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Original article

ON ASSESSING THE GROWTH POTENTIAL OF THE LIFE EXPECTANCY OF THE POPULATION AS A RESULT OF IMPLEMENTING INTEGRATED MEASURES (ON THE EXAMPLE OF A CONSTITUENT ENTITY OF THE RUSSIAN FEDERATION)

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The development vector of the current government policy in the Russian Federation aimed at improving social conditions – one of the critical indicators of which is life expectancy at birth [LE] – dictates the research relevance. Currently, the search and testing of new analytical systems capable of forecasting LE, considering the multifactorial influence on this indicator, remains relevant and timely. The research goal is to establish the growth potential of LE of the population estimation on the example of one of the constituent entities of the Russian Federation, considering integrated heterogeneous factors that possess a modifying effect on LE. The estimation includes modeling cause-and-effect relationships between indicators of habitat, quality of life, and life patterns – determinants of population health. The utilized model is a set of algebraic equations in the form of a factor transformation of independent variables and an artificial neural network and is implemented in three stages. They include (1) developing the basic scenario and calculating LE, (2) developing the target scenario and calculating LE, and (3) calculating the growth potential of LE as the difference between the indicators obtained at previous stages. The developed model and the three-stage algorithm application allows one to obtain the growth potential of LE on the example of one constituent entity of the Russian Federation in the context of a single change in determinants by 2024, which amounts to +1.24 years (453.0 days) relative to the baseline scenario (the actual LE value in 2018). The forecast value of LE is 70.47 years. Ranking of individual indicator groups according to their isolated effect on LE demonstrates that the most significant determinant groups are (1) socio-demographic indicators (2.6 years – 949.0 days), (2) indicators of sanitary and epidemiological safety (1.75 years – 638.75 days), and the (3) population lifestyle indicators (1.41 years – 514.65 *days). The obtained results confirm the predominance of the influence of social indicators on population health in the form of LE on the example of the analysis of changes in the indicators of one of the constituent entities of the Russian Federation. The research relevance implies studying the combined influence of heterogeneous factors of the environment and lifestyle on the indicative indicator of population health (LE), a complex system with the properties of emergence, variability, opposite influence, and adaptation.*

Keywords: *life expectancy; neural network; modifying determinants*

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Научная статья

К ВОПРОСУ ОЦЕНКИ ПОТЕНЦИАЛА РОСТА ОЖИДАЕМОЙ ПРОДОЛЖИТЕЛЬНОСТИ ЖИЗНИ НАСЕЛЕНИЯ В РЕЗУЛЬТАТЕ РЕАЛИЗАЦИИ КОМПЛЕКСНЫХ МЕРОПРИЯТИЙ (НА ПРИМЕРЕ СУБЪЕКТА РОССИЙСКОЙ ФЕДЕРАЦИИ)

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Актуальность исследования продиктована вектором развития текущей государственной политики в РФ по улучшению условий социальной сферы, одним из ключевых показателей которой является ожидаемая продолжительность жизни при рождении (далее ОПЖ). В современных условиях поиск и апробация новых аналитических систем, способных к прогнозированию ОПЖ с учётом многофакторного влияния на данный показатель, сохраняет свою актуальность и своевременность. Целью настоящей работы являлось установление прогнозных оценок потенциала роста ОПЖ населения на примере одного из субъектов РФ с учётом комплекса разнородных факторов, оказывающих модифицирующее влияние на ОПЖ. Данная оценка осуществлялась с использованием моделирования причинно-следственных связей между показателями среды обитания, качества и образа жизни – детерминантами, определяющими популяционное здоровье. Используемая модель представляет собой совокупность алгебраических уравнений в виде факторного преобразо-

