Mathematical and informational approaches to assessment and analysis of health-related quality of life

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Abstract[1]

The article deals with the mathematical and informational aspects of study of health-related quality of life as a complex system. The analysis hierarchy method, as it is shown, becomes the new instrument of the study complex and bad formalized object with a set interacting heterogeneous subjective and objective factor. Automated use of the analytic hierarchy process in the system analysis of HRQoL being an extremely complex object with lots of multidimensional, heterogeneous relationships allows authors to estimate the degree of influence of individual components of the object as a whole. This study highlights the importance of developing the automated system, which significantly facilitates the work of researchers on the collection and data processing in multicentre studies and automated use of analytic hierarchy process on the system analysis of HRQOL.

1. Introduction

Just as category of quality assessment and quality management recognized as a leading incentive industry, the category of quality of life (QoL) assessment and management is the basis for development and improvement of the social sphere, the tool for effective social and economic policy. This fact is confirmed by the experience of many countries. And in the Russian and foreign scientific literature, we have met the different approaches to the QoL assessment. The most relevant is the system approach that considers QoL as a holistic formation consisting of interacting subsystems with specific functions [1]. Thee assessment QoL only in objective terms of economic development, income and profits are not correct, since income is often mediated result, which actually can be not only economic but also social, socio-economic, socio-psychological, and so on [2].

It should be noted that health status is one of the most important structural elements of quality of life as a system and its deterioration which has negative social and psychological consequences. The physiological, spiritual and cultural relations between man and society, nature, the technosphere and the biosphere are reflected in the health. Health is such an indicator, which summarizes all the variety of QoL, so health-related quality of life (HRQoL) can be regarded as an integral characteristic of the physical, mental and social functioning of a person based on his subjective perception. At the same time, objective indices registered by instrumental methods are often more variable than subjective ones. The existence of subjective indicators of HRQoL requires assessment methods that can characterize these subjective indicators are quantitatively as precisely as possible.

Precision of HRQoL assessment and its value for comparative analysis increases if it is produced on a single methodological platform, at simultaneous multi-center survey of respondents in different territories. These studies allow getting information about the territorial and professional features of HRQoL and reducing the time of collecting the required amounts of information to obtain reliable results. The specificity multi-center study is caused by the geographical remoteness of research and the complexity of the organization of information exchange between them [3]. Due to the large quantities of data in studies of this kind, as well as to solve logistical problems and the organization of an effective informational exchange, the use of automated systems for the collection, processing, storage, analysis and presentation of data on the HRQoL of persons participating in the multi-center study is actual.

The study of HRQoL of persons sets two serious problems:

1) To collect information in different territories, reflecting the objective indices of functioning of all regional areas of life and subjective assessment of life satisfaction

2) Assessment and analyze HRQoL.

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The solution to this problem is not possible without the creation of mathematical and informational models of such complicated system.

Despite the fundamental importance of these problems for the implementation of quality of life management, they are studied insufficiently.

2. Results and discussion

Not numerous automated systems [4, 5] both in Russia and abroad are more focused on the managerial sector, they are not intended for application in the multicentre study of HRQoL that does not allow performing comparative analysis with other research.

2.1 Work accomplished

The basis of a methodological platform for multicentre studies was standardized questionnaire SF-36, developed in the United States and approved by World Health Organization, is one of the most widespread methods of assessment of HRQOL [6]. SF-36 allows us to characterize the respondent's HRQOL on two scales (physical and psychological), which is a generalization of eight private scales. Elements of the social components are included in the psychological scale. We used the Russian-language version of this questionnaire of Interethnic Research Center of QoL (St. Petersburg, 1998). HRQoL contains three main components: physical (satisfaction with their health), psychological (satisfaction with their psychological status) and social (satisfaction with the realization their actual social needs).

Analysis of the current approach to the organization of information support of HRQoL studies allowed making requirements for the information technology multicentre study of HRQoL. The automated system, which implements this technology, developed A.A. Blokhin (Melentiev Energy Systems Institute). The system being developed from the point of view of a client-server architecture of the automated system were found the database management systems PostgreSQL, Python programming language, Django framework and development environment PyCharm JatBrains. The development and design of the system allows organizing the process of remote information gathering both from respondents and researchers via the Internet.

2.1 Work in progress

Construction of the integral index of HRQoL refers to the problems of multi-criteria analysis of hierarchies, in which there are not only algorithmic, but also conceptual difficulties. To reflect in mathematical and information models of HRQoL is necessary to have knowledge about its structure, to be able to translate qualitative information about it in the quantitative information, as well as to assess the degree of influence of its components to the object as a whole.

Thus, the application of the concept of HRQoL terms "worse" and "better" leads to the task ordering and selection the relationship of domination on the set of states of the investigated object. The researcher must enter the scale of weight coefficients to determine the degree of formalization of the proposed approach to substantiate linkages between qualitative gradations and associated quantitative quality indicators.

One of the modern methods of research systems with a large number of interaction of subjective and objective factors of varying degrees of diversity and the importance of a hierarchy analysis method (HAM) T. Saaty [7]. The successful use T. Saaty hierarchy's analysis method (HAM) in medicine, sociology and the economy [8,9,10] has prompted us to use it as a tool for qualitative analysis and numerical ranking of criteria HRQoL, as the object of interaction with a large number of diverse factors of varying degrees of importance.

The first step in the application of the HAM is the decomposition and construction of hierarchical structural model system in which HRQoL indicators are distributed through the levels, the higher level elements are dependent on the downstream elements.

