous system (the main element of the system). At the second level, there are endocrine glands, such as the pancreas, adrenal medulla, parathyroid glands, and hypothalamus.

The hypothalamus secretes nine hormones that control the pituitary gland, a gland located at the third level of the hierarchy. The anterior part of the pituitary gland produces three effector hormones that act directly on the organs and four tropes that control the fourth level glands: adrenal cortex, thyroid, and gonads.

When exposed to external factors, the response of the endocrine system is to consistently alter the elementary physiological functions and regimes at the corresponding levels of its structure. The first level of reaction will, accordingly, be those structures that are the first to respond to the influence factor. The states of these structures of the endocrine system are identified with the states of the formal elements of the hierarchical structure. Each element can have N states.

At the initial moment (before external influence) each state (S_i) is characterized by some probability $P(S_i)$. The impact effect is recorded as the transition of each element to a new state. This process is completed by establishing a new probability distribution of the state of elements favorable to the body.

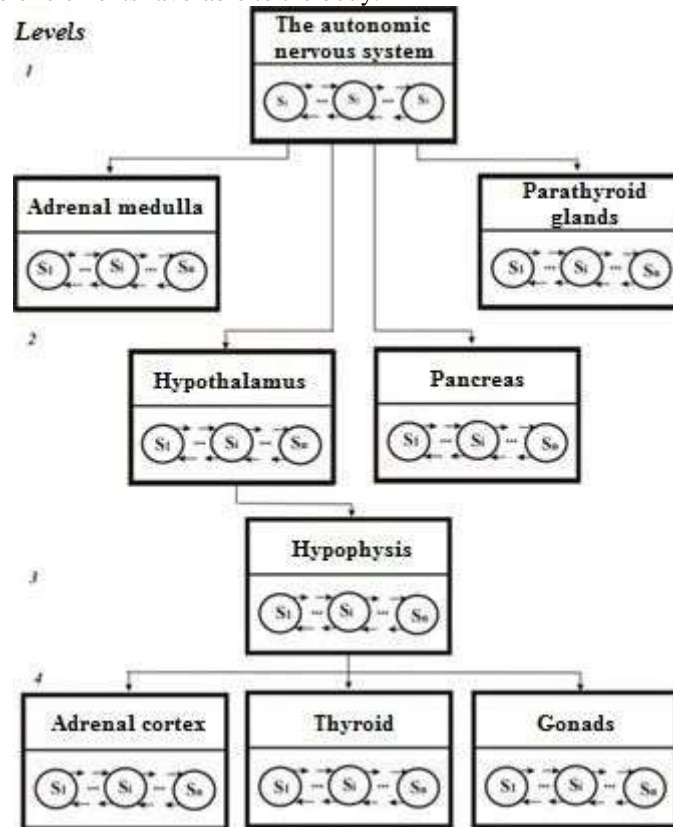


Fig. 2. Hierarchical structure of the endocrine system

Processes that are represented as a hierarchical structure can be described using Markov process theory. That is, the description of the j -th element of the i -th level of

the hierarchy can be performed using the Kolmogorov differential equation system (1) [11].

$$\frac{dP_{i,j,l}}{dt} = \lambda_{i,j,l-1,l} \cdot P_{i,j,l-1} - (\lambda_{i,j,l,l-1} + \lambda_{i,j,l,l+1}) \cdot P_{i,j,l} + \lambda_{i,j,l+1,l} \cdot P_{i,j,l+1}; \quad (1)$$

where $i = 1, 2, \dots, N$ is the order number of the hierarchy level; N is the number of hierarchy levels; $j = 1, 2, \dots, M_i$ is the order number of the element of the i -th level of the hierarchy; M_i is the number of elements of the i -th level of the hierarchy; $l = 1, 2, \dots, L_j$ is the order number of the state, j is the element, and the i -th level of the hierarchy; L_j is the number of states of the j -th element; i -the probability of the l -th state, the j -th element, the i -th level of the hierarchy; $\lambda_{i,j,l,l+1}$ is intensity of transition of the system under study from state l to state $l+1$, j -th element, i -th level of hierarchy.