вания независимых переменных и искусственной нейронной сети и реализуется в 3 этапа: а) разработка базового сценария и расчет ОПЖ, б) разработка целевого сценария и расчет ОПЖ, в) вычисление потенциала роста ОПЖ, как разности между значениями, полученными на предыдущих этапах. Применение разработанной модели и 3-х этапного алгоритма позволило получить потенциал роста ОПЖ на примере одного субъекта РФ при сценарии единого изменения детерминант к 2024 году, который составил +1.24 года (453.0 дня) относительно базового сценария (фактического значения ОПЖ 2018 г.) и прогнозное значение ОПЖ – 70.47 года. Ранжирование отдельных групп показателей по их изолированному эффекту на ОПЖ показало, что наиболее значимыми группами детерминант являются социально-демографические показатели (2.6 года – 949.0 дня), показатели санитарно-эпидемиологического благополучия (1.75 года – 638.75 дня) и показатели образа жизни населения (1.41 года – 514.65 дня). Полученные результаты подтверждают превалирование влияния показателей социальной сферы на популяционное здоровье в виде ОПЖ на примере анализа изменения показателей одного из субъектов РФ. Научной новизной данной работы является исследование совокупного влияния разнородных факторов среды обитания и образа жизни на индикативный показатель популяционного здоровья (ОПЖ), представляющий собой сложную систему со свойствами эмерджентности, вариативности, противоположного влияния и адаптации.

Ключевые слова: *ожидаемая продолжительность жизни; нейросеть; модифицирующие детерминанты*

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Introduction

The values of the life expectancy at birth [LE] indicator in recent decades possess an increase trend [28]. Therefore, globally, LE increased by 8.0% over the period from 2000 to 2016. In low-income countries, this indicator increased the most (21.0 %), while in high-income countries, the growth of LE was less pronounced (4.0%). Such differences in the growth of LE between countries fit into the theory of epidemiological transition, which explains the differences in the structure of mortality of the population depending on the current stage of transition [19]. Low-income countries still possess a high burden of infectious diseases and associated, among other things, infant mortality rates in the context of the existing insufficient provision of medical services.

Nonetheless, the gradual improvement of the situation by increasing the availability of medical care to the population, increasing the coverage of preventive vaccinations, etc., provides a more substantial increase (in comparison with high-income countries) in the LE indicator. The observed situation indicates that the mentioned countries are overpassing the initial stages of the epidemiological transition. The issue of the potential opportunities and ways to increase LE in average- and high-income countries that are at later stages of the epidemiological transition, including taking into consideration the regional characteristics of the development of territories, remains relevant [9].

At the present stage, the high-priority task of internal policy the Russian government is facing is implementing the Concept of Demographic Policy, designed to improve the situation in this area by reversing the negative trend observed in recent decades [6]. The practical tools for implementing the Concept are national projects aimed at developing human capital, creating a comfortable living environment, and stimulating economic growth. One of the essential national development goals in the demographic sphere is to increase life expectancy to 78 years by 2030 [7]. However, achieving this goal involves solving many tasks. First of all, according to the latest data of the United Nations Development Program, the Russian Federation is at the beginning of the third quartile of countries with a life expectancy value of 72.6 years. It is slightly lower than the global indicator (72.8 years) and significantly lower than the "leaders" of the list – Hong Kong (84.9 years) and Japan (84.6 years) [13]. Second, according to the same data, the differences in LE between the male and female population of the Russian Federation (10.7 years in 2019) remain at a high level compared to other countries. More significant gender differences are observed only in Lithuania (11.1 years in 2019) [13]. Third, the regional differentiation of constituent entities of the Russian Federation according to the totality of socioeconomic, sanitary-epidemiological, and demographic indicators, due to the vastness of the country's territory with significant weather and climatic differences and the historical context of development also complicates the development of a universal approach to forecasting and managing medical and demographic processes.

Previously performed scientific research in the field of forecasting life expectancy and assessing the contribution of environmental and lifestyle factors to LE is most often limited to studying a small number of determinants or studying mainly one group of influencing factors [4, 26; 10]. The paper is a continuation of the previously performed research of the authors in establishing estimates of the growth potential of life expectancy [5].

The paper consists of several sections. The "Materials and methods" section describes the methodological approach and the mathematical apparatus used to forecast LE. It also provides a list of the used statistical data. The "Results" section contains the study results, including estimates of the contribution of factors/groups of factors to the growth potential of the LE of the population on the example of the studied constituent entity of the Russian Federation. The "Discussion" section contains the results of other studies on the issue under study with their brief description. The last section – "Conclusions" – includes a generalization of the study results.

Materials and methods

The research goal is to obtain forecast estimates of the growth potential of the life expectancy of the population on the example of one of the constituent entities of the Russian Federation, considering integrated heterogeneous factors that possess a modifying effect on LE.

