

Grouping of the Turkistan Area Regions based on a Complex Evaluation of Demographic Processes, Indices of Health, Medication Provision, and Social-economic Development of the Territory

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Abstract

The research objective was to elaborate methodological approaches to group the Turkistan regions through a complex evaluation of their demographic situation, public health, healthcare system, and social-economic development. The regions were grouped by normalizing a set of indices with various dimensions and vectors. The indices used were budget expenses per capita, unemployment rate, birth rate, death rate, income per capita, availability of pharmacies, provision with medical and pharmaceutical personnel, etc. During the studied period, the Turkistan area regions showed varied normalized values. The differences amounted to 1.2 times by normalized values and up to 2.4 times by complex values, which is due to the various development levels, multi-faceted character and complex spatial hierarchy of the Turkistan area regions. The research showed the normalizing method to be very effective for the regional and municipal statistical service as they have consolidated medical-statistical tables for the whole area and individual regions.

Key-words: Region, Typologization, Normalization, Ranking, Profile.

1. Introduction

Many social-hygienic tasks require classifying various settlements and administrative regions into separate groups and identifying their ranking. This is necessary when estimating the performance of healthcare service, the provision with healthcare resources, and when selecting a representative

settlement and performing a medical zoning. The methods of classification for a multi-dimensional grouping of various territories are well-known (Boyer & Savageau, 1989; Enright, 2000; Heidenreich, n.d.; Hertog, 2001; Lavrik, 2002; Shigane, 1968). This approach shows the degree of certain indices' deviation from the average, normative, and given and allows distinguishing the best, intermediate and worst objects. Sometimes, it is necessary to take into account several indices simultaneously and perform the so-called multi-factor grouping of administrative territories. After determining the set of factors for the multi-factor grouping, it is necessary to choose a mathematical method for simultaneous account of the selected factors. Formal classification methods are often used for the multi-factor grouping of various territories. Some authors use the cluster analysis to classify a country's regions by multiple multi-factor indices (Dohse & Staehler, 2008; Eickelpasch 2008; Eickelpasch et al., 2002). The obtained data allow substantiating the prospective planning of capital investment and resources allocation in the studied territory.

With the software using the algorithms of automated classification, we arranged 34 rural regions of Kazakhstan Republic into 10 groups (Koschatzky, 2000, 2005). Based on the method of correlation between the indices of health and healthcare, an integral indicator was developed, which allowed making a comparative analysis of the regions, ranking the administrative territories, and detecting disproportions in the development of the regional healthcare systems (Liu Ben-Chieh, 1975; Territorial differentiation..., n.d.; State of the Regions Report, 2020). Multilevel classification methods were used to rank regions by the incidence of socially significant pathologies, in particular tuberculosis, oncological diseases and myocardial infarction. As a result, several levels of administrative regions by disease incidence were allocated (Hensher & Rose, 1999; Thomas, 1990; Zimmerbauer, 2011). The Russian researchers elaborated a multilevel classification method based on estimating the Euclidean distance for typization of the rural regions of Western Siberia in terms of public health indices. It allowed grouping the regions of each area and identifying the regions for in-depth medical-social examination, which is necessary for reforming the healthcare system (Bobadilla et al., 1999; Delcheva et al., 1997). There are multilevel grouping methods which do not require software for data processing. Among them are the methods of normalized indices and distance estimation. When using the normalization method, all relevant indices are impersonified and transformed. The normalized indices applied are average indices of public health and healthcare of the studied area, which are used to divide the empirical indices of the region. Thus, normalized values (NV) are obtained. Summing up of the normalized values for each administrative region yields the complex indices, which become the basis for the regions' classification (Ensor, 1977; Ensor &

