Decision support system for initiating projects of medical and social development in regions

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Abstract
An algorithm and a substantiated structure of a decision support system for initiating medical and social development projects of regions are developed. They involve the use of computational intelligence methods. The proposed decision support system includes databases and knowledge, as well as eight interconnected blocks. The proposed decision support system for initiating projects of medical and social development of regions involves the formation of databases and knowledge from real data of electronic systems of medical and social records. This ensures the training of computational intelligence models for planning the components of medical and social projects. Based on the developed decision support system, a quantitative assessment of the duration of projects related to the treatment of diabetes in children with different characteristics of their disease was made. The regularities of changes in the duration of diabetes treatment projects in children are established. The proposed decision support system for initiating medical and social development projects of regions based on computational intelligence has theoretical and practical value. The results obtained are the basis for initiating projects of medical and social development of regions.

Keywords
Decision support system, initiation, projects, medical, social, development, management, regions.

1. Introduction

Currently, one of the tools for ensuring sustainable development of regions is the creation of effective means of developing the medical and social spheres. However, significant problems in these areas often require an integrated approach to project management [1-5]. Thus, to initiate and successfully implement projects aimed at improving social well-being

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Proceedings of the 5nd International Workshop IT Project Management (ITPM 2024), May 22, 2024, Bratislava, Slovakia
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and public health in the regions, it is important to develop appropriate decision support systems.

One of the promising areas that is significantly changing the medical and social spheres is the use of computational intelligence (AI) technologies [6-8]. Intelligent analysis and forecasting systems significantly increase the efficiency of medical and social projects. It is the use of computational intelligence technologies that ensures high-quality compliance with one of the characteristics of these projects - the uniqueness of actions to create the desired project product. Computational intelligence (AI) will help to create individualized recommendations for people that can improve their social status and health.

In this article, we have developed an algorithm and substantiated the structure of a decision support system for initiating medical and social development projects in regions. On their basis, it is possible to create functional blocks of a management decision support system that will improve the quality and accuracy of management decisions on the evaluation of medical project components, taking into account the current state of the project environment. The results obtained are the basis for initiating projects of medical and social development of regions.

2. Analysis of published data and problem sets

Many scientific papers [9-12] are devoted to the development of effective decision-support systems for managing development projects in specific industries and regions. They are also of interest to project managers in various fields, such as medicine, social work, economics, and management. The analysis of well-known scientific papers made it possible to better understand the trends and prospects for further research.

Today, there is a state system in place that is used to make decisions on the development of the medical industry in Ukraine [13]. The system includes modules for forecasting the need for medical services, assessing the effectiveness of medical institutions, and monitoring health indicators. There is also a system that is used to collect and analyze data on the social development of the regions of Ukraine. The system includes modules for monitoring living standards, evaluating the effectiveness of social programs, and predicting social risks. Separate decision support systems are used to manage healthcare and social development projects in the regions. Such systems include modules for project planning, monitoring their implementation, and evaluating their results.

The advantages of the existing systems are that they collect and analyze data on various aspects of health care and social development in the regions. However, they have drawbacks. In particular, they are not region-specific and are not integrated with other systems. Therefore, to make the decision support system for managing development projects of individual sectors and regions more effective, it should take into account the specifics of the regions and integrate with other systems.

In scientific papers [14-18], their authors highlight the basic concepts and methods underlying the development of decision support systems. The authors explore modern technologies that help to solve complex problems in decision-making, and some of them can be used in decision support systems for health and social development projects.

The analysis of scientific papers [19-23] provides important insights into which aspects of decision support systems are important for initiating and implementing projects for the health and social development of regions and identifies possible areas for further research in this area. In particular, some authors pay a lot of attention to the role of computational intelligence in managerial decision-making [24-29]. Some scientific papers emphasize the importance of using computational intelligence in the medical and social sectors and its potential for automating and optimizing various aspects of project planning.

Some scientific papers [30-35] deal with the creation of intelligent information systems for planning activities in the medical and social spheres. The authors emphasize the importance of an individual approach to the development of tools and architecture of planning systems, taking into account their project environment [36-39]. At the same time, the task of developing an algorithm and justification of the structure of a decision support system for initiating projects of medical and social development of regions based on computational intelligence methods remains unaddressed by scientists. At the same time, there is a need to develop and use the following tools to improve the performance of project managers.