The tasks for achieving this goal are the following:

- Collecting the statistical material characterizing the factors of the habitat and lifestyle that meet the conditions of their probable influence on the LE indicator or the indicator of morbidity/mortality of the population;
- Creating a neural network capable of forecasting LE based on the difference between the baseline and target scenarios;
- Developing a baseline and target scenarios for changes in environmental factors and lifestyle that affect LE and calculating of the growth potential of LE on the example of a constituent entity of the Russian Federation.

In order to solve the tasks and achieve the set goals, the authors utilize the data obtained from official statistical observations of the Federal State Statistics Service and the Federal Service for Supervision of Consumer Rights Protection and Human Welfare for the period of 2010–2018 for all constituent entities of the Russian Federation. The data selected for the analysis characterize the factors of the environment, lifestyle, and quality of life that potentially affect the life expectancy indicator. The selection of indicators (148 determinants) has been carried out according to relevant scientific data on the levels of evidence of the relationship between indicators reflecting the parameters of the habitat, lifestyle, and quality of life and indicators of morbidity and mortality of the population, which modify the LE values. Information on modifying factors is combined into a single data array in the form of a matrix and is conditionally divided into six groups. These groups include (1) "Indicators of the healthcare system" (nine indicators, including the number of doctors of all specialties, the capacity of outpatient clinics, etc.), (2) "Indicators of sanitary and epidemiological safety of territories" (53 indicators, including emissions of pollutants departing from all sources into the atmospheric air, the proportion of workers employed in conditions that do not meet hygienic standards of working conditions, etc.), (3) "Indicators of the economic sphere" (14 indicators, including average per capita monetary income of the population, gross regional product per capita, etc.), (4) "Indicators of the lifestyle of the population" (30 indicators, including alcohol consumption per capita of the adult population, the share of the population engaged in physical culture and sports, etc.), (5) "Indicators of the socio-demographic sphere" (34 indicators, including the Gini coefficient, the number of registered crimes, etc.), and (6) "Indicators characterizing the weather and climatic conditions of the area" (eight indicators, including average monthly air temperature for July; average monthly precipitation for July, etc.).

The forecast of the growth potential of life expectancy has been carried out based on a mathematical model reflecting a system of cause-and-effect relationships between a set of indicators of habitat, lifestyle, and quality of life acting in the context of weather and climate factors and the life expectancy of the population according to regional level data.

The mathematical model is a set of algebraic equations describing a system of mutual influences between 148 modifying determinants acting as independent variables and their cumulative effect on life expectancy (a dependent variable).

The mathematical model consists of a submodel of factor transformation of a system of independent variables into general factors and an artificial neural network. The submodel of factor transformation is a system of linear algebraic equations that are written in matrix form as the relation (1):

$$Y = A\widetilde{X} \quad (1)$$

where $\widetilde{X} = \{\widetilde{x}_1, \widetilde{x}_2, ..., \widetilde{x}_I\}^T$ - column-vector of standardized values of independent variables, I=148; $Y = \{y_1, y_2, ..., y_J\}^T$ – column-vector of common factors, J=33;

$A=\begin{bmatrix} a_{11} & a_{12} & ... & a_{1J} \\ a_{21} & a_{22} & ... & a_{2J} \\ ... & ... & ... & ... \\ a_{I1} & a_{I2} & ... & a_{IJ} \end{bmatrix}$ matrix of factor labels of factor analysis.

In the component form, the expression (1) is written in the following form (2):

$$y_j = \sum_{i=1}^{I} a_{ij}\widetilde{x}_i \quad (2)$$

Standardization of the system of independent variables is performed by the ratio (3):

$$\tilde{x}_i = \frac{x_i - \bar{x}_i}{\sigma_i} \quad (3)$$

Where x_i – the value *of the i* variable; $\bar{x}_i$, $\sigma_i$is the mean and standard deviation *of the i* variable from the sample data.

The factor transformation submodel utilizes the principal components of the factor analysis method and allows one to consider the internal relationships between independent variables with a decrease in the dimension of the system of initial features. The factor transformation obtained from the study of the system of cause-and-effect relationships between determinants allows the authors to move from a system of 148 interrelated indicators to 33 pairwise independent general factors. We conducted the factor transformation using the Statistica software package: the method of principal components with rotation of factors (varimax normalized). We used the Kaiser criterion to determine the amount of factors.