The study of the endocrine system in statics in order to predict its states and states of its components when $t \rightarrow \infty$ and $dP/dt = 0$ can be performed on the basis of the solution of the system of algebraic equations (2) obtained for the j -th element i -th level of the hierarchical structure by transforming the system of differential equations (1).

$$\lambda_{i,j,l-1,l} \cdot P_{i,j,l-1} - (\lambda_{i,j,l,l-1} + \lambda_{i,j,l,l+1}) \cdot P_{i,j,l} + \lambda_{i,j,l+1,l} \cdot P_{i,j,l+1} = 0; \quad (2)$$

This approach to modeling the endocrine system was tested by us when modeling the effect of mineral water "Naftusia" on the endocrine part of the pancreas. According to the classification given in [8,10,12], the pancreas can be in one of five major conditions characterized by physiological glucose tolerance. This classification makes it possible to represent the main phenotypes of glucose tolerance by a graph of states (Fig. 3).

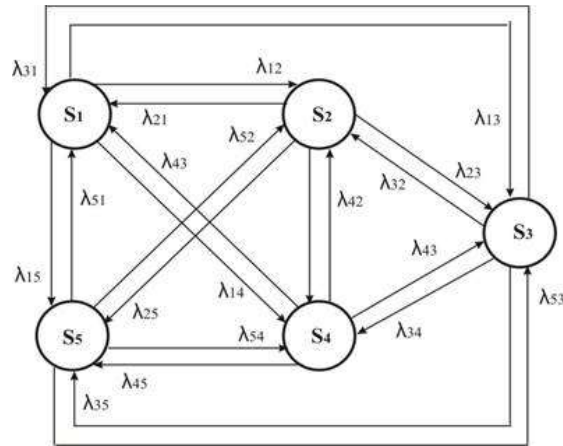


Fig. 3. The graph of the states of the pancreas

where S_1 is a state with increased glucose tolerance;
 S_2 is a condition in which tolerance is not compromised;

S_3 is a state with borderline glucose tolerance;

S_4 is a condition with a potential impaired glucose tolerance;

S_5 is diabetes mellitus;

λ_{ij} is intensities of transitions from the i -th to the j -th state, $i, j = 1, 2, \dots, 5; i \neq j$.

This graph can be described by the Kolmogorov system of differential equations (3).

$$\begin{aligned}
dP_1 / dt &= -(\lambda_{12} + \lambda_{13} + \lambda_{14} + \lambda_{15}) \cdot P_1 + \lambda_{21} \cdot P_2 + \lambda_{31} \cdot P_3 + \\
&+ \lambda_{41} \cdot P_4 + \lambda_{51} \cdot P_5, \\
dP_2 / dt &= -(\lambda_{21} + \lambda_{23} + \lambda_{24} + \lambda_{25}) \cdot P_2 + \lambda_{12} \cdot P_1 + \lambda_{32} \cdot P_3 + \\
&+ \lambda_{42} \cdot P_4 + \lambda_{52} \cdot P_5, \\
dP_3 / dt &= -(\lambda_{31} + \lambda_{32} + \lambda_{34} + \lambda_{35}) \cdot P_3 + \lambda_{13} \cdot P_1 + \lambda_{23} \cdot P_2 + \\
&+ \lambda_{43} \cdot P_4 + \lambda_{53} \cdot P_5, \\
dP_4 / dt &= -(\lambda_{41} + \lambda_{42} + \lambda_{43} + \lambda_{45}) \cdot P_4 + \lambda_{14} \cdot P_1 + \lambda_{24} \cdot P_2 + \\
&+ \lambda_{34} \cdot P_3 + \lambda_{54} \cdot P_5, \\
dP_5 / dt &= -(\lambda_{51} + \lambda_{52} + \lambda_{53} + \lambda_{54}) \cdot P_5 + \lambda_{15} \cdot P_1 + \lambda_{25} \cdot P_2 + \\
&+ \lambda_{35} \cdot P_3 + \lambda_{45} \cdot P_4.
\end{aligned} \tag{3}$$

This makes it possible to investigate the pancreas of patients with respect to glucose tolerance in a dynamic mode, and to study the same states in a steady state it is necessary to transform the system of differential equations (3) into a system of algebraic equations (4).