3. Setting the objectives of the study

The purpose of our study is to develop an algorithm and justify the structure of a decision support system for initiating projects of medical and social development of regions.

To achieve the stated purpose of the article, we solve the following tasks:

– to develop an algorithm and substantiate the structure of a decision support system for initiating projects of medical and social development of regions based on computational intelligence methods;

– develop a user window of the decision support system with a tab for estimating the duration of projects related to the treatment of diabetes in children, as well as quantify the projected duration of these projects.

4. Development of an algorithm and justification of the structure of the decision support system for initiating projects of medical and social development of regions

The proposed decision support system for initiating projects of medical and social development of regions is based on the methods of computational intelligence. It consists of a database (BD), a knowledge base (BK), and 8 systematically interconnected functional blocks (Fig. 1).

The decision-making support system for initiating healthcare and social development projects in the regions consists of the following functional units:

1) unit (Unit_1) for creating a database on the state of the project environment and previously implemented projects of medical and social development of regions;

2) unit for entering data on the state of the region's population (Unit_2). It involves entering data on the current state of the region's residents in need of medical and social protection;

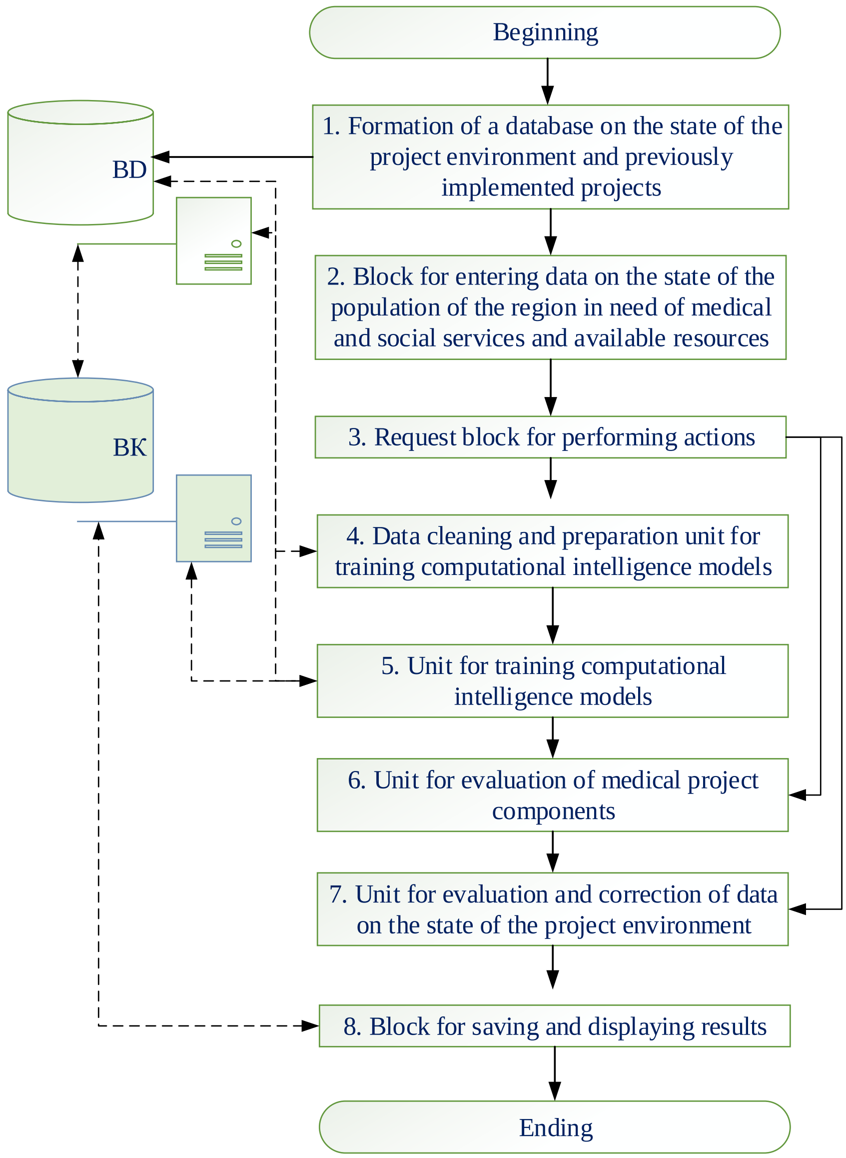


Figure 1: Algorithm of the decision support system for initiating projects of medical and social development of regions.

