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Research Article

**MONITORING OF REGIONAL HEALTH CARE SYSTEMS
EFFICIENCY: METHODOLOGICAL FOUNDATIONS AND
EMPIRICAL RESULTS****TatyanaN.Russkikh^{1*}, ViktoriyaI.Tinyakova², Elena N.Kamyshanchenko²,
Svetlana G.Gorelik², Laura L.Avidzba²**¹Orel State University named after I.S. Turgenev (Komsomolskaya street 95, 302026 Orel, Russia), e-mail: trusskih@rambler.ru²Belgorod State University, Pobedy street 85, 208000 Belgorod, Russia**Abstract:**

Effective management of the health care system involves comparative analysis of the efficiency of its subsystems at various levels of its regional subsystems. In this paper, the authors propose their own original methodology for typology building upon various efficiency components using fuzzy clustering procedures.

Efficiency analysis of regional health care subsystems is based on the three-dimensional approach: structure - process of health care delivery - outcome of the health care delivery. The method includes selection of a system of statistical efficiency indicators, preliminary graphic analysis of sample data using the principal component method, building of typological groups of regions in terms of efficiency level based on fuzzy clustering procedures and development of an efficiency map.

The most important task for the national health care policy is to reduce the death rate of the population from cardiovascular diseases. On this account, the article pays special attention to the problem of analyzing the efficiency of health care subsystems from the perspective of circulatory diseases. We have constructed typologies and ratings of constituent units in the Central Federal District and analyzed the efficiency of regional health care systems by the structure – outcome synthetic categories. This method is primarily intended for state and municipal authorities, since the results obtained from its use should serve as guidelines for the development of a policy aimed at improving health care efficiency.

Key words: *Monitoring, health care system, efficiency, typology, rating*

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INTRODUCTION:

The priority task of any government is to provide the population with affordable and high-quality medical care. In the current conditions of the Russian health care system development, significant disproportions remain in the levels of financial and resource provision of regional health care subsystems. This causes a high territorial differentiation in the levels of regional health care systems functioning effectiveness, and as a consequence, the need for a comparative analysis of their activities efficiency.

Various systems of criteria and methodologies for assessing the efficiency of health care subsystems functioning are presented in the works of Russian specialists in the field of health economics (Andreeva, Belova, 2010; Batievskaya, 2010; Glinsky, Tretyakova, Skripkina, 2012; Kakorina, 2011; Korablev, 2015; Kudelina, Eremina, 2016; Starodubov, Son, Leonov, Sterlikov, 2010; Stepanov, Golovschinsky, 2011; Tikhomirova, 2012; Ulumbekova, 2010; Karyakin, Kochubey, Mukhin, 2013). The authors suggest to perform a comparative analysis of health care systems efficiency on the basis of ranking regions using scores, calculating efficiency indicators or constructing efficiency based typologies of regions. Typologization is carried out, as a rule, using the apparatus of cluster analysis, quartile analysis, methods of discriminant analysis or factor analysis (Glinsky, Tretyakova, Skripkina, 2012; Starodubov, Son, Leonov, Sterlikov, Gazheva, Shebaev, 2013; Tikhomirova, 2012). And it should be noted that cluster analysis is used most often in empirical studies. As practice shows, the cluster analysis procedures give optimal results, in terms of comprehensive interpretation of designed groups, only in case of high homogeneity of sample surveys (Tikhomirova, 2012; Russkikh, Sirotkina, Tinyakova, 2015). Otherwise, it is not always possible to obtain the required grouping of objects.

METHODS:

The authors of this paper developed a formalized methodology for constructing typologies of regional health care subsystems (Russkikh, Tinyakova, Stroev, 2017) using fuzzy clustering procedures. The methodology assumes a multi-criteria evaluation of efficiency in the context of three synthetic efficiency categories: "health care system resources", "health care delivery process", "outcome of the health care delivery". Thus, in the framework of developing the methodology for monitoring the efficiency of healthcare subsystems described in the paper (Russkikh, Sirotkina, Tinyakova, 2015), it was suggested to analyze the overall efficiency in terms of

three components: resource efficiency, health care delivery efficiency and medico-social efficiency.

The developed formalized methodology suggests implementation of the following stages:

- formation of a hierarchical structure of partial effectiveness criteria;
- primary data processing, including standardization and unification of source data (Paklin, Oreshkov, 2010);
- preliminary graphical analysis of performance indicators using the principal component method (Ayvazyan, 1989);
- construction of fuzzy divisions of subjects into typological groups on the basis of fuzzy *k*-means method (Gan, Ma, Wu, 2007; Theodoridis, Koutroumbas, 2009; Everitt, Landau, Leese, Stahl, 2011);
- selecting optimal partition, including calculation of the Hie-Bani index (Xie, Beni, 1991);
- constructing ratings and efficiency chart of regional subsystems in the context of synthetic efficiency categories.