$$\begin{aligned}
&-(\lambda_{12} + \lambda_{13} + \lambda_{14} + \lambda_{15}) \cdot P_1 + \lambda_{21} \cdot P_2 + \lambda_{31} \cdot P_3 + \lambda_{41} \cdot P_4 + \lambda_{51} \cdot P_5 = 0, \\
&-(\lambda_{21} + \lambda_{23} + \lambda_{24} + \lambda_{25}) \cdot P_2 + \lambda_{12} \cdot P_1 + \lambda_{32} \cdot P_3 + \lambda_{42} \cdot P_4 + \lambda_{52} \cdot P_5 = 0, \\
&-(\lambda_{31} + \lambda_{32} + \lambda_{34} + \lambda_{35}) \cdot P_3 + \lambda_{13} \cdot P_1 + \lambda_{23} \cdot P_2 + \lambda_{43} \cdot P_4 + \lambda_{53} \cdot P_5 = 0, \\
&-(\lambda_{41} + \lambda_{42} + \lambda_{43} + \lambda_{45}) \cdot P_4 + \lambda_{14} \cdot P_1 + \lambda_{24} \cdot P_2 + \lambda_{34} \cdot P_3 + \lambda_{54} \cdot P_5 = 0, \\
&-(\lambda_{51} + \lambda_{52} + \lambda_{53} + \lambda_{54}) \cdot P_5 + \lambda_{15} \cdot P_1 + \lambda_{25} \cdot P_2 + \lambda_{35} \cdot P_3 + \lambda_{45} \cdot P_4 = 0.
\end{aligned} \tag{4}$$

The results of the analyzes obtained by the methods of examination of the state of glucose tolerance through the subsystem of the collection of diagnostic information are recorded in the machine history, on the basis of which the state of the patient's tolerance to glucose is determined. All patient data are entered into the machine archives of case histories to further investigate large patient samples in order to determine the intensities of transitions from one state to another for glucose tolerance for each patient and the intensities of transitions of patients from one classification group to another during their classification. The resulting transition intensities are used as coefficients of the above differential and algebraic equations, which allows for the tracking of the probability of glucose tolerance states of each patient and each classification group of patients in dynamic and in-patient modes.

Analyzing the results of studies on the likelihood of glucose tolerance in patients and their classification groups, it is possible to draw conclusions about the choice of the

optimal methods of recovery and their effectiveness. This method of computer diagnostics and prognosis of patients with regard to the incidence of diabetes mellitus or belonging to the risk group of this disease was the basis for the development of appropriate software for the intellectual technology of health in the conditions of the resort of Truskavets, which makes it possible to study the effect of mineral water "Naftusya »On the condition of tolu-rarity to glucose of patients in their recovery.

Testing of this recommendation system was carried out using clinical data of a selected group of patients with diabetes, which were examined at the beginning of the sanatorium and spa health and before its completion. The studies were performed on the basis of a standard pyruvate glucose tolerance test [10, 12]. A total of 104 patients were examined, who were divided into classification groups as follows:

1. Hyperinsulinism - 88 people;
2. Normal glucose tolerance - 6 people;
3. Border glucose tolerance - 8 people;
4. Potential impairment of glucose tolerance - 2 persons;
5. Diabetes mellitus - 0 patients.

After the sanatorium and spa rehabilitation, this group of patients was again examined with the help of a pyruvate test, and they were thus divided into classification groups:

1. Hyperinsulinism - 77 people;
2. Normal glucose tolerance - 13 people;
3. Border glucose tolerance - 13 people;
4. Potential impairment of glucose tolerance - 1 person.

To evaluate, analyze and predict the effect of Naftusia mineral water on the pancreas of Langerhans using the developed software, the states of the pancreas are presented in the form of a graph of the states shown in Fig. 4.

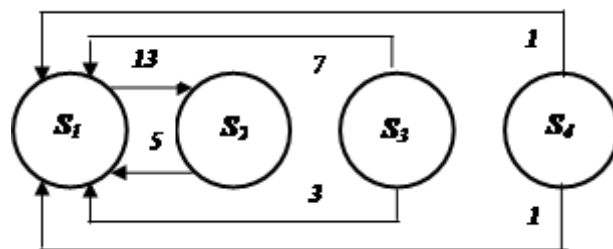


Fig. 4. The graph of the states of the pancreas obtained from the experiment

Analyzing the results of the study of the dynamics and statics of glucose tolerance states obtained by solution using the developed software based on the fourth-order numerical Runge-Kutta method for solving the differential equation system and Gaussian numerical method for solving systems of algebraic equations [8] and depicted in Fig.