Rittman, 1997; Ensor & Savelieva, 1998). Applying the method of the Euclidean distance estimation yielded the same results. The normalized values are the best values for each indicator. In compliance with the formula for estimating the Euclidean distance, the distances and square distance were calculated. The obtained values were summed up and extracted from the square root. The obtained results allowed grouping the regions by provision with medical resources. The proposed methods allowed distributing the studied regions into 3 groups by provision with healthcare resources. To estimate the differences reliability, t-test was applied, while the homogeneity of the obtained groups was provided with variation coefficient. At present, social-economic, medical-demographic and other classifications are elaborated. For their statistical processing and analysis, software is developed, which can also be used for social-hygienic research. For example, some researchers propose a classification for country regions, estimating their social-economic development with multi-dimensional indices (European Bank..., 1997, 1998; European Expertise..., 1998; Falkenham, 1999; Government of the Republic..., 1998). For social-hygienic research, as well as for solving the practical tasks of healthcare organization and management, it is expedient to elaborate a complex evaluation of “non-medical” situation in tehregion, which requires simultaneous accounting of several aggregated blocks of parameters. The multifactor grouping of the external factors allows distributing the regions into a certain number of classes.

The multifactor evaluation of regions may be improved by introducing a “weight” for each factor. At that, experts may calculate the weight of each type of healthcare resources with the method of expert estimations. The reliability of differences of the obtained groups can be estimated with t-test, and the homogeneity of the selected groups – with varioation coefficient (Committee of Health..., n.d.; Vyalkov et al., 2009). Finally, it should be noted that simple mathematical methods of multifactor groupings to a large extent depend on the correct selection of factors, estimation of the vector of their action, and cause-and-effect interaction. At the same time, selecting a large number of factors included into the multifactor evaluation for electronic processing does not yield objective results. That is why, to obtain reliable results it is necessary to combine social-hygienic grouping with preliminary qualitative analysis of the studied phenomenon.

The research objective was to elaborate methodological approaches to group the Turkistan regions through a complex evaluation of their demographic situation, public health, healthcare system, and social-economic development of the regions.

2. Materials and Methods

The groupings of regions by certain social-hygienic indices, described in the scientific literature, do not allow objective evaluation of the public health and socio-economical development of a region. As differences between regions in the studied area are numerous, we use not a single indicator, but a set of indices for analysis, which allowed simultaneous accounting for the most significant elements of a statistical ensemble. The informational basis of the research was the data of Medical-statistical Center of the Healthcare Department of the Turkistan area. To estimate the results of multifactor grouping we applied the methods of normalized indices and evaluation of distances.

The complex evaluation of the socio-economical conditions and health of the population, as well as the resource provision of healthcare institutions, determined the average indices, which were transformed into normalized indices and grouped within the set scores (Enright, 2000; Shigane, 1968). The evaluation comprises the total of 16 indices, including 3 demographic indices, 6 indices of disease incidence, 4 indices of socio-economical conditions of the population way of living, and 3 medical-pharmaceutical indices characterizing the resource provision of healthcare and pharmaceutical institutions. Each element (subject) of the complex evaluation had a definite set of properties and an appropriate scale for their quantitative measurement. To maintain the logic of evaluation and its compliance with the basic principle – the larger indicator, the higher evaluation, and vice versa – the probability was inverted for the indices characterizing disease incidence and death rate, and an alternative probability was obtained. In accordance with this condition, each property was assigned a ranking from 1 (for the territory where the indicator had the smallest value) to 14 (for the territory where the indicator had the largest value). If two or more indices were equal, the next ranking was assigned in an alphabetical order. Complex evaluation was carried out for 14 regions and towns, thus 14 rankings were used. After normalizing all the accounted indices for each region, their total sum was calculated, yielding their complex evaluation (K) which became the basis for grouping. The minimal and maximal values of rankings were set ($K_n = X_{\min} - X_{\max}$) for each type of administrative regions. The method of normalized indices is very convenient for grouping the indices with different measurements. While doing so, the indices were impersonalized and transformed, as was mentioned above. The multidimensional grouping of the regions was carried out in stages: stage I was devoted to normalizing the indices. The normalized indices were the average indices formed in the area or the normative indices stipulated by the order of the Republic of Kazakhstan Ministry of Healthcare. All indices were divided by the relevant normalized value. At

stage II, the normalized values were summed up by each accounted indicator in a region; and at stage III, the regions were grouped by the levels of complex indices integrated in a certain interval.