3) Request for action unit (Unit_3). This unit ensures the formation of a request to the decision support system for initiating projects of medical and social development of the regions based on the actions selected by project managers and the entered data and known knowledge contained in the DB;

4) data cleaning and preparation unit for training computational intelligence models (Unit_4). In this unit, the data obtained from the database, taking into account the results of previous actions, are cleaned, if necessary, fill in gaps, and converted to the desired format, which generally ensures the preparation of this data for use in training computational intelligence models;

5) unit for training computational intelligence models (Unit_5). This unit involves training computational intelligence models to evaluate the components of regional health and social development projects based on the prepared data;

6) unit for evaluating the components of regional health and social development projects (Unit_6). In this unit, trained computational intelligence models are used to evaluate the components of regional health and social development projects based on the input data on the state of the region's residents;

7) a unit for assessing and correcting data on the region's residents (Unit_7). Periodic assessment of the health status of the region's residents may affect the components of regional health and social development projects, so this block provides for the necessary correction of these data;

8) a unit for saving and displaying results (Unit_8). The results of the assessment of the components of the regional health and social development projects are saved to a separate file and displayed to the user in a dialog box in the form of graphs and/or text descriptions.

9) Let's describe in more detail the operation of the decision support system for initiating projects of medical and social development of regions. For this purpose, we assume:

D – a set of data on previously implemented health and social development projects and the state of the region's population, which is stored in the database;

P – a set of characteristics of the state of the project environment (population of the region) entered in Unit_2;

Q – an action request created in Unit_3;

R – results of previous activities that can be used to prepare data (e.g., data on regional population adjustment) and data for model training;

M – trained models of computational intelligence used to evaluate the components of medical and social development projects in the region;

$E(t)$ – evaluation of the components of medical and social development projects in the region obtained using computational intelligence models M ;

ND – new data on the state of the project environment, which can be adjusted or updated after the evaluation of the components of the health and social development projects in the region.

The process of forming a database (DB) on the components of health and social development projects in the region can be summarized as follows:

$$Database\_formation() \Rightarrow D, \qquad (1)$$

where $Database\_formation()$ – a function that performs the database formation operation.

Let's take a closer look at the function $Database\_formation()$ that creates a database for evaluating the components of medical and social development projects in a region.

Let $P_1,\ P_2,\ldots,P_n$ some data reflect the characteristics of the project environment and the state of the region's population (treatment features, weight, height, age, gender, test results, health status, etc.) In this case, the set of data about the n-th inhabitants of the region stored in the database is represented as a set of tuples, where each tuple contains the values of parameters for a particular inhabitant:

$$D = \{(P_1,\ P_2,\ldots,P_n),(P_1,\ P_2,\ldots,P_m),\ldots\}, \qquad (2)$$

where n, m – number of residents of the region in the database, persons; P_i – values of the characteristics of individual residents of the region, which reflect specific data for each person.

In a real-world implementation, a set of data D on the treatment of various diseases of patients or the provision of social assistance is represented as a table or data structure. In general, the function $Database\_formation()$ provides the creation of this set of tuples that reflect data on the treatment of patients and the social status of the population.

Let's take a closer look at the process of entering a set of characteristics P of the state of the region's residents into Unit_2. Characteristics P of the state of the region's residents are a set of information about the population in need of medical and social protection. These characteristics can be obtained from electronic medical records (EMR) [13].

We can present the process of entering a set of characteristics P of the state of the region's residents into Unit_2:

$$P_i = \{p_1, p_2, \ldots, p_k\}, \quad (3)$$

where $p_1, p_2, \ldots, p_k$ – are the real values of the characteristics of the region's residents; k – the number of characteristics of the region's residents.

The function of entering the characteristics P of the state of the region's residents is a process in which the project manager enters the value of each characteristic of the region's P_i residents in the user window.