The artificial neural network (ANN) makes it possible to predict the growth potential of LE by constructing a relationship between a set of indicators transformed into a system of general factors and the indicator of life expectancy, acting as a dependent variable.

The ANN was trained in the process of studying the regularities of the influence of indicators characterizing the factors of habitat, lifestyle, and weather and climate conditions (after factor transformation) on life expectancy. In the course of the study, one trained many neural networks with different structures (the number of internal layers and neurons), from which the optimal model with the minimum average prediction error (on a test sample) was selected, corresponding to a four-layer perceptron with two internal layers containing eight and three neurons, respectively. Linear functions are used to calculate input signals to neurons. As an activation function (for the output signal), we used a sigmoid, taking values from 0 to 1. Training and testing of the neural network is performed using a script developed by the authors in the RStudio software product (the “neuralnet” package). The network was trained on randomly selected 75% of all records of the main retrospective data (2010–2018 for 85 subjects of the Russian Federation) using the criterion of minimizing the sum of squares of errors. Network testing was performed on the remaining 25% of observations.

The general algorithm for forecasting the growth potential of the life expectancy of the population consists in the sequential execution of the following three stages:

- Forming the baseline and target scenarios for changes in indicators characterizing 148 determinants;

- Performing calculations of forecast values of life expectancy according to the baseline and target scenarios;
- Calculating the growth potential of the life expectancy of the population as the difference between the calculated baseline and target scenario values of LE.

The mathematical model underlying the methodology for forecasting the growth potential of life expectancy has a definition area limited by the observed values of determinants in constituent entities of the Russian Federation. Scenario calculations containing values of indicators outside the scope of the model definition lead to significant errors and cannot be used to assess the growth potential of life expectancy at the regional level.

According to the described algorithm for forecasting the growth potential of life expectancy of the population, at the first stage, the baseline and target scenarios for changes in the indicators of the habitat and lifestyle were formed. The baseline scenario in the paper is the values of 148 indicators (determinants) of the analyzed constituent entity of the Russian Federation in 2018. The construction of the target scenario includes a set of approaches to determining the expected (forecast) changes in indicators by 2024:

- The values of 19 indicators will be at the baseline level due to the impossibility of adequate estimates of their changes;
- 51 indicators will change by 10.0% relative to the baseline scenario, considering their biological meaning of the impact on LE;
- 48 indicators will change according to the trends of their change by 2024 by logarithmic approximation;
- For 17 indicators, the values will be set according to the target indicators reflected in the Strategic Development Plans of the territories;
- 13 indicators will change to the trends of their change by 2024 by logarithmic approximation, considering their mutual relationship.

Results

According to the proposed mathematical model using the values of 148 determinants at the level of 2018 is 69.23 years, while the actual value of LE in this constituent entity of the Russian Federation in 2018 is 68.99 years. The comparability of the calculated value of LE in the baseline scenario and the actual, registered value of LE indicates the correctness of the estimates of the applied mathematical model. In the target scenario of changes in the entire set of analyzed determinants, the value of LE is 70.47 years, and the growth potential is 1.24 years (453.0 days). The assessment of the growth potential of LE from the scenario change of each conditional group of indicators, when only the indicators of one group change in accordance with the described approaches, and the values of the other determinants remain at the level of the baseline scenario, demonstrates that the most significant forecast values of the growth potential of life expectancy are “Indicators of the socio-demographic sphere” (+2.6 years [950.0 days]) (Table 1). In descending order, there are “Indicators of sanitary and epidemiological safety of territories” (+1.75 years [640.0 days]), “Indicators of the lifestyle of the population” (+1.41 years [515.4 days]), “Indicators of the economic sphere” (+0.15 years [54.0 days]), and “Indicators of the healthcare system” (-0.24 years [-87.0 days]).

Table 1.

The growth potential of life expectancy by groups of indicators of habitat and lifestyle

Total annual income group	Baseline scenario, in years	Target scenario for the group, in years	LE of growth potential, in years (days)	Rank
Indicators of the socio-demographic sphere	69.23	71.83	2.6 (949.0)	1
Indicators of sanitary and epidemiological safety of the territory	69.23	70.98	1.75 (638.75)	2
Indicators of the lifestyle of the population	69.23	70.64	1.41 (514.65)	3
Indicators of the economic sphere	69.23	69.38	0.15 (54.75)	4
Health system indicators	69.23	68.99	-0.24 (-87.6)	5

The growth potential of LE from changes in each indicator “in isolation” (in accordance with the target scenario, only one indicator has changed, and the remaining indicators remain at the baseline level) range from 0.02 days (the level of registered unemployment at the end of the year, in%) to 32.0 days (the number of hours worked per week, on average, per employee, in hours), while out of 148 determinants for the analyzed constituent entity of the Russian Federation, only 85 indicators have values other than zero and do not contradict the biological meaning of their impact on population health.