RESULTS AND DISCUSSION:

At present, one of the key objectives of the state health policy is to reduce the death rate from cardiovascular diseases. High mortality from cardiovascular diseases determines Russia's lagging behind other countries in terms of life expectancy.

As shown by empirical results of the research conducted by the authors, subjects of the Russian Federation can take the leading positions by level of medical and social efficiency in terms of a set of particular criteria for morbidity and mortality, but at the same time have extremely high rates of mortality from diseases of blood circulatory system (Russkikh, Tinyakova, Stroev, 2017). For that reason, this article pays special attention to the problem of analyzing the effectiveness of health care subsystems in the context of diseases of blood circulatory system.

Here are the results of verification in the context of circulatory system diseases by the example of federal subjects of the Central Federal District (hereinafter referred to as CFD).

21 federal subjects were considered as objects of clustering: 17 subjects of the Central Federal District, a subject with average performance indicators in the Russian Federation, a "reference federal subject" with average values for the CFD, "leader federal subject", and "outsider federal subject". "Leader federal subject" and "outsider federal subject" are

determined by the best and the worst in the sample values of indicators.

We will analyze the of subsystems efficiency level in the context of synthetic categories "resources-result". In the system of synthetic categories "resources - result", resource provision is the input parameter, and the result or medico-social efficiency is the output. The results of providing medical services to the population of the region is determined not only by the current resource security of the system, but also by its long term condition. In this connection, we will analyze the dynamics of resource availability in regional health care systems of the Central Federal District and compare obtained results with the "current" level of medical and social efficiency in terms of blood circulatory system diseases. The information base for the analysis of resource security was a sample of observations of statistical indicators for 2010-2015, analysis of medico-social efficiency – for 2015.

For the category "resources", the following particular effectiveness criteria were considered: provision of cardiac profile beds; provision with beds of cardiosurgical profile; the provision of beds for vascular surgery per 10,000 population; the availability of cardiologists (the entire population) per 10,000 population; provision of the population with doctors (cardiovascular surgeons) per 10,000 population. Partial criteria of the synthetic category "result" are: the incidence of blood circulatory system diseases (diagnosed for the first time in life) per 100 thousand of the total population; mortality of the

population from blood circulatory system diseases per 100 thousand population; mortality of the population from blood circulatory system diseases per 100 thousand population in 2015 in percents compared to 2014.

For each group of criteria, a preliminary graphical analysis of sample data in the feature space was performed using the principal component method, fuzzy clustering of objects into 2, 3, 4, 5, 6 clusters was carried out, an analysis of the values of the fuzzy clustering functional and the values of the Xie-Beni index was performed. As a result of the multistage analysis of fuzzy clusters optimality, an optimal number of clusters equal to 3 was determined for each group of criteria.

The obtained centroids of clusters of optimal fuzzy partitions allowed us to put clusters qualitywise and specify fuzzy clusters using a linguistic scale:

cluster 1 – federal subjects with resource security above the average level (with the level of medico-social efficiency higher than average);

cluster 2 – federal subjects with average level of resource security (with average level of medico-social efficiency);

cluster 3 – federal subjects with low level of resource security (with low level of medico-social efficiency).

Optimal fuzzy partitions by groups of resource provision indicators, medico-social efficiency allowed to build ratings of the CFD subjects (Table 1).

Table 1. Ratings of health care subsystems of the CFD subjects

Clustering Object	Rating					
	2010	2011	2012	2013	2014	2015
Belgorod Region	7	6	6	5	6	8
Bryansk Region	9	10	11	8	10	9
Vladimir Region	12	14	13	12	12	11
Voronezh Region	3	1	1	1	2	1
Ivanovo Region	5	3	4	4	4	5
Kaluga Region	8	10	8	7	12	10
Kostroma Region	11	13	13	11	13	12
Kursk Region	7	12	9	6	7	4
Lipetsk Region	7	9	10	9	10	9
Moscow Region	14	16	14	13	14	14
Orel Region	8	11	12	6	9	6
Ryazan Region	1	4	3	3	3	3
Smolensk Region	10	8	11	11	11	7
Tambov Region	15	17	16	14	16	15
Tver Region	4	5	5	8	5	4
Tula Region	13	15	15	14	15	13
Yaroslavl Region	2	2	2	2	1	2
Reference CU	6	7	7	6	8	8
Maximum rating	15	17	16	14	16	15

The obtained ratings for each region of the CFD determine the trend in the resource security of health care systems in the context of blood circulatory system diseases. According to the data in Table 2, conclude that during years 2010-2015 Voronezh, Ryazan, Yaroslavl Regions, occupy leading positions and belong to the group of "leader federal subjects" in terms of the health care systems resource security level. In 2011, Ryazan Region lost its position, taking 4th place, mostly due to the decrease in the number of doctors (cardiovascular surgeons) per 10,000 population. The value of this indicator in 2011 was 0.09, with the values of 0.17 and 0.16 in 2010 and 2012 respectively. The third place in the rank of regions in 2011 was occupied by Ivanovo region.