5, showed that the greatest value here is the probability of the state $P(S_2)$, which in steady state can acquire a value equal to 0.375.

The values of the probabilities of the other states in the statics were distributed as follows: $P(S_1) = 0.144$; $P(S_3) = 0.337$; $P(S_4) = 0.144$, which leads to the following conclusion: the low-mineralized Naftusia water stabilizes the release of inulin by the pancreas with minor impaired glucose tolerance.

Therefore, in the conditions of the resort of Truskavets, patients at risk of diabetes mellitus or diabetic patients with minor impaired glucose tolerance can be effectively recovered. That is, Naftusia water can be used, on the one hand, as an effective means of preventing diabetes, and on the other, as a means of restoring the health of patients.

Thus, Naftusya contributes to the effective development of the rehabilitation and recreational components of the wellness process in Truskavets.

Appraisal of the proposed mathematical and software evaluation, analysis and prediction of patients' conditions for the purpose of further decision-making about patients' health conditions and methods of their healing, lead to the conclusion that this approach to the organization of intelligent healing technologies promotes rapid diagnosis, the choice of the optimal treatment complexes and, accordingly, the effective healing of patients by using exclusively natural medical factors. It is advisable to extrapolate the states here on the basis of deductive, inductive and abductive inferences, evaluating alternative solutions, using the values of cause and effect, and linking individual diagnoses into a single system for the whole organism. Therefore, the recommend system should include special tools that are included in the source language and provide standardization of outgoing messages. The optimal range of treatment measures and remedies is determined by manipulating machine history data. Therefore, machine history must store all patient information from outside and generated by technology.

The description of therapeutic measures is advisable to be in the form of a tree of signs and pathological conditions, so they should include the following characteristics: form of recovery (clinical treatment: inpatient, outpatient; rehabilitation; recreation), object (organs and systems of the body), therapeutic agents, display - their mechanism of action, daily dose, duration, frequency and conditions of reception, their antagonists, side effects, compatibility with other agents, cumulateness, etc. As the therapeutic measures in the conditions of the resort should focus mainly on natural healing factors: internal mineral water intake, therapeutic baths, hydrotherapy, ozokeritotherapy, physiotherapy, diet therapy, phytotherapy, physical therapy, therapeutic massage, psychotherapy, psychotherapy, psychotherapy use a multilevel language of knowledge representation, because the procedure of recommendation of the treatment complex must take into account different variations of data values at different levels of the knowledge hierarchy. It is important to make ambiguous decisions.