Thus, based on summing up the values of several integrated indices, we calculated the complex indices characterizing the development in terms of the accounted factor. The levels of the complex indices allowed grouping the Turkistan area regions, which took into account the health status of the population, the levels of resource provision of healthcare system and socio-economic development.

3. Results

Turkistan area is characterized by high birth rate and low death rate, which form a high level of natural increase of the population (Table 1). Applying the method of normalized indices allowed distributing the Turkistan area administrative regions into three groups.

The first group of regions with relatively low level of demographic development ($K_{Id}=2.30-2.51$) includes Baydybekskiy, Otraraskiy, Makhtaralskiy regions and Kentau town.

Table 1- Complex Evaluation of the Turkistan Area Regions by Normalized Demographic Indices

Regions and towns of the area	Demographic indices						Complex indicator (K_d)
	Birth rate		Death rate		Natural increase		
	‰	NV*	‰	NV	‰	NV	
Kentau	18.1	0.70	4.6	0.95	13.5	0.65	2.30
Baydybekskiy	19.4	0.75	4.7	0.97	14.7	0.71	2.43
Otraraskiy	19.6	0.77	4.8	1.00	14.8	0.71	2.48
Makhtaralskiy	20.3	0.79	4.6	0.95	16.0	0.77	2.51
Tyulkubasskiy	19.5	0.76	5.8	1.20	13.7	0.66	2.62
Sozakskiy	21.4	0.84	4.9	1.02	16.5	0.79	2.65
Shardarinskiy	23.0	0.90	4.3	0.98	18.7	0.90	2.69
Tolebiyskiy	22.4	0.87	5.5	1.14	16.9	0.81	2.82
Arysskiy	23.5	0.92	5.1	1.06	18.4	0.89	2.87
Ordabasynskiy	26.0	1.01	5.4	1.12	20.6	0.99	3.12
Sayramskiy	27.3	1.07	4.7	0.98	22.6	1.09	3.14
Kazgurtskiy	26.3	1.03	5.4	1.12	20.9	1.01	3.16
Turkistan	27.2	1.07	5.1	1.06	21.7	1.04	3.17
Saryagashskiy	27.0	1.08	5.1	1.06	21.9	1.05	3.19
Normalized value	25.5	1.0	4.8	1.0	20.7	1.0	3.0

*NV – normalized value

The second group of regions with intermediate level of demographic development ($K_{Id}=2.30-2.51$) includes Tyulkybasskiy, Sozakskiy, Shardarinskiy, Tolebiyskiy and Arysskiy

regions. The third group of regions with relatively high level of demographic development ($K_{III}=3.12-3.19$) includes Ordabasynskiy, Sayramskiy, Kazgurtskiy, Saryagashskiy regions and Turkistan town. Grouping the Turkistan area regions by the levels of normalized indices of general and primary incidence, and incidence of socially significant pathologies (Table 2), showed that the regions with relatively low levels of incidence are Ordabasynskiy, Baydybekskiy, Sozakskiy and Shardarinskii regions ($K_{II}=4.46-5.18$).

Table 2- Complex Evaluation of the Turkistan Area Regions by Normalized Indices of General and Primary Incidence, and Incidence of Socially Significant Pathologies (K_h)

