Analysis of RF Healthcare System Development
Based on Fuzzy Public Opinion Modelling

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Abstract. This article deals with the assessment of the situation in the Russian Federation healthcare. To solve the problem, a fuzzy model has been built, which maps fuzzy data of the public opinion polls conducted by Russian Public Opinion Research Centre (VCIOM) into the clear number, expressing the immense assessment of the poll result. Modelling revealed a very negative trend in the research area; the trend has been developing since 2014. The main reasons of the current situation are a dramatic reduction of medical institutions, erroneous legal regulation and personnel policy. The methodology and vision statement of the major mechanisms have been proposed, which are helpful in solving the problems in the field of the Russian Federation healthcare.

Introduction

One of the urgent issues of Russia in the field of healthcare is to shape an adequate policy aimed at providing the quality and availability of medical services. There are quite a few studies in this area, which are devoted to the assessment of the given indices. Statutes and regulations are also available [1-4]. Techniques described in the studies and documents rely on some system of criteria, which are used for assessing medical service quality and availability. Such approach is sure to be helpful in identifying the problems in the system. Nevertheless, the synthesis of integral estimation based on this approach does not always give proper results. The explanation of the fact is that when ranking the criteria system, it is rather problematic to define the criteria weight coefficients. The matter is that different people in various life situations and in various moods give different estimations of indicator and condition importance. The problem is solved by sociological survey of public opinion when the respondents have to give the general assessment of the healthcare system. Estimating this system common people think of the quality and availability of medical services or, in terms of system analysis, system output. Russian Public Opinion Research Center (VCIOM) and other similar research institutions conduct such polls regularly. In view of this, there is an urgent problem of developing the model of the public opinion interpretation based on sociological data. It is also important to analyze and explain the dynamics of ongoing changes in the healthcare system of the Russian Federation.

Methodology

Methodology of the ongoing research relies on the theory of fuzzy logic and fuzzy sets; this being explained by the character of the data analyzed. In this paper poll results (see Table 1) [5, 6] are represented in the form of fuzzy sets where each linguistic variable corresponds to the percentage of the voters.

According to Andrzej Piegat’s study [7], there are two kinds of uncertainties: stochastic and lexical. It could seem that the poll results must be associated with the first kind of uncertainties. But in practice the stochastic uncertainties can not be accepted for the assessment of the fact that the quality of medical service in Russia is completely satisfactory with the probability of 15% (as an example). They rather demonstrate the fuzziness in the evaluation of this or that indicator by society as a whole.
Table 1. The results of public survey about medical services quality conducted by VCIOM.

| Date           | Completely unsatisfactory | Rather unsatisfactory | Neither agree or disagree | Rather satisfactory | Completely satisfactory |
|----------------|----------------------------|-----------------------|---------------------------|--------------------|------------------------|
| 28.06.2005     | 33.56%                     | 43.04%                | 2.07%                     | 17.94%             | 3.39%                  |
| 21.09.2005     | 35.75%                     | 36.56%                | 2.19%                     | 20.38%             | 5.13%                  |
| 30.08.2006     | 24%                        | 43%                   | 4%                        | 25%                | 4%                     |
| 11.03.2007     | 39%                        | 35%                   | 5%                        | 18%                | 4%                     |
| 07.07.2007     | 34%                        | 35%                   | 6%                        | 23%                | 2%                     |
| 21.12.2008     | 53%                        | 2%                    | 40%                       | 5%                 |                        |
| 20.09.2009     | 27%                        | 33%                   | 7%                        | 28%                | 4%                     |
| 30.04.2011     | 52%                        | 5%                    | 35%                       | 8%                 |                        |
| 26.01.2012     | 46%                        | 7%                    | 36%                       | 11%                |                        |
| 17.03.2013     | 55%                        | 1%                    | 57%                       | 6%                 |                        |
| 22.02.2017     | 47%                        | 3%                    | 44%                       | 7%                 |                        |
| 28.01.2018     | 37%                        | 23%                   | 7%                        | 17%                | 15%                    |

The method of comparison of fuzzy numbers suggested by V.I. Ukhobotov and E.S. Mikhailov in the paper “Comparison of fuzzy numbers in decision-making problems” [8] was applied for mapping fuzzy survey data in the clear numbers and for creating an appropriate time series. For the comparison of fuzzy numbers, each of them is sorted by \( \alpha \)-levels, and then the task of comparing the segments at each level is done by the following criteria:

\[
(1 - \nu) \cdot g(\alpha) + \nu \cdot G(\alpha) \rightarrow \max, \quad \nu \in [0, 1],
\]

(1)

where \( g(\alpha) \) - left border of a fuzzy number at the selected \( \alpha \)-level; \( G(\alpha) \) – right border of a fuzzy number at the selected \( \alpha \)-level; \( \nu \) – event probability \( G(\alpha) \).