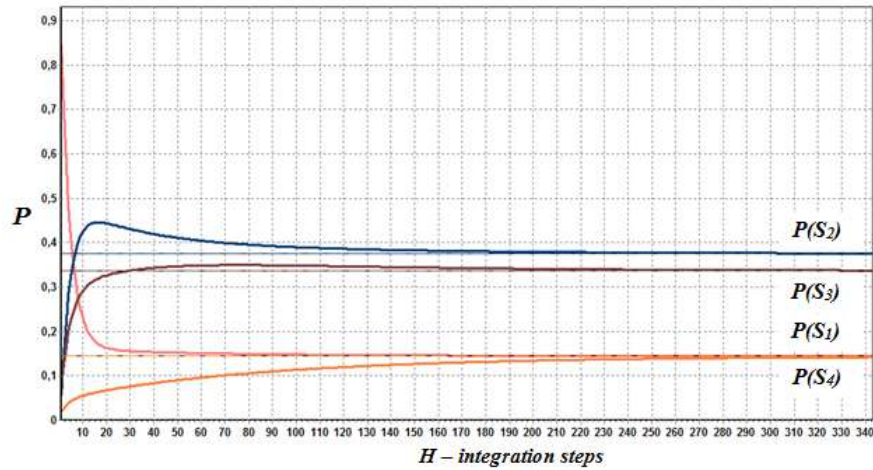


Fig. 5. Dynamic and static characteristics of pancreatic conditions

For different biosystems, the list of possible combinations of data on the presence and absence of damage should consist of a number of elements, which predetermines models of generative type to be used in the diagnosis of conditions of the organism - models that allow to build different pathologies on the basis of the input data and not select them from the specified list. This approach is possible due to the fact that the structure of the knowledge base must be formed from the knowledge of anatomy, normal and pathological physiology, description of clinical forms of the disease course. In this case, it is advisable to separate the model from the diagnostic model and in the presence of input data, it is advisable that the models work separately. Collaborative work should be possible provided that the output of the first model is fully consistent with the input of the other, and decisions on the choice of optimal healing techniques should be made on the basis of decisions about the state of the organism.

The main methods and principles (criteria, tasks) of optimizing the technology of health, focused on improving the health and economic efficiency in the conditions of the resorts, include: optimization of technology in terms of timing, choice of health complexes, health and health fools, innovations to diagnose and predict patients' health are relevant here; optimization of processes of adaptation of patients to conditions of the external environment of the resort on the basis of rhythmological characteristics of organisms.

Conclusions

Thus, the scientific and practical results of the optimization of health technologies in resort conditions should be the methodology of optimizing innovations, determining the optimal terms of recreation, rehabilitation and treatment, the appointment of health complexes. Analyzing research and publications, starting with work [2], in which the solution of this problem for spa resorts as institutions of post-clinical rehabilitation was

initiated, says that the current optimal terms of recovery are determined not by scientific means, but by the duration of the period vacation. However, when organizing a national network of health resorts, organizing market relations of health resorts with the population, enterprises and organizations, when it comes to the health care of healthy or practically healthy people, there was a need to study this problem on a new basis, to develop scientifically valid terms of stay patients on health, depending on the nature of the body's predisposition to a particular disease, resource and health conditions, stages of the course of health, age of the patient and other indicators. All this leads to the application of individual approach to each patient, which is impossible without the use of high technologies of healing, which are based on new highly intelligent information systems as means of artificial intelligence.

References

1. Simulation and Modeling Efforts to Support Decision Making in Healthcare Supply Chain Management, <https://www.ncbi.nlm.nih.gov/pubmed/24683333>, last accessed 2019/08/11.
2. A Dynamic System Model for Personalized Healthcare Delivery and Managed Individual Health Outcomes, <https://arxiv.org/pdf/1910.09104.pdf>, last accessed 2019/08/11.
3. Zhong, X.: From production systems to health care delivery systems: a retrospective look on similarities, difficulties and opportunities. *International Journal of Production Research* 55 (14), 1–15 (2017).
4. Internet of Things for Healthcare: A Review, https://www.researchgate.net/publication/323855758_Internet_of_Things_for_Healthcare_A_Review, last accessed 2019/08/11.
5. Tomashevskyi, V., Yatsyshyn, A., Pasichnyk, V., Kunanets, N., Rzheuskyi A.: Data warehouses of hybrid type: features of construction. *Advances in Intelligent Systems and Computing II (AISC)* 938, 325–334 (2019).
6. Mobile application for preliminary diagnosis of diseases, <http://ceur-ws.org/Vol-2255/paper25.pdf>, last accessed 2019/08/11.
7. Kazarian, A., Kunanets, N., Pasichnyk, V., Veretennikova, N., Rzheuskyi, A. Leheza, A., Kunanets O.: Complex information e-science system architecture based on cloud computing model. *CEUR Workshop Proceedings* 2362, 366-377 (2019).
8. Gela, A., Odrekhivsky, M., Soloviev, V., Fedorkiv I.: The decision support system for the rehabilitation of patients with pathologies of the endocrine system. *Cybernetics and computer engineering. Medical cybernetics. Science. Dumka, Kyiv* (1994).
9. Chester-Jones, I., Ingleton, P., Phillips, J.: *Fundamentals of comparative vertebrate endocrinology*. Springer US (2013).
10. Hart Ian R., Newton R.W.: *Endocrinology*. Springer Science & Business Media (2012).
11. Kolmogorov, A., Zhurbenko, I., Prokhorov A.: *Introduction to probability theory*. Moscow (2015).
12. Tomashevsky, Ya., Tomashevskya, O.: *Fundamentals of prophylactic endocrinology*. Lviv (1992).