The last position in the list of regions in terms of the level of the regional health care systems functioning efficiency in 2010-2015 is occupied by Moscow, Tambov, Tula Regions. It should be noted that Tambov Region had the worst rating for six years. Which is determined by the low values of all the partial criteria for the resource security group. Analysis of the ratings of other regions is advisable to be carried out in comparison with the ratings of the "reference federal subject". So, for example, Belgorod, Ivanovo, Tver Regions in terms of resource security level are ranked higher than the "reference federal subject". On the contrary, Bryansk, Vladimir, Kaluga, Kostroma, Lipetsk, Smolensk Regions occupy positions below the positions of the "reference federal subject". Ambiguous positions are occupied by Kursk and Orel Regions. In particular, the increase in the level of resource security for Orel Region by 2015 is determined by the increase in the number of cardiologists per population.

According to the data in Table 1 Lipetsk, Moscow and Tambov Regions occupy leading positions by the level of medico-social efficiency. In these regions in 2015, with low values of morbidity and mortality,

there was a decrease in the death rate from diseases of the blood circulatory system compared to 2014. The outsider regions include Tver (rating 16), Orel (rating 15), Voronezh and Belgorod Regions (rating 14). Orel Region has the highest mortality rate from blood circulatory system diseases – the highest level in the Central Federal District (949.7 per 100,000 population, with an average of 635.3 in the Russian Federation and 664.8 in the CFD, respectively). High mortality rate is typical for Tver Region (939.5 per 100,000 population). Voronezh Region has the highest rate of blood circulatory system diseases incidence in the Central Federal District (making 5201.5 per 100,000 population, with an average of 3119.6 in the Russian Federation, and 2593.7 in the CFD). The highest rate of increase in mortality from blood circulatory diseases was observed in Belgorod Region in 2015 compared to 2014 (105.2%).

A comprehensive analysis of health care subsystems efficiency for the two groups of partial efficiency criteria will be carried out according to the data for year 2015 in the context of the following typological groups:

- 1) Typological group 1 – leading regions with rating positions 1, 2, 3.
- 2) Typological group 2 – regions, not included in the group of leading ones, with positions in the rating not lower than of the "reference federal subject";
- 3) Typological group 3 – regions, not included in the group outsider regions, with position in the rating lower than of the "reference federal subject";
- 4) Typological group 4 – outsider regions, occupying the last three positions in the rating.

The designed map of the CFD regional health care subsystems efficiency in "resources-result" framework is given in Table 4. The corresponding ratings of the CFD federal subjects are given in brackets.

Table 2: Chart of the CFD subjects regional health care subsystems efficiency in the system of "resources-result"

Structure, the typological groups	Outcome of health care delivery, the typological groups			
	1 (rating 1-3)	2 (rating 4-10)	3 (rating 11-13)	4 (rating 14-16)
1 (rating 1-3)		Yaroslavl Region (2;5)	Ryazan Region (3;13)	Voronezh Region (1;14)
2 (rating 4-8)		Ivanovo Region (5;4) Kursk Region (4;6) Smolensk Region (7;8)		Belgorod Region(8;14) Orel Region (6;15) Tver Region (4;16)
3 (rating 9-12)	Lipetsk Region (9;1)	Vladimir Region (11,7) Kaluga Region (10;9)	Kostroma Region(12,11)	
4 (rating 13-15)	Moscow Region (14;2) Tambov Region (15;3)		Bryansk Region(9;12) Tula Region (13;11)	

According to the data in Table 2, we conclude that for Belgorod, Voronezh, Orel, Ryazan, and Tver Regions, in conditions of medium level of resource security, in conditions of blood circulatory system diseases, extremely low indicators of systems effectiveness are typical. That indicates low efficiency of resource use. And, on the contrary, such regions as Lipetsk, Moscow, Tambov with a low level of resource security, have sufficiently high levels of medico-social efficiency in the context of blood circulatory system diseases. For other regions, there is some correlation between the level of resource security and the level of medical and social efficiency of health care systems.

CONCLUSION:

In the paper, great attention is paid to the problem of analyzing the efficiency of health care subsystems in the context of blood circulatory system diseases. As a result of the study, typologies and ratings of the Central Federal District regions according to various partial efficiency criteria were constructed for a set of sample observations of statistical indicators for 2010-2015 in the context of blood circulatory system diseases. A comparative analysis of regional subsystems functioning effectiveness was conducted, as a result leading regions and outsider regions were identified. The obtained empirical results of efficiency monitoring justify the possibility of using the developed methodology for constructing ratings and typologies in practice.

These results allow making only preliminary conclusions regarding the overall efficiency of health care subsystems. For a more comprehensive analysis,

firstly, monitoring is required in the context of three synthetic "resource-result-process" categories for individual classes of diseases of the blood circulatory system; secondly, it is necessary to analyze the external risks of morbidity, which are not directly related to the management mechanisms of health care systems in regions.

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