In terms of games theory the expression in (1) corresponds to the expected gain (progress) \( c_\alpha \). So, when comparing two alternatives one selects the greater \( c_\alpha \). To assess the total win it is necessary to carry out the summation at all \( \alpha \)-levels. The total number mapping of some fuzzy number \( A \) is expressed by the following formula:

\[
c(A, \nu) = \int c(\alpha) d\alpha = \int \left[ (1 - \nu) \cdot g(\alpha) + \nu \cdot G(\alpha) \right] d\alpha
\]

(2)

However, the mapping (2) cannot be directly applied to the data in Table 1, as it is impossible to outline left and right borders in the original fuzzy sets. For building the borders of the sets on some ground set \( U = \mathbb{R} \); [0,1] one carries out their approximation at the nodal points corresponding to the respondents’ answers. In this research the approximation was carried out by cubic spline provided that the first derivative in the two neighboring points is equal to zero.

**Results**

Analysis of each survey result from Table 1 led to the building of the corresponding displays, which are marked by triangles in figure1. Additionally, there was carried out the approximation of the received results by cubic polynomial (continuous line).

On \( OY \) axis in figure 1 there are mappings of \( c \) of fuzzy numbers characterizing the public opinion at the time of conducting a sociological survey; the corresponding dates are given on \( OX \) axis. The mappings are dimensionless values and, in accordance with (2), characterize the integral interaction with a fuzzy number.

The results received are in good agreement with the course of events in the area of health service and in the country as a whole. After the breakup of the USSR, the National Health Service System was being destroyed slowly and gradually. The number of doctors and hospitals was decreasing;
buildings, equipment and transport were getting out of order. According to the available statistics, in the period of 2000–2010, the number of medical organizations reduced from 10.7 up to 6.3 thousands [9]; the reduction continues until now, but not at such high rate. This tendency is well traced on the diagram,—the negative trend in the period of 2005-2007 is clearly visible.

In order to remedy the situation the national project “Zdorovie (Health)” was launched in 2008; it was being realized until 2014. In accordance with the project, 5834 doctors and more than 150 thousand medical workers received training and retraining, obtained additional payments for a total of more than 6,6 bn. Rubles. 3267 units of diagnostic equipment were delivered to the regions. By the end of 2009, the average lifetime had increased up to 69 years. Our diagram shows, that the trend at this period was steady and positive, but it began to slow down by 2014.

In 2012, in order to optimize the budgetary costs there were developed and adopted the standards of first health care provision. According to these standards, a doctor is entitled to assign a medical examination and therapy to the fixed percent of the citizens who applied. For example, in accordance with the standards of “The first healthcare for coxarthrosis, rheumatoid arthritis, gout with the defeat of the hip joint, osteonecrosis, cysts of the femoral head” only 15% of patients can have free study of the level of total calcium in the blood and study of the level of inorganic phosphorus in the blood. 10% of patients can have ultrasound examination of soft tissues. 50% of patients can have ultrasound examination of the joint. 1% of patients can have electro-diagnosis and MRI (magnetic resonance imaging) of joints [10]. This policy is sure to have caused discontent of the population; it can be seen on our diagram,—from 2012 the positive trend began weakening.

In 2014 quite a lot of important events occurred, one of which was the transition to ruble free float, that resulted in the sharp reduction of the population real income. Before 2014 the selectivity in prescribing medical procedures could be balanced by paid medicine, and after 2014 most of the people lost such possibility because of the lack of money. Ominous economic situation affected the medical personnel who was no longer interested in the due performance of their responsibilities. S.N.Cherkasov and A.Yu. Kostikov presented the results of their research in the article saying that only 7% of the staff are satisfied with their work by 80-90%, 39% of the staff—by 60-70%, 26% of the staff—by 50% [11]. Such state of affairs couldn’t help but influence on the public opinion, which went down dramatically.

**Conclusion**

Thus, there are apparently serious problems in the system of healthcare and they are of a system
character. It is impossible to solve these problems by just the increase of funding or minor changes of regulation rules, which are more like an imitation of the positive activity in the field. Such measures could only temporary improve the situation but are not able to alter the current negative trend. In order to change the situation and shape the proper social policy we consider it necessary to realize the system approach to the solution of the conceivable problems. This approach provides a detailed study of the reasons of the problems arising, consideration of interests of all the parties concerned, the development of the plan for putting the system in the target state.

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