Let's take a closer look at what the process of generating a request for action looks like in Unit_3. This unit plays a key role in the interaction between the project manager and the decision support system to initiate projects for the medical and social development of regions. The main idea is to use the entered data about the residents of the region, the known knowledge from the knowledge base (KB), and the generated previous queries to determine the specific actions that the decision support system should perform to evaluate the components of the regional health and social development projects. Let there be known the set of data D on the medical and social status of the region's residents, which is stored in the database, the set of known knowledge K contained in the knowledge base (KB), and the set of queries Q generated at the previous stages. Thus, the function of forming a request for action has $Request\_formation(D, K, Q)$ the following form:

$$Request\_formation(D, K, Q) \Rightarrow \{O_i\}, \quad (4)$$

where $Request\_formation(D, K, Q)$ – the function of generating a request for action; $\{O_i\}$ – a set of selected decision-making operations when generating a request.

This process may include training of computational intelligence models M, evaluation of the components of regional health and social development projects $E(t)$, which is provided using models M, clearing all fields of the system user window, and saving the results of the evaluation of the components of regional health and social development projects $E(t)$. Query generation $Request\_formation(D, K, Q)$ is a complex function that takes into account various characteristics of the region's residents and the rules that determine the selected actions. It is important to note that we have presented a general concept and its implementation, which takes into account the specifics of the decision support system for initiating healthcare and social development projects in the regions based on computational intelligence, as well as using the proposed methods and models.

Let's consider the process related to data cleaning and preparation in Block_4. In particular, the function $Data\_cleaning\_preparation(D,R)$ of the data cleaning and preparation unit is as follows:

$$Data\_cleaning\_preparation(D,R) \Rightarrow D_c, \quad (5)$$

where $Data\_cleaning\_preparation(D,R)$ – a function of data cleaning and preparation; D – a set of data on previously implemented projects of medical and social development of regions, which is stored in the database; R – results of previous actions; D_c – a set of prepared data.

In reality, process (5) is quite complex and includes many data processing steps that depend on the type of data, the presence of gaps and anomalies, and the requirements of a particular AI model M.

Let's consider the process of training computational intelligence models M, which takes place in the training unit (Unit_5). Let us define the following elements:

X – a training set of input features (properties) prepared at the previous stage of data preparation (Unit_4);

Y – a training set of relevant target values, which in our case represents the evaluation of medical project components $E(t)$;

M – a model of computational intelligence that we want to train;

θ – parameters of the model M to be trained.

The training of a computational intelligence model is to find such parameters θ that minimize the error between the forecasts of the component projects using the model and the true values of the target indicators. This error can be expressed as a loss function $L(\theta)$ that the model tries to reduce

$$L(\theta) = \frac{1}{N}\sum_{i=1}^{N} L\left(y_i, M\left(x_i, \theta\right)\right), \quad (6)$$

where N – number of examples in the training set, x_i, y_i – input features and corresponding target values for the *i*-th example; L – loss function that determines the difference between the model's $M\left(x_i, \theta\right)$ prediction and the actual value y_i of the duration of medical and social services.

When training computational intelligence models, an optimization algorithm is used to find the optimal parameters θ that minimize the loss function $L(\theta)$. It can be gradient descent, Adam, RMSProp, etc. Parameter updates are usually performed by rule:

$$\theta_{t+1} = \theta_t - \alpha \cdot \nabla L(\theta_t), \quad (7)$$

where α – learning step (learning rate), $\nabla L(\theta_t)$ – gradient of the received loss function with respect to the parameters θ at the step t.

Therefore, the process of training computational intelligence models in the model training unit (Unit_5) is to find such model parameters θ that minimize the loss function

$L(\theta)$, which includes the discrepancy between model predictions and the true values of target variables, such as the duration of regional health and social development projects.

In the unit for estimating the components of regional health and social development projects (Unit_6), based on the input data on the state of the region's residents P, trained computational intelligence models M are used to make a forecast of the project components $E(t)$. This process can be represented as follows:

$$E(t)=M(P), \tag{8}$$

where $E(t)$ – an assessment of the components of health and social development projects in the regions, which is obtained using a trained model M; P – a vector of input characteristics of residents of the region in need of medical or social support.

This process (8) implies that computational intelligence models, after being trained on a suitable dataset D, can make predictions based on the input data. For example, a computational intelligence model uses the input characteristics of the inhabitants of a region P to determine the duration of a healthcare or social assistance project $E(t)$. It should be noted that the accuracy and quality of forecasts using such models largely depends on the quality of training, data volume, model architecture, and other factors.

