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# Multi-Criterial Evaluation Bazed on Hierarchical Information Modeling of Innovation Projects in the Healthcare

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***Abstract— In this article the authors highlight the problems of modeling and hierarchy building specialized criteria used to evaluate innovative projects in the field of healthcare. Relevance of the development of effective and visual tools to ensure decision support for the selection of innovative projects by responsible persons with the absence of a formalization mechanism that is currently convenient for practical use and evaluation of various qualitative and quantitative parameters of projects. Within the multi-criteria evaluation of the proposed information model representation of the project hierarchy indicators that combine data in numerical and linguistic form, which allows to take into account the specifics of weak formalization of the subject area. The developed theoretical provisions of the software implemented within the framework of the research prototype of the decision support system «Project selection. Healthcare», the pilot operation of which testifies to their practicalutility.***

***Keywords: innovative project, healthcare sphere, hierarchical information model, multicriteria estimation, decision support system.***

## I. INTRODUCTION

The uncertainty in achieving the commercial success of the innovation project in the field of health care is quite high and the financial costs are quite high, so the distribution of budget funds depends primarily on the instrumental mechanism for assessing the prospects of projects and, most importantly, on their importance from the point of view of the health sector of the region. At the stage of scientific and economic expertise errors are a significant factor determining the economic efficiency of the implementation of innovative projects (IP) in the health sector.

The expansion of the range of tasks to be solved within the framework of health programs [1], along with the improvement of computer information technologies and the methodology of their use, actualizes research aimed at developing the theoretical foundations of the methodology and tools for the design, creation and maintenance of specialized systems to support management decision-making in the health sector. The methodology of using information computer technologies includes methods of formalized representation of subject areas, database and corporate data warehouse design technologies, communication technologies, intelligent technologies, etc.The expansion of the range of tasks to be solved within the framework of health programs [2], along with the improvement of computer information technologies and the methodology of their use, actualizes research aimed at developing the theoretical foundations of the methodology and tools for the design, creation and maintenance of specialized systems to support management decision-making in the health sector. The methodology of using information computer technologies includes methods of formalized representation of subject areas, database and corporate data warehouse design technologies, communication technologies, intelligent technologies, etc.

In the process of assessing the IP in the health sector, difficulties arise, mainly due to the lack of very important factors. First, there is currently no clearly structured hierarchy of specific criteria for the evaluation of projects in the field of health. Secondly, mechanisms for formalizing and evaluating qualitative and quantitative indicators have not been developed. Third, the tools that support the optimal decision-making on the project by the responsible persons are not effective and clear enough. Both the theoretical basis of expert evaluation and its existing practical implementation are undeveloped. Within the framework of the proposed approach, theoretical foundations have been developed, which have been brought to the level of practical implementation.

The use of modern information technologies for the assessment and selection of IP in the health care system necessitates the development of models and algorithms that take into account the specifics of the subject area [3,4]. Therefore, the task of multi-criteria assessment of IP in the health sector becomes important. The problem is the choice of projects that are cost-effective on the one hand, but socially significant on the other. It is the social significance of the project that determines the possibility of state co-financing it within the framework of socio-economic programs[2]. For this reason, the development and

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improvement of information tools used by experts in the evaluation of projects is currently an urgent and practically important task[6].

The aim of the study is to develop tools to support decision-making in multi-criteria expert evaluation of IP in the health sector.

In order to conduct the IP competition, objective characteristics (which are converted by special methods of evaluation into indicators measured in points) and generalized indicators (formed in accordance with expert judgments about the relative importance of specific indicators) should be considered. Software implementation of project evaluation methods in the form of procedures and algorithms provides for the availability of parameters that determine the amount of information that requires processing, the necessary costs for this processing and the form of presentation of results.

The need to register and account for a large number of indicators and to define the relationships between these indicators is very common in the information modelling of health care IP. Indicators of health-care projects are generally both quantitative and qualitative. This is the reason that in this area it is necessary to use modern expert technologies, which are based on the theory of decision-making and simulation [5]. In many works [3-8] it is proposed to use more complex information models, but these studies do not take into account the diversity and heterogeneity of the project information used in the creation of an information model of the project in the health sector. Heterogeneity of information is manifested in the presence of a large number of both qualitative and quantitative indicators.