Regions, towns	General disease incidence		Primary incidence		Circulatory diseases incidence		Tuberculosis incidence		Oncological diseases incidence		Mental diseases incidence		Complex indicator (K_h)
	%00	NV*	%00	NV	%00	NV	%0	NV	%00	NV	%00	NV	
Ordabacynskiy	67,678.6	0.83	32,227.9	0.83	1,981.4	0.69	51.0	0.99	100.3	0.94	91.9	1.01	4.46
Baydybekskiy	66,238.4	0.80	31,545.1	0.81	1,939.3	0.68	39.8	0.77	121.3	1.13	50.7	0.56	4.75
Sozakskiy	88,781.5	1.08	42,576.9	1.09	1,447.3	0.51	31	0.60	104.4	0.97	65.8	0.72	4.97
Shardarinskii	64,369.4	0.78	30,452.1	0.77	1,646.8	0.58	72.0	1.40	98.5	0.92	66.8	0.73	5.18
Saryagashskiy	78,248.7	0.95	37,261.3	0.96	2,768.2	0.98	49.8	0.97	75.2	0.70	77.1	0.85	5.41
Arysskiy	80,420.5	0.98	38,295.5	0.98	2,362.8	0.83	56.8	1.10	108.1	1.01	50.1	0.55	5.45
Otrarskiy	80,813.1	0.98	38,482.4	0.99	2,121.7	0.75	49.6	0.96	95.5	0.89	77.5	0.85	5.70
Sayramskiy	102,908.4	1.25	48,004.0	1.23	2,564.9	0.90	23.9	0.47	95.0	0.88	88.5	0.97	5.70
Tolebiyskiy	92,291.5	1.12	42,988.3	1.10	2,653.4	0.93	53.8	1.05	97.3	0.91	76.2	0.84	5.95
Kazgurtskiy	89,717.9	1.09	42,702.8	1.07	2,188.3	0.77	55.2	1.08	86.4	0.80	104.1	1.15	5.96
Kentau	93,857.2	1.14	42,693.9	1.09	2,521.7	0.89	56.0	1.09	138.3	1.29	59.5	0.65	6.15
Tyulkubasskiy	99,360.0	1.21	44,314.3	1.13	2,524.9	0.89	50.7	0.99	98.6	0.92	98.0	1.08	6.22
Makhtaralskiy	119,034.2	1.46	56,682.1	1.45	1,806.4	0.63	51.0	0.99	78.4	0.73	91.6	1.01	6.27
Turkistan	116,872.9	1.42	53,653.8	1.37	1,952.8	0.69	76.3	1.49	89.4	0.83	81.0	0.89	6.69
Normalized value	38,981.4	1.00	389,981.4	1.00	2,832.6	1.00	51.2	1.00	106.9	1.00	90.6	1.00	6.00

*NV – normalized value

Table 3 - Evaluation of the Regions by Complex Index of Social-economic Conditions (K_{sec})

Regions, towns	Per capita income of the population		Unit weight of the unemployed		Amount of the living wage		People with wages below living wage		Complex indicator (K_{sec})
	tenge	NV*	%	NV	tenge	NV	%	NV	
Sozakskiy	89,692	1.35	3.1	0.81	34,916	1.07	3.6	0.82	3.73
Turkistan	92,164	1.39	2.9	0.76	35,398	1.08	3.7	0.84	3.74
Saryagashkiy	88,498	1.34	3.2	0.84	33,928	1.03	4.0	0.90	3.75
Kentau	84,386	0.97	3.4	0.89	34,772	1.06	4.1	0.93	3.85
Tolebiyskiy	64,372	0.97	3.5	0.92	31,897	0.97	4.6	1.04	3.90
Tyulkubasskiy	64,997	0.98	3.6	0.94	31,862	0.97	4.9	1.03	3.92
Makhtaralskiy	64,839	0.98	3.8	1.00	31,857	0.97	4.1	0.93	3.92
Kazgurtskiy	65,729	1.27	3.8	0.73	31,394	0.96	4.2	0.95	3.99
Shardarinskiy	63,872	0.96	3.9	1.02	30,094	0.92	4.9	1.11	4.01
Baydybekskiy	61,867	0.93	4.2	1.10	30,046	0.91	4.8	1.09	4.03
Otrarskiy	61,843	0.93	4.3	1.13	30,039	0.91	4.9	1.11	4.08
Ordabacynskiy	63,839	0.96	3.9	1.01	32,269	0.98	4.8	1.09	4.04
Sayramskiy	63,575	0.96	3.7	0.97	33,271	1.01	4.9	1.11	4.05
Arysskiy	64,902	0.98	3.9	1.02	32,741	1.00	4.7	1.07	4.07
Normalized value	65,982	1.00	3.8	1.00	32,689	1.00	4.4	1.00	4.00

*NV – normalized value

Table 4- Evaluation of the Turkistan Area Regions by Complex Medical-pharmaceutical Indices