When assessing the components of health and social development projects in regions $E(t)$, real data on the state of the region's residents should be taken into account P, as they may be incorrect or irrelevant due to changes in the content and duration of health or social services. Therefore, it is necessary to adjust the population data to reflect the new projected state of the project after estimating its duration, which is provided by Unit_7. This process can be recorded using the data adjustment function $Data\_adjustment(P,E(t))$ as follows:

$$Data\_adjustment(P,E(t)) \Rightarrow P', \tag{9}$$

where P' – a vector of adjusted characteristics of a healthcare or social care project; P – initial patient characteristics; $E(t)$ – evaluation of project components.

The proposed decision support system for initiating projects of medical and social development of regions based on computational intelligence to evaluate their components has a data correction function $Data\_adjustment(P,E(t))$. It includes various steps to adjust the characteristics of projects based on the evaluation of their components. In particular, it provides for changes by how treatment or social protection affects certain health parameters of the region's residents. The implementation of the function of adjusting individual data in the proposed decision support system for initiating regional health and social development projects may vary depending on the specifics of the region's residents and the type of data about them.

The final step is the process of saving and outputting the results of the assessment of the components of the projects for the health and social development of the regions, which is implemented by the unit of saving and outputting results (Unit_8). At this stage, we already have an assessment of the components of health and social development of the regions $E(t)$, which was obtained after the data assessment and correction. Usually, the results of the project component assessment are saved in the form of a file or a database. To present these results, a text format (CSV file, JSON structure, or other format) is used, which is convenient for saving and further processing of data. This process is made possible by the function $Save\_results(E(t),\ File)$ of saving results, which can be written as:

$$Save\_results(E(t),\ File) \Rightarrow File\_\text{text}, \qquad (10)$$

where $Save\_results(E(t),\ File)$ – functions for saving results; $E(t)$ – evaluation of project components; $File\_\text{text}$ – a text file with saved results.

In the proposed decision support system for initiating projects of medical and social development of regions based on computational intelligence, it is also assumed that the results are displayed to the user in a dialog box. For this purpose, separate fields have been created to display a text description and a graph for visualizing the results of assessing the duration of medical and social services to the population. The text description contains information about both the entered characteristics of the region's residents P and information about the defined indicators of the project components $E(t)$. At the same time, the graph is used to visually display the evaluation indicators of the project components $E(t)$, as well as to compare them with the average values determined based on available data in the database. The graph is presented in the form of a bar chart of the distribution of project component indicators $E(t)$, which displays the predicted value and the average. This process is performed by the output function $Output\_results(E(t),\ Text,\ Graph)$, which is written as follows:

$$Output\_results(E(t),\ Text,\ Graph) \Rightarrow (Text\_E(t),\ Graph\_E(t)), \qquad (11)$$

where $Output\_results(E(t),\ Text,\ Graph)$ – function of outputting results; $Text\_E(t)$ – textual description of the results obtained, $Graph\_E(t)$ – a graph to display the results of the evaluation of project components $E(t)$.

Function (11) in the block of saving and outputting results (Unit_8) completes the cycle of the system's operation of the decision support system for initiating projects of medical and social development of regions based on computational intelligence to evaluate the components of projects, and the results are provided to project managers for further analysis and decision-making.

5. Results of the development of a decision support system user window with a tab for assessing the duration of diabetes treatment projects in children

Based on the described structure, a decision support system for initiating regional health and social development projects has been developed, which provides processes for evaluating the components of these projects. It is written in Python 3.11. Its user window is shown in Fig. 2.

Let's look at the example of forecasting the duration of projects related to the treatment of diabetes in children.

