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Development of a set of indicators as the basis for the morbidity map analysis

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Abstract

The relevance of the research topic is due to high morbidity and mortality both in the world and in Russia, where every 13th Russian citizen suffers from cardiovascular pathology. In the general structure of mortality in Russia, mortality from diseases of the circulatory system (CVD) is 49%. Based on such high morbidity and mortality, cardiovascular diseases are considered a national problem. When comparing the numerical indicators of general morbidity and mortality on the territory of the Chuvash Republic, the disproportions between the mortality and general morbidity in certain administrative-territorial regions are especially clearly visible. Particularly important is the ratio of morbidity and mortality by administrative-territorial entities, in particular areas with low morbidity. Low morbidity and high mortality may be a performance index of the outpatient-polyclinic link and the quality of primary health care.

A mapping study of the ratio of morbidity and mortality from circulatory diseases in a particular region of Russia is useful for identifying the "weakest link" in the system of providing outpatient medical care, assessing the effectiveness of management measures at the level of regional au-thorities, assessing the performance of heads of medical organizations, developing the necessary set of measures, based on the characteristics of the level of medical and demographic indicators with due regard to the leading principles of strategic planning. Trend maps show the emergence, development, past states, changes in time, and spatial movement of the analyzed phenomenon. One of the main methodological requirements, the conditions for the reliability of the medical and geographical assessment of morbidity and the preparation of a research forecast in the study of the spatial and temporal patterns of the spread of diseases among the population and the creation of nosogeographic maps are track of changes in morbidity. Trend maps show the emergence, development, past states, changes in time, movement in space of the analyzed phenomenon. Analysis of medical and geographical maps showed the limited set of methods and techniques used to show dynamic aspects.

Keywords: morbidity and mortality from circulatory diseases, public healthcare performance, assessment of the activity of the outpatient service, primary healthcare, cartographic analysis, forecasting of numerical indicators.

Resumen

La relevancia del tema de investigación se debe a la alta morbilidad y mortalidad tanto en el mundo como en Rusia, donde uno de cada 13 ciudadanos rusos padece patología cardiovascular. En la estructura general de la mortalidad en Rusia, la mortalidad por enfermedades del sistema circulatorio (ECV) es del 49%. Sobre la base de una morbilidad y mortalidad tan elevadas, las enfermedades cardiovasculares se consideran un problema nacional. Al comparar los indicadores numéricos de morbilidad y mortalidad general en el territorio de la República de Chuvashia, las desproporciones entre la mortalidad y la morbilidad general en ciertas regiones administrativo-territoriales son especialmente claramente visibles. De particular importancia es la razón de morbilidad y mortalidad por entidades administrativo-territoriales, en particular áreas con baja morbilidad. La baja morbilidad y la alta mortalidad pueden ser un índice de desempeño del vínculo ambulatorio-policlínico y la calidad de la atención primaria de salud.

Un estudio de mapeo de la proporción de morbilidad y mortalidad por enfermedades circulatorias en una región particular de Rusia es útil para identificar el "eslabón más débil" en el sistema de atención médica ambulatoria, evaluando la efectividad de las medidas de gestión a nivel de las autoridades regionales. evaluar el desempeño de los jefes de organizaciones médicas, desarrollando el conjunto necesario de medidas, basadas en las características del nivel de indicadores médicos y demográficos con la debida atención a los principios rectores de la planificación estratégica. Los mapas de tendencias muestran la emergencia, el desarrollo, los estados pasados, los cambios en el tiempo y el movimiento espacial del fenómeno analizado. Uno de los principales requisitos metodológicos, las condiciones para la confiabilidad de la evaluación médica y geográfica de la morbilidad y la elaboración de un pronóstico de investigación en el estudio de los patrones espaciales y temporales de la propagación de enfermedades entre la población y la creación de mapas nosogeográficos. son un seguimiento de los cambios en la morbilidad. Los mapas de tendencias muestran el surgimiento, desarrollo, estados pasados, cambios en el tiempo, movimiento en el espacio del fenómeno analizado. El análisis de mapas médicos y geográficos mostró el conjunto limitado de métodos y técnicas utilizados para mostrar aspectos dinámicos.