Regions, towns	Provision of medical establishments with resources						Complex indicator (K_{mpp})
	Medical personnel		Pharmaceutical personnel		Average population per 1 pharmacy		
	%0	NV*	%0	NV	Thousand people	NV	
Ordabasynskiy	17.01	0.67	2.2	0.70	2.1	0.67	2.04
Shardarinskiy	16.26	0.64	2.4	0.77	2.0	0.64	2.05
Otrarskiy	19.96	0.79	2.0	0.64	2.2	0.70	2.13
Kazgurtskiy	18.33	0.73	2.4	0.77	2.0	0.64	2.14
Saryagashkiy	14.41	0.57	2.6	0.83	2.5	0.80	2.20
Arysskiy	19.26	0.76	2.6	0.83	2.0	0.64	2.23
Baydybekskiy	20.66	0.82	2.2	0.70	2.3	0.74	2.26
Tyulkubasskiy	18.24	0.72	2.7	0.87	2.2	0.70	2.27
Sayramskiy	21.37	0.85	2.5	0.80	2.1	0.67	2.32
Tolebiyskiy	20.98	0.83	2.3	0.74	2.4	0.77	2.34
Makhtaralskiy	15.63	0.62	2.7	0.87	2.9	0.93	2.42
Sozakskiy	21.03	0.83	2.9	0.93	2.1	0.67	2.43
Turkistan	16.04	0.63	2.7	0.87	2.9	0.93	2.43
Kentau	17.71	0.70	2.9	0.93	2.9	0.93	2.56
By normative provision	25.10	1.00	3.1	1.00	3.1	1.00	3.00

*NV – normalized value

The regions with intermediate levels of incidence include Saryagashskiy, Arysskiy, Otrarskiy, Sayramskiy and Tolebiyskiy regions ($K_{Ith} = 5.41-5.95$). The third group of regions with high levels of incidence include Kazgurtskiy, Tyulkubasskiy, Makhtaralskiy regions and Kentau and Turkistan towns ($K_{IthIII} = 5.96-6.69$). Typologization of regions by complex indices of socio-economic conditions showed (Table 3) that Sozakskiy, Turkistanskiy, Saryagashskiy regions and Kentau and Turkistan towns have relatively high levels of socio-economic development ($K_{I sed} = 3.73-3.85$). In these regions, the average income per capita is rather high, the unit weight of the unemployed is low, the living wage is significantly higher than in other regions, and the share of people receiving wages below the living wage is rather small.

In Tolebiyskiy, Tyulkubasskiy, Makhtaralskiy and Kazgurtskiy regions, the level of socio-economic development is intermediate ($K_{II sed} = 3.90-3.99$). This is confirmed by the included indices of socio-economic development.

The levels of socio-economic development were rather low ($K_{III sed} = 4.01-4.08$) in Shardarinskiy, Baydybekskiy, Otrarskiy, Ordabassinskiy, Sayramskiy, and Arysskiy regions.

We also grouped the Turkistan area regions by the medical-pharmaceutical indices (Table 4), including such indices as the provision with medical and pharmaceutical personnel and the average number of population per one pharmacy. The lowest levels of provision with these resources were shown by Ordabasynskiy, Shardarinskiy, Otrarskiy and Kazgurtskiy regions ($K_{I mpp} = 2.04-2.14$). The intermediate levels of provision with these resources were shown by Saryagashskiy, Arysskiy, Baydybekskiy, Tyulkubasskiy, Sayramskiy, and Tolebiyskiy regions ($K_{II mpp} = 2.20-2.34$). The highest levels of provision with medical personnel and pharmacies was marked in Makhtaralskiy and Sozakskiy regions and in Turkistan and Kentau towns ($K_{III mpp} = 2.42-2.56$). Similarly, multifactor groupings of regions can be obtained by other indices of socio-economic development, demographic situation, etc. The best estimations of health and healthcare were obtained for Sozakskiy and Saryagashskiy regions and in Turkistan and Kentau towns, which show low levels of general death rate and death rate of working-age population, as well as the highest levels of healthcare financing per resident. The worst indices were registered in Otrarskiy, Shardarinskiy, Ordabasynskiy and Kazgurtskiy regions.