Proposed information model ofIP:

Inf Mod=<Ind, w>,

where *Ind* is a formal indicator,

Ind = < Name, $Val^{abs}$, $Val^{verb}$, $Val^{rel}$, Scale(abs, verb), Scale(verb, rel ) >,

*Name* – name (identifier) of the indicator;

$Val^{abs}$– absolute numeric value (expressed in absolute units of measurement) of the indicator;

$Val^{verb}$ – verbal (expressed in terms of a subset of natural language) value of the indicator;

$Val^{rel}$ – relative numerical (expressed in points) value of the indicator;

*Scale (abs, verb)*– conversion scale for values from an absolute numerical scale verbal scale;

Scale (verb,rel) - the scale of the transfer values from the verbal scale of the relative point scale;

w-weight ratio.

The existence of three types of formal indicators in the model made it possible to convert their values depending on the method of obtaining and the purpose of using data to a unified type - a relative numerical indicator, which gave the expert to compare projects on a small number of indicators, using verbal data and obtain more reliable results.

Measurement of estimated indicators of IP was accompanied not only by the definition of absolute values ($Val^{abs}$), but also by expert evaluation ($Val^{verb}$) of these values in a verbal scale with the following semantic differentials: <*very low, low, below the average value of the indicator, the average, above the average, high, very high)*>. This approach reflects the importance of a specific absolute value of the indicator in the context of the project in accordance with the scale transition rule (abs, verb). However, the use of values of indicators in the overall hierarchy of evaluation requires the transition from verbal values to relative numerical values ($Val^{rel}$) using the rule (verb, rel) on a scale <1,...7>.

Due to the fact that the formal indicator includes scales of transition Scale (abs,verb), Scale (verb, rel) from absolute values of $Val^{abs}$ indicators*Ind*to verbal values $Val^{verb}$ and from verbal values to relative values $Val^{rel}$ it is proposed to apply hierarchical verbal-numerical information modeling of projects.

Figure 2 shows a hierarchical information conceptual model based on the views of each individual expert on the subject area in the form of a description of the indicators and the links between them necessary for decision-making.

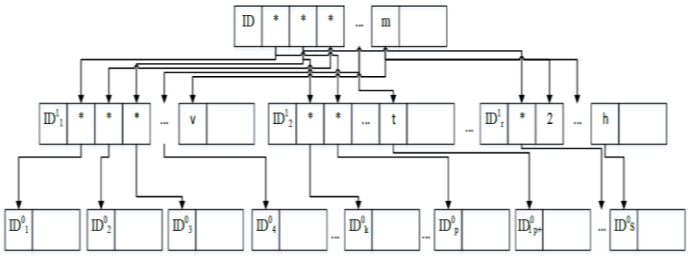

**Figure 2-Information hierarchical conceptual model of IP indicators in health care**

The scheme (figure 3) shows the result of building a hierarchical information model of indicators, where

$ID_i^0$– the indices of the zero level ($Ind_i^0$), where $i° \in [1;s]$, *s* is the number of indicator;

$ID_j^1$ – indicators of the first level ($Ind_j^1$), where $j \in [1;r]$,

*r* - the number of composite indicators; *v*, *t*,..., *h*-the number of attributes of the *j*-th composite indicator;

$ID_m$-integral exponent ($Ind^n$ ).

Each indicator ($Ind_k^n$), starting from the second level of the hierarchy, is represented as a linear convolution of the indicators of the previous level:

$$\mathrm{Ind^n} = \mathrm{w_1^{n-1}}\cdot\mathrm{Ind_1^{n-1}} + \mathrm{w_2^{n-1}}\cdot\mathrm{Ind_2^{n-1}} + \cdots + \mathrm{w_k^{n-1}}\cdot\mathrm{Ind_k^{n-1}},$$

where the weight coefficients $w_1^{n-1}$,$w_2^{n-1}$,…, $w_k^{n-1}$ reflect the relative importance of the lower level.

A hierarchy of measures is used to determine the relative values of measures.A hierarchy of measures is used to determine the relative values of measures.