Discussion

The study results on the assessment of life expectancy losses are presented in the national and foreign scientific literature. However, in most cases, one has conducted the studies in the context of a single factor or a separate group of factors. Therefore, there are estimates of LE losses from tobacco smoking: the life expectancy of smokers compared to those who have never smoked is 5.2–5.3 years lower, and the life expectancy of the healthy is 2.6–3.2 years lower [4]. According to the research conducted in Denmark, Finland, and Sweden, it has been found that life expectancy is shorter by 24–28 years in people with alcohol consumption disorders [26]. One of the primary reasons for differences in LE between the male and female population of the Russian Federation are diseases of the circulatory system, which explain up to 55.0% of these differences [2]. In Russia, as in other countries with an average value of LE according to clustering, the indicators "Share of the urban population," "Health care expenditures per capita," and "GDP per capita" possess the closest relationship with LE [3]. Scholars note that in countries of this type, there is an excellent potential for LE growth.

Several studies are demonstrating the relationship between environmental factors and LE. Therefore, scholars demonstrate a positive correlation between the indicator of LE and CO2 emissions and between LE and gross domestic product on the data of a long period (1960–2018) in Turkey [22]. The study reports that the negative impact of PM2.5 demand for LE in the United States becomes more significant with an increase in income inequality of the population [12]. The report states that, despite the lower relative risk from exposure to air pollution than from smoking, the loss of LE for the general population is more significant, especially with long-term exposure in the case of living in the most polluted cities [20]. The increase in the content of suspended matter (PM10) in ambient air at 10 μg/m3 reduces expected life expectancy by 0.64 years (95.0 % CI=0.21-1.07), while elevated levels of mortality are due to cardio-respiratory diseases [11]. There are similar results achieved by other scholars [10].

The most widely presented studies on the impact of socioeconomic status (SES) on the health of the population – including on LE – are described in more detail in the studies [18]. According to the Lifepath research consortium, lower socioeconomic status is associated with increased population mortality [25]. Low SES causes the loss of LE in 2.1 years while being closely related to alcohol consumption, obesity, diabetes, hypertension, lack of physical activity, smoking, etc. The causal relationship between health status and socioeconomic status is bi-directional [24]. Studies report that the relationship between income inequality and population health is not always evident. It occurs only in certain conditions in territories with their distributions of health risk factors [15; 16]. According to the data obtained from studying 22 European countries, some differences in morbidity and mortality may be associated with the different socioeconomic status of the population, which is associated with factors such as smoking, obesity, alcohol consumption, and insufficient medical care [17]. According to a joint report of the Commission on Social Determinants of Health and the World Health Organization, one must adhere to the three principles in order to eliminate health inequities, including according to the LE indicator: (1) improving the conditions of everyday life; (2) overcoming injustice; (3) distributing power, money, and resources at all levels; (4) assessing the scale of issues, (5) developing human resources, and (6) raising public awareness [27]. The study devoted to assessing the growth of LE in 139 countries with different economic statuses for the 1950–2009 period, one has detected a slowdown in the growth of LE in all countries. The analysis of countries after stratification has demonstrated that economic growth has a more significant impact on countries with low values of LE, while emissions of CO2 have a more significant adverse effect on countries with a high LE. In addition, the HIV epidemic has reduced the growth of LE in countries of all types [8]. The study results depict the discrepancy between the Preston model implying high levels of well-being at a high level of gross domestic product in the form of values of the LE indicator. It indicates the need to consider the economic inequality in the territories [1; 21].

The health of the population is an integrated adaptive system with numerous dynamic nonlinear interactions between subsystems and determinants of various origins [14]. The interaction between determinants (factors) has a contextual character for a certain period, and their analysis should be multi-level and multi-scale, while intervention policies should be integrated. A comprehensive systematic approach to assessing the impact of factors of different nature on the health of the population is also discussed [23]. The health of the population should be considered as a complex system with several properties such as emergence, feedback, and adaptation. The authors raise the question of the need for a transition (shift) in the thinking of scholars from simple linear cause-and-effect models to the consideration of ways to study the processes and results of change at the level of the entire system.