Palabras clave: morbilidad y mortalidad por enfermedades circulatorias, desempeño de la salud pública, evaluación de la actividad del servicio ambulatorio, atención primaria de la salud, análisis cartográfico, previsión de indicadores numéricos.

Introduction

One of the tasks of forming the activities of medical organizations and predicting the values of indicators in the health sector is the creation of tools to determine and measure the level of influence of each individual medical organization on health indicators[1]. Therefore, the scientific approach to the assessment of morbidity and the organization of medical and preventive measures is one of the main tasks of the management of state and territorial legislative and executive authorities, which determines the policy of health protection, economic, legal, and social measures. Thus, the ability to manage health indicators through improving the work of the system of governing bodies of medical organizations allows timely finding sufficient resources, primarily financial, for areas that contribute to achieving maximum efficiency with minimal use of resources (increasing the efficiency) in the management of activities and the performance of medical organizations[2].

Methods

The following reporting forms were selected for federal statistical observation in healthcare: No. 12 "Information on the number of diseases registered in residents of the service area of a medical organization" for 2010-2019, "Distribution of deaths by sex, age groups and causes of death" mortality tables, demographic yearbooks of the Chuvash Republic, published by the Territorial Body of the Federal State Statistics Service in the Chuvash Republic, as well as data from demographic yearbooks published by the Federal State Statistics Service for the corresponding years[3,5].

The correlation coefficient was calculated between general morbidity and mortality in the Chuvash Republic. It is a selective linear correlation coefficient calculated by the formula:

$$r_{xy} = \frac{\overline{xy} - \bar{x} * \bar{y}}{S(x) * S(y)}.$$

The connections between signs can be weak and strong (close). Their criteria are assessed on the Chaddock scale: $0.1 < r_{xy} < 0.3$: weak; $0.3 < r_{xy} < 0.5$: moderate; $0.5 < r_{xy} < 0.7$: noticeable; $0.7 < r_{xy} < 0.9$: high; $0.9 < r_{xy} < 1$: very high.

The administrative-territorial regions of the Chuvash Republic were grouped by levels of mortality and general morbidity using the mapping analysis. On the basis of cartographic analysis, the administrative-territorial regions are grouped according to morbidity and mortality[4,6,7,8,10]:

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1) We calculated the arithmetic mean of the relative indicators for the administrative-territorial regions of the Chuvash Republic for each analyzed year (national average data - M1-10) according to the formula $M = \Sigma V/n$, where M is the arithmetic mean; V is relative indicators of the administrative-territorial regions of the Chuvash Republic; n is the number of observations.

2) We determined the standard deviation of variations in the statistical series of average data for the regions of the Chuvash Republic by year: $\delta = \sqrt{\Sigma d2/n-1}$, where d is the deviation (the difference between the average value and each variation); n is the number of observations.

3) The intervals for grouping the administrative-territorial regions of the Chechen Republic by the level are presented: $M-0.5\delta \leq M^1 \leq M + 0.5\delta$ - the indicator within the average republican data (average) for the Chuvash Republic; $M + 0.5\delta < M^1 \leq M + 1.5\delta$ - the indicator higher than the average republican data (high); $M-1.5\delta \leq M^1 < M-0.5\delta$ - the indicator lower than the average republican data (low); $M^1 > M + 1.5\delta$ - ultra-high indicator; $M^1 < M-1.5\delta$ - ultra-low indicator.

4) We determined the average value of the administrative-territorial regions of the Chuvash Republic for the decade $M^1 1-M^1 85$ was determined according to the arithmetic mean formula.

5) We grouped the administrative-territorial regions of the Chuvash Republic according to the distribution $M^1 1-M^1 25$ according to the corresponding intervals.

We used our original methodology to evaluate the effectiveness of medical care in the administrative-territorial regions of Chuvash Republic[9].