At the second stage, a complex evaluation of socio-economic development of the Turkistan area regions was carried out. The indices with different measurement units become comparable only after they are reduced to one measure, thus, the quantitative values of indices (P) were transformed to their qualitative differences (Kp). To obtain the qualitative characteristics of the indicators, we used the method of interval statistics; the quantitative value of each indicator got the number of the interval

into which the quality fell. The numerical values of the weight (entropy) of the indicators were defined with C. Shannon's formula: $F = EP_k - \log(1/P_k)$, where P_k is the probability of each qualitative evaluation in the K -th group of the Turkistan area regions. The complex evaluation of a region's development was calculated with the formula: $(KP(I) = EC - K$, where $KP(I)$ is the qualitative analogue of $P(I)$ indicator, $F(PI)$ is the coefficient of the significance of each P indicator. In accordance with the complex evaluation, each region was assigned a ranking from 1 (for the territory where the indicator had the smallest value) to 14 (for the territory where the indicator had the largest value). By the results of classification according to the socio-economic development, the most actively developing are Sozakskiy and Saryagashskiy regions and Turkistan and Kentau towns, which are characterized by well-developed industry and agriculture, high per capita incomes of the population, and low unit weight of the unemployed ($K_{sec} = 3.73-3.85$).

4. Discussion

The obtained rankings within the complex evaluation of public health and healthcare (K_{Iinc}) were compared with the complex evaluation of the socio-economic conditions of the population (K_{IIIsec}). Multifactor groupings of the regions can be obtained in a similar way by other indices of socio-economic development, demographic situation, etc.

According to numerous research data, high levels of health and healthcare are registered in the regions with low levels of general disease incidence and death rate of the working-age population, and the highest levels of healthcare financing per resident (Hertog, 2001; Lavrik, 2002; Shigane, 1968). We found that Baydybekskiy, Otrarskiy, Shardarinskiy, Arysskiy, Ordabasynskiy and Sayramskiy regions (Table 1), having low levels of socio-economic development ($K_{sec} = 4.03-4.08$), at the same time show high rankings of public health ($K_{inc} = 4.46-5.18$) and healthcare, as well as medication provision of patients ($K_{mpp} = 2.04-2.14$). However, Turkistan and Kentau towns and Saryagashskiy region, having high levels of socio-economic development (rankings 1 and 4), show low levels of public health and healthcare (rankings 10 and 14).

The obtained results allow evaluating the development level of the Turkistan area regions by normalized indices, characterizing public health and healthcare (K_{III}) and socio-economic development (K_k). During the studied period, the Turkistan area regions showed a dispersion of the normalized indices' levels. The differences amounted to 1.2 times by the normalized indices and 2.4 times by the complex indices, thus proving the different development levels, multifaceted character and complex spatial hierarchy of the Turkistan area regions. A complex evaluation was carried out

with a system of indices adequately describing the subjects as a management object; then three stable groups – complex typologies – were formed. Based on the indices characterizing public health and healthcare, medication provision and socio-economic development, the obtained typologies objectively demonstrate the situation in the Turkistan area regions and may serve as the basis for forming an efficient regional policy. When researching the interrelation between the socio-economic development and the parameters characterizing public health and healthcare, it was stated that the Turkistan area regions with high level of socio-economic development mainly refer to the intermediate ranking in terms of public health and healthcare. Given the relatively positive correlation between the disease incidence and the socio-economic development indices, we eliminated the 1st group of properties by two indices, including the normalized and complex indices. Probably, there is a wide range of factors influencing the health of the Turkistan area regions' population and there are various mechanisms of transmitting the influence of socio-economic development, thus, it may be assumed that its influence on public health is varied in value and character. In accordance to the hypothesis, actively discussed in scientific literature, on the character of correlation between socio-economic factors and public health, a further in-depth study is required to reveal the causes of this situation.

5. Conclusion

The proposed normalized analysis method based on the complex evaluation of the characteristics of public health, healthcare, medication provision and socio-economic development is the most effective for typologization of regions with multi-level and multi-vector indices of development.

The developed methodology allows annually monitoring of the medical-social and economic development of regions

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