The second step is to construct a matrix of pairwise comparisons for each group of criteria, which are compared in pairs relative to their common components of a higher level of the hierarchy. Taking into account the human psychological limit, acting as an expert, it is considered acceptable simultaneous comparison of a maximum of 9 criteria and therefore nine-point scale is used for subjective pairwise comparisons. For the subjective pairwise comparisons, we used nine-point scale, that operated with such concepts of excellence as an equal, moderate, substantial, very strong, absolute and four intermediate, depending on the expert opinion. Detailed analysis of the problem scales and measurements are in [7, 11].

The third step is to obtain the weighting factors that are characteristic for every quantitative criterion HRQoL. It should be noted that there are a relationship of weighting coefficients in the matrix of pairwise comparisons, but the values of these coefficients are not known in advance and have to be determined by mathematical methods. The path from each criterion of hierarchy to the target hierarchy, uniquely defined, so that the degree of influence or "contribution" of each criterion in the components of the higher levels can be obtained by multiplying the weight criteria coefficients encountered along the way. This weighting coefficient is equal to the share of the private criterion changes, which aim of the hierarchy, will change.

The fourth step is to calculate the attitude consistency (AC) for the matrices of paired comparisons. It is measure the accuracy of the paired comparisons. AC is equal to zero in the ideal case completely agreed back symmetric matrix of pairwise comparisons. If AC, calculated simultaneously with the normalized priority vector (weight vector) exceeds 0.15, it is necessary to return to step 2 and revision of paired comparisons for groups of criteria in this matrix.

After the sequential execution these four steps, we can carry out a factor analysis of the studied system in accordance with the intended purpose of the study. This can be a hierarchy of indicators as the HRQoL of the object, the numerical expression of their mutual influence on each other at every level of the hierarchy and the ultimate goal.

We have used HRQoL scales indicators for the construction of its three-level hierarchical model, reflecting all the functional relationship between the elements, which are combined into groups and distributed between levels. The first level is the integral index of HRQoL - purpose of the study.

Computational part of the method is simple and can easily be algorithmic. The process of constructing the matrix of pairwise comparison of HRQoL indicators (basis for calculation procedures of analytic hierarchy process) requires informal participation of experts and can be automated only partially. For information support of analytic hierarchy process, the software in the environment of Delphi object-oriented programming (version Turbo Delphi Explorer), which is based on ObjectPascal language developed the bachelor D. Zhernov under the guidance I. Finogenko.

3. Conclusion

In this paper, the authors proposed mathematical and informational approaches to assessment and analysis of health-related quality of life. The authors have substantiated development the automated system, which significantly facilitates the work of researchers on the collection and data processing in multicentre study. Automated system is used to measure HRQoL of respondents, taking into account the socio-economic characteristics of the different territories; it allows researchers to reduce the time to the collection of information for HRQoL assessment. It becomes possible to the competent organization of business processes of multi-center study. Analytic hierarchy process is used for numerical comparison of the criteria studied object, for comparison of alternatives and selects the best solution from a set of possible or proposed. In the future, the authors see the continuation their work in solving the following tasks:

1) Development of a technique of constructing a system of generalized indicators of HRQoL assessment with integration mathematical and intellectual approaches.

2) Development of methodologies for measuring, evaluation and optimization of HRQoL

3) Design, implementation and testing of a prototype multi-agent intelligent systems for the integrated assessment QoL

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References

1. Rukavishnikov V. (Ed), Health related quality of life: assessment and management, Irkutsk: NC PBX, 2012, 168p.
2. Gundarov I.A. Quality of life as the main criterion for evaluating the effectiveness of public administration/ The quality of life of the Russians: implementation of national projects through the interaction of science, government, business and society// Proceedings of All-Russian scientific-practical conference. Moscow, 2008, p. 45.
3. Novik A.A., Ionova T.I. Guide to the study of quality of life in medicine. 2nd ed., Moscow: Olma Media Grupp, 2007, 320 p.
4. Wright E.P., Selby P.J., Crawford M. Feasibility and compliance of automated measurement of quality of life in oncology practice, Journal of clinical oncology, 2003, vol 2, pp. 374-382.
5. Shtevnina Y.I., Shvyrev S.L., Zarubina T.V., Shirokorad I.V, Dolgih D.V. Development and implementation of an automated evaluation of the quality of life of cancer //Medical Technology. Evaluation and selection, 2012, vol. 2, pp. 106-113.
6. Ware J.E., Sherbour C.D. The MOS 36-item short form health survey: conceptual framework and item selection. Medical Care, 1992. Vol. 30. pp. 473-483.
7. Saaty T.L. Making decisions with dependencies and feedbacks. Analytic network. M .: URSS, 2001. 357 p.
8. Kagan E.S. Integrated assessment model of social capital of entrepreneurs in the region // Vector Science TSU, 2012, vol 4 (22), pp.55-58.
9. Stepin V.V. Forecast of scenarios for the development of political processes of hierarchy analysis method // Bulletin of Voronezh State University. Series: Linguistics and Intercultural Communication. 2010. available at: http://cyberleninka.ru/article/n/prognozirovanie-stsenariev-razvitiya-politicheskih-protsessov-metodom-analiza-ierarhiy (accessed 09.12.2015).
10. Zilina N.M. The method of analysis of hierarchies in order to prove the effectiveness of solutions in medical research // Informatics and control systems, Blagoveshchensk, 2008. vol 2 (16) available at: http://ics.khstu.ru/media/2010/N16_06.pdf (accessed: 12.09.2015).
11. Shikin E..V., Chkhartishvili A.G. Mathematical methods in management. M .: KDU, 2009, 440 p.