The first level of the hierarchy is formed by indicators, the values of which are presented in the applications and expert assessments of the IP. The values of the indicators are quantitative or qualitative: for example,the number of specialists involved in the project or the level of scientific validity of scientific and innovative solutions used in the project. Therefore, it is advisable to convert these indicators into relative quantitative ones and to register their values

within one measuring point scale (from 0 to N points), which is based on expert opinions.

Integral assessment Crit is an overall assessment of IP indicators and can serve as a criterion for making management decisions when choosing an IP in the health sector of the region. The formation of project evaluation criteria and the choice of the evaluation method taking into account the features of the information model is shown in figure 3.

## RESULTS & DISCUSSIONS

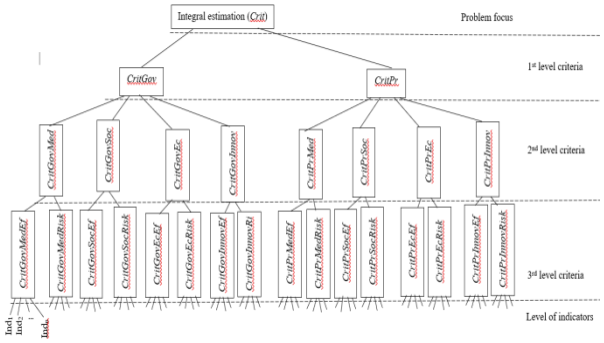


**Figure 3 – Hierarchical scheme for the evaluation of projects in the health sector**

The considered method of ordering, corresponding to the scheme of the analytic hierarchy process (AHP) [9] and shown in figure 3, is convenient to classify in relation to the participants of public-private partnership: public (Gov) or private (Pr), as well as the compliance of medical (Med), social (Soc), economic (Ec) and innovation (innovation) components of IP. The need to distinguish from the social component of the project medical and scientific-innovative aspects is consistent with the specifics of innovative projects in health care.

Another classification criterion is whether the project performance criterion (*Ef*) or the loss criterion corresponds to a possible (with some probability) improper implementation of the project (*Risk*).

The constructed system of indicators and criteria for assessing the IP in the health sector of the region was used in the development of the DSS«Project selection. Health» evaluation of IP. In the process of design and implementation of the information system, the proposed hierarchical scheme (figure 3) was used as a basis to support the work of the tender Commission on evaluation and selection of IP.

The software implementation is an executable file created in the C++ Builder environment that does not require installation. The database used in the system runs SQLite 3 (figure 4). By means of an algorithmic subsystem containing software modules that implement methods and algorithms for modifying estimates, data are generated from the entire set of indicators, based on utility functions are ranked, and then various alternatives for DM are formed.

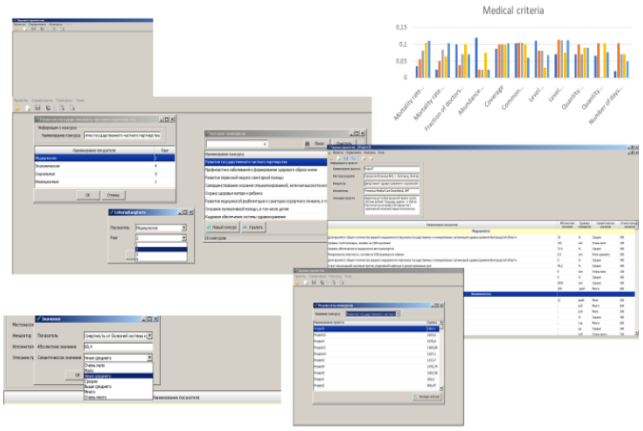


**Figure 4 – Screen forms for evaluation and selection of DSS «Project selection. Health»**

Thus, the justification of investment decisions in the field of health care is advisable using the presentation of information models of IP in the form of a hierarchy of indicators that combine numerical and linguistic data types. This makes it possible to take into account the peculiarities of a poorly formalized description of IP in the health sector.

Developed decision support tools, software implemented in the form of DSS «Project Selection. Health care» can reduce the costs associated with the examination and improve the scientific validity of management decisions.

In further studies related to the selection of the best innovative project from a large number of alternatives, it is planned to use evolutionary algorithms ([10, 11]) to avoid a complete enumeration of the variants, the expert evaluation of which by a large number of criteria is a very time-consuming task.

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