The numerical indicators of general morbidity and mortality in the Chuvash Republic were compared. The difference between the mortality and general morbidity in certain areas was clearly defined.

The ratio of morbidity and mortality by administrative-territorial entities is particularly important, especially in low morbidity areas. Thus, low morbidity and high mortality are an indicator of the effectiveness of primary health care.

The overall mortality/morbidity (SI coefficient) was calculated and the ratio of the averaged indicators of the general morbidity and general mortality was determined. A special coefficient, SI, has been determined for each administrative-territorial region of the Chuvash Republic, i.e. SI = the level of overall cardiovascular morbidity/mortality[9].

Finding the special indicator (SI) allowed us to identify the subjects with the maximum level of the special coefficient, as well as with the minimum SI (administrative-territorial areas with ultra-low overall morbidity and ultra-high overall mortality).

To distribute the regions of the Chuvash Republic by the value of the special indicator, its intervals were determined. For this, Δ has been calculated: $\Delta=(k_{max}-k_{min})/4$, where

k_{max} is the level of maximum SI of the administrative-territorial regions of the Chuvash Republic,

k_{min} is the level of minimum SI of the administrative-territorial regions of the Chuvash Republic.

The grouping intervals for the administrative-territorial regions of the Chuvash Republic have been determined according to the following method: superhigh SI group – SI higher than the average for the Chuvash Republic; high SI group: $SI - \Delta$; medium SI group: $SI - 2\Delta$; low SI group: $SI - 3\Delta$; ultra-low SI group: $SI - 4\Delta$.

Thus, we used the exponential smoothing method (exponential average), discovered by Brown and Holt, to predict the indicators of overall mortality in the administrative-territorial regions of the Chuvash Republic and the prevalence of diseases. The formula for simple exponential smoothing is as follows:

$St+1 = \alpha \times Xt + (1- \alpha) \times St$, where Xt is the actual value at a given point of the series t; St is the forecast at the point of the series t; α - some predetermined smoothing coefficient (from 0.1 to 0.9), constant throughout the row.

Thus, each new smoothed value was determined as a weighted average of the current observation and smoothed series. The smoothing result depended on the parameter α (alpha).

To build an exponential smoothing curve, the root-mean-square error of approximation (mean square of errors) was calculated as the root-mean-square deviation of the true values of the series from its approximation and the relative error of approximation in relation to the absolute error of approximation to the range of values of the series. The range was estimated as the difference between the maximum and minimum values of the series after excluding 10% of its largest and smallest values.

In practice, the smoothing parameter was searched for on the grid according to Gardner's recommendations (1985). Possible values of the parameter were distributed by grid with a certain step. Value grid–from $\alpha=0.1$ to $\alpha = 0.9$, with a step of 0.1. Then α was chosen for which the sum of the squares (or mean squares) of the residuals (observed values minus one step ahead predictions) was minimal.

Mathematical processing of the obtained data was carried out using STATISTICA 6.0 and "Excel 7.0" on IBM-PC, confidence level = 0.95.

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To assess the effectiveness of the outpatient-polyclinic link, the presence and the closeness of the relationship between the indicators of general mortality and morbidity from diseases of the circulatory system of the population of the Chuvash Republic were determined for the study period:

$$r_{xy} = \frac{\overline{xy} - \bar{x} * \bar{y}}{S(x) * S(y)} = \frac{191470,959 - 359.21 \times 535.83}{25.168 \times 57.903} = -0.689.$$

According to the Chaddock scale, the relationship between mortality rates and disease prevalence is noticeable and inverse = -0.689.

Considering the forecasts made up to 2029, the pattern of a decrease in mortality with an increase in the incidence of cardiovascular diseases is clearly visible.