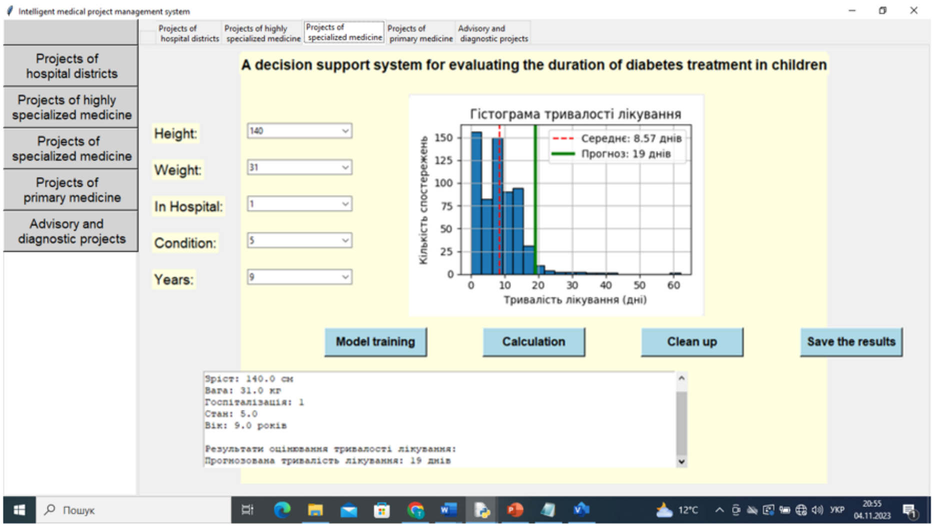


Figure 2: The user window of the decision support system with a tab for estimating the duration of diabetes treatment projects in children.

The proposed decision support system involves the use of a database formed from electronic medical records (EMR). In addition, it uses the neural network model of direct communication developed by us and published in [40]. The proposed neural network for predicting the duration of pediatric diabetes treatment projects is a deep network with two levels. The first layer is a dense type with 64 neurons and the ReLU activation function. The second level is of the dense type and has one neuron used to solve regression problems. The total number of model parameters is 385.

On the basis of the developed and tested for adequacy decision support system using data from electronic medical records (EMR) for the treatment of diabetes in children at the inpatient department of the Lviv hospital "Ohmatdyt" (Lviv, Ukraine), a quantitative assessment of the duration of projects for different indications of their disease was carried out.

Quantifying the duration of treatment projects for different disease characteristics, we modeled the patient intake. We assumed that children are admitted to inpatient treatment with a diagnosis of newly diagnosed diabetes mellitus, with average weight and height. Provided that the weight values of patients are accurate, they can be useful for health care providers. For example, healthcare providers can use patients' weight records to assess their risk of developing diabetes. Based on the study, the quantitative values of the projected duration of diabetes treatment projects in children were established depending on patient characteristics (Fig. 3).

The obtained dependencies of the duration of diabetes treatment projects in children on the characteristics of patients are described by the equations:

low weight

$$t_{дм} = 0.03 \cdot A^2 + 1.02 \cdot A + 7{,}88, \quad (12)$$

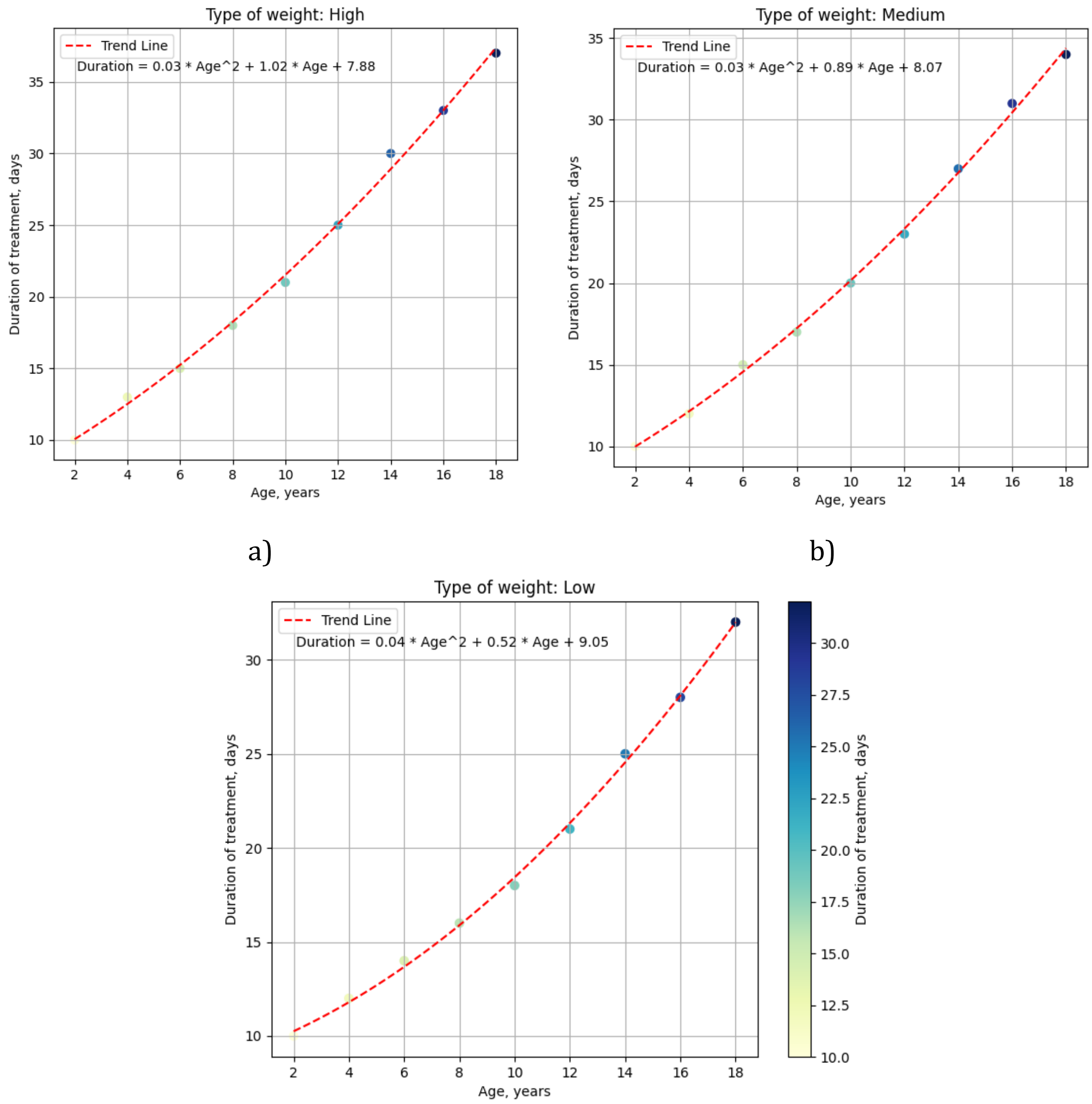
average weight

$$t_{dc} = 0.03 \cdot A^2 + 0.89 \cdot A + 8{,}07\,, \tag{13}$$

heavyweight

$$t_{dв} = 0.04 \cdot A^2 + 0.52 \cdot A + 9{,}05\,. \tag{14}$$

where t_d – projected duration of diabetes treatment projects in children, days; A – age of patients, years; W – weight of patients, kg.



c)

Figure 3: Dependence of the projected duration of diabetes treatment projects in children on the age of patients and low (a), medium (b), and high (c) weight.

The resulting dependencies (Fig. 3) are used by project managers to make decisions about the projected duration of diabetes treatment projects in children, depending on the age of the patients and their weight. It was found that the duration of diabetes treatment in children ranges from 8 to 37 days. It increases with increasing age and weight of patients.

The proposed decision support system for initiating medical and social development projects of regions based on computational intelligence has theoretical and practical value. On its basis, it is possible to create other functional blocks of the management decision support system, which will improve the quality and accuracy of management decisions on the evaluation of medical projects, taking into account the current state of the project environment. The results obtained are the basis for initiating projects of medical and social development of regions.

6. Conclusions

1. The developed algorithm and the substantiated structure of the decision support system for initiating medical and social development projects of regions based on computational intelligence methods include a database, a knowledge base, and 8 systematically interconnected blocks. It provides for the systematic formation of databases and knowledge from real data of electronic medical and social record systems, which are the basis for training computational intelligence models for planning components of medical and social projects.
2. The developed neural network model, which was trained on the data of the Lviv Regional Children's Clinical Hospital "Ohmatdyt" (Lviv, Ukraine), made it possible to quantify the duration of diabetes treatment projects in children under different conditions of disease progression. The identified trends in the duration of pediatric diabetes treatment projects depending on changes in the project environment are the basis for improving the quality and accuracy of decision support in assessing the duration of these projects.
3. The proposed decision support system for initiating medical and social development projects of regions based on computational intelligence has theoretical and practical value. On its basis, it is possible to create other functional blocks of the management decision support system, which will improve the quality and accuracy of management decisions on the evaluation of medical projects, given the current state of the project environment. The results obtained are the basis for initiating projects of medical and social development of regions.

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