The mathematical model underlying the methodology for predicting life expectancy describes a complex system of nonlinear cause-and-effect relationships between the analyzed determinants, which violates the additivity properties of the calculation results for various scenarios. For this particular reason, the growth potential of LE when combining individual scenarios by indicators or groups of indicators is not equal to the growth potential for the target scenario of a single change in the values of indicators by 2024. At the same time, the nonlinearity of the system of cause-and-effect relationships and the complexity of the mathematical model do not allow one to comprehensively analyze the patterns of formation of the growth potential of life expectancy and determine the structure of the contributions of individual determinants. Violation of the additivity properties of the calculation results for different scenarios is demonstrated in the table. It shows that the total value of the growth potential of LE from scenario changes in groups of indicators separately does not coincide with the results of a complex scenario change in all indicators. A negative value of the growth potential of LE is formed for a group of indicators of the health care system, which, in the initial analysis, may contradict the biological meaning in the implementation of the scenario change in indicators and the expected effect on LE. A more detailed analysis of this result indicates that the current situation on the indicators included in this group of determinants is more favorable in the territory of the analyzed subject of the Russian Federation compared to the rest of the regions of the Russian Federation.

The research results concerning the forecast assessment of the growth potential of LE on the example of the constituent entity of the Russian Federation as a whole demonstrate continuity in assessing the contribution of heterogeneous factors to the health of the population and complement and deepen the previously obtained research results in this area. Therefore, the most significant factors forming the growth potential of LE in the analyzed constituent entity of the Russian Federation are the determinants of the socio-demographic sphere and lifestyle of the population and factors of sanitary and epidemiological safety. Simultaneously, the model used for predictive assessment of the growth potential of LE has some limitations, such as the scope of the model definition; an adequate predictive assessment of the growth potential of LE is carried out only for the macro-level – constituent entities of the Russian Federation.

Conclusion

The result of the modeling of cause-and-effect relationships between the determinants of the habitat, quality and lifestyle, and the indicator of life expectancy of the population is an assessment of the growth potential of LE for one of the constituent entities of the Russian Federation. The research results are consistent with the previously set research goal to obtain forecast estimates of the growth potential of LE of the population on the example of one of the constituent entities of the Russian Federation, taking into consideration integrated heterogeneous factors that have a modifying effect on LE and the set tasks.

Using the mathematical model constructed within the framework of the presented research based on the baseline scenario allows one to obtain reliable estimates of life expectancy relative to the actual value of LE in the analyzed constituent entity of the Russian Federation in 2018. It indicates sufficient accuracy in forecasting the utilized model (the differences are 0.24 years [87.6 days]). The conditional decomposition of the entire set of analyzed determinants into separate groups and their further analysis in the form of individual scenarios of their change by 2024, followed by ranking of the values of the growth potential of LE, demonstrate compliance with the current paradigm of the priority of the influence of social, lifestyle, and environmental determinants on the health of the population. In the target scenario of changes in the entire set of analyzed determinants, the value of LE is 70.47 years, and the growth potential is 1.24 years (453.0 days). The highest forecast values of the growth potential of life expectancy are "Indicators of the socio-demographic sphere" (+2.6 years [950.0 days]), "Indicators of sanitary and epidemiological safety of territories" (+1.75 years [640.0 days]), and "Indicators of the lifestyle of the population" (+1.41 years [515.4 days]).

The developed algorithm for determining the growth potential of life expectancy of the population can act as a tool for determining priority factors/groups of factors that affect the integral indicator of health (LE) in the territory for people who make managerial decisions in the area of improving the quality and life expectancy of the population. Additionally, the proposed assessment model corresponds to modern ideas regarding the health of the population as a complex system that requires a multi-faceted approach in research, analysis, and interpretation of results.

Promising areas described in the paper are (1) expanding the scope of the model definition by updating statistical data, (2) obtaining estimates at the meso-level (based on municipal data of constituent entities of the Russian Federation), and (3) developing a model for assessing the growth potential LE on the example of other countries (CIS, BRICS, and EU) for cross-country comparison opportunities.

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