Our map analysis of the incidence of cardiovascular diseases (BCS) among the population of the Chuvash Republic in 2010-2019 found its super-high level in the following administrative-territorial districts of Chuvash Republic: in Kozlovsky, Shumerlinsky, Poretsky, Alatyrsky, Yadrinsky, Yalchiksky, Yantikovsky districts, as well as in the cities of Alatyr and Shumerlya. Ultra-low levels fore found in Cheboksary, Tsivilsky, Vurnarsky administrative-territorial districts, as well as in the cities of Novocheboksarsk and Kanash.

Our map analysis of mortality from cardiovascular diseases of the population of the Chuvash Republic found its super-high levels in the following administrative-territorial districts of the Chuvash Republic during the study period: Kozlovsky, Shumerlinsky, Poretsky and Alatyrsky, high - in Shemurshinsky and Krasnoarmeysky. Ultra-low levels were found in Morgaushsky, Cheboksary administrative-territorial districts of the Chuvash Republic, as well as in the cities of Cheboksary, Novocheboksarsk, Kanash. Low mortality was noted in Tsivilsky, Yantikovsky, Vurnarsky, Ibresinsky, Komsomolsky and Batyrevsky districts of the Chuvash Republic.

Comparison of the numerical indicators of overall morbidity and overall mortality in the Chuvash Republic clearly showed the imbalance between these indicators in its individual administrative-territorial regions. We have found low level of overall mortality in some regions of Chuvashia, accompanied by a relatively high level of overall morbidity, and vice versa, a low overall morbidity is combined with a high level of overall mortality.

Thus, the quantitative values of the ratio of indicators of general morbidity and total mortality, SI, were determined for all administrative-territorial districts of the Chuvash Republic. In Yalchik, Yantikovsky, Morgaushsky, Cheboksary, Ibresinsky, Yadrinsky, Alikovsky, Komsomolsky, Mariinsko-Posadsky, Krasnochetaysky and in the cities of Cheboksary and Novocheboksarsk we have found an ultra-high SI lev-

els that formed during the studied period. An ultra-low SI value was determined in the Kozlovsky, Krasnoarmeysky, Alatyrsky and Shumerlinsky administrative-territorial districts of the Chuvash Republic.

Summary
1. The numerical indicators of general morbidity and mortality in the Chuvash Republic clearly show the difference between the mortality and general morbidity in certain areas.

2. Low morbidity and high mortality are an indicator of the effectiveness of outpatient care and the quality of primary health care.

3. A mapping study of the ratio of morbidity and mortality from circulatory diseases in a particular region of Russia is useful for identifying the "weakest link" in the system of providing outpatient medical care, assessing the effectiveness of management measures at the level of regional authorities, assessing the performance of heads of medical organizations, developing the necessary set of measures, based on the characteristics of the level and trends of medical and demographic indicators with due regard to the leading principles of strategic planning.

4. An extremely high SI (overall mortality/morbidity ratio) indicates insufficient efficiency of the organization of medical examination, low provision with medical personnel and medical equipment, lack or insufficiency of primary care institutions in these constituent entities of the Russian Federation, including a decrease in the availability of medical care, and on the need for a thoughtful and clear approach to making appropriate management decisions in each administrative-territorial unit.

Analysis of the ratio of mortality and morbidity from diseases of the circulatory system makes it possible to single out the administrative-territorial districts of the constituent entities of the Russian Federation, where, first of all, it is necessary to assess the quality of medical care and develop a specific plan to achieve health indicators defined as indicators of the implementation of the state «Health Development" program, regional and municipal plans to reduce mortality from cardiovascular diseases.

Most of the performance indicators provided for by the programs of demographic and medico-social development of the constituent entities of the Russian Federation are associated with the activities of medical institutions, and the achievement of the planned health indicators really depends on the performance indicators of healthcare institutions.

The provision of health authorities at the federal level with sound scientific and methodological advice on the use of

tools to measure the overall morbidity/mortality ratio helps to create conditions that motivate the achievement of target (expected) results expressed in terms of public health. Analysis of the ratio of indicators of overall morbidity and mortality from cardiovascular diseases allows timely finding sufficient resources (material, technical, personnel and financial) in those areas that contribute to the achievement of the best efficiency of medical institutions.

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