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Research article

LIFE EXPECTANCY AT BIRTH IN RF REGIONS WITH DIFFERENT SANITARY-EPIDEMIOLOGICAL WELLBEING AND DIFFERENT LIFESTYLES. MANAGEMENT RESERVES

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The article focuses on estimating reserves of growth in life expectancy at birth (LEB) for the RF population in regions with different sanitary-epidemiological wellbeing and people's lifestyles. The existing trends in the country development within the regional context corroborate relevance of the present study.

The methodical approach includes use of factor and cluster analysis, artificial neural networks, and scenario forecasting. Activities performed by Rospotrebnadzor within its authority produce positive modifying effects on LEB as an integral health indicator. Differentiated contribution made by these activities to achieving regional target LEB levels by 2024 (COVID-related processes excluded) amounts to 8–62 % as per the group of indicators that describes a sanitary-epidemiological situation on a given territory and 5–45 % as per the group of lifestyle-related indicators.

We identified priority factors for each of four types of regions; these factors provide the maximum positive effect on LEB. Working conditions for working population, quality of drinking water, ambient air and nonfoods are priority manageable factors in regions where the sanitary-epidemiological situation is the most unfavorable. Levels of alcohol and food consumption, balanced diets and people's physical activity are the priority manageable factors in regions with the most unfavorable lifestyle-related indicators.

The study revealed that additional LEB growth would be secured if the targets set within national projects were achieved. By 2024, this additional LEB growth would equal 6–420 days and 107–659 days accordingly given the existing trends and regional differentiation as regards improved sanitary-epidemiological situation in regions and people's lifestyles. Improved working conditions, better quality of drinking water and ambient air are reserves of LEB growth for all types of the RF regions in short and middle-term. A potential reserve of LEB growth and priority determinants were identified for each type of regions. These identified national and regional determinants should be considered when building an optimization model of LEB management allowing for reserves of its growth.

The study results develop the authors' methodical approach to estimating potential LEB growth based on scenario modeling; they are consistent with the results obtained by other relevant studies. We have identified limitations of the present study as well as prospects and trends for future research.

Keywords: *life expectancy at birth, LEB, socio-hygienic determinants, environmental factors, lifestyle factors, sanitary-epidemiological wellbeing, RF regions, forecast, artificial neural networks, cluster analysis.*

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Over the last three years (2020–2022), the medical-demographic situation has deteriorated due to the COVID-19 pandemic, a global adverse factor [1, 2]. Although the number of confirmed cases and deaths caused by to COVID-19[1] has declined due to spread of Omicron (B.1.1.529) strain, which is more contagious and less pathogenic [3, 4], global outcomes of the pandemic are only becoming apparent now and we can expect more of them in future [5]. Forced concentration of production, research and social efforts on maintaining public healthcare systems has led to growing expenses or redistribution of funds previously allocated on programs aimed at providing sustainable economic development [6]. This also concerns national programs[2] [7] aimed at satisfying the existing population needs as regards minimizing influence exerted on the environment [8]. The immediate forecasts issued by the RF Ministry of Economic Development [9] expect economic recession in developed countries and stricter sanctions; this can become additional risk factors for public health. The IHME[3] experts [10] put forward a concept of a syndemic which will combine aggravation of chronic diseases, social inequality and the COVID-19 pandemic. This combination makes population groups with the existing burden of diseases even more vulnerable. Therefore, some additional risk factors have already been described by now and more are expected to occur in future against the background of the global imperative to ease off the global burden of diseases [11–14].

The authors of the Global Burden of Diseases study analyzed 286 death causes, 369 various diseases and injuries and 87 health risk factors in 204 countries. They concluded that the greatest share of disease prevention was based on a complex approach aimed at mitigating effects produced by risk factors (environmental, occupational, behavioral and metabolic ones). They also noted that the leading role here belonged to the Social Determinants of Health (SDoH for short) [15]. The authors also highlighted that it was vital to trace influence exerted by risk factors on public health and to estimate its intensity in dynamics (a decline, stagnation or growth). This makes it possible to timely adjust managerial decisions on minimizing effects produced by such factors.

Deep integration interactions between different countries given the globalization and digitalization on the global scale exert their influence on internal policies. Thus, for example, the global trends in sustainable development [16] are presented in this or that form in the programs for national development of the Russian Federation and are being implemented by step-by-step achievement of target indicators outlined in the National projects[4] and state programs[5] taking into account environmental issues[6] and spa-

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[1] Daily new confirmed COVID-19 cases and deaths per million people. *Our World in Data*. Available at: https://ourworldindata.org/explorers/coronavirus-data-explorer?zoomToSelection=true&time=2022-01-01..latest&uniformYAxis=0&hideControls=true&Metric=Cases+and+deaths&Interval=Cumulative&Relative+to+Population=false&Color+by+test+positivity=false&country=OWID_WRL~RUS (November 15, 2022).

[2] Kreml' dopustil korrektirovku natsproektov iz-za pandemii [The Kremlin admits necessary adjustment of the National projects due to the pandemic]. *RBK*. Available at: https://www.rbc.ru/politics/03/05/2020/5eaece1e9a7947b157729429 (November 03, 2022) (in Russian); National Projects: Expectations, Results, Outlook. *ROSCONGRESS*. Available at: https://roscongress.org/en/materials/natsionalnye-proekty-ozhidaniya-rezultaty-perspektivy/ (November 03, 2022); A black swan with white feathers. The state of the Russian economy during the pandemic. *ROSCONGRESS*. Available at: https://roscongress.org/en/materials/chernyy-lebed-s-belymi-peryami-ekonomika-rossii-v-epokhu-koronakrizisa/ (November 03, 2022).

[3] IHME is the abbreviation for the Institute for Health Metrics and Evaluation.

[4] Natsional'nye proekty [The National projects]. *The Russian Government*. Available at: http://government.ru/rugovclassifier/section/2641/ (October 16, 2022) (in Russian).

[5] Gosudarstvennye programmy [The State programs]. *The Russian Government*. Available at: http://government.ru/rugovclassifier/section/2649/ (October 16, 2022) (in Russian).

[6] Ob ogranichenii vybrosov parnikovykh gazov: Federal'nyi zakon ot 02.07.2021 № 296-FZ [On limiting emissions of greenhouse gases: The Federal Law issued on July 02, 2021 No. 296-FZ]. *KonsultantPlus*. Available at: http://www.consultant.ru/document/cons_doc_LAW_388992/ (November 11, 2022) (in Russian); Ob utverzhdenii strategii sotsial'no-ekonomicheskogo razvitiya Rossiiskoi Federatsii s nizkim urovnem vybrosov parnikovykh gazov do 2050 goda: Rasporyazhenie Pravitel'stva RF ot 29.10.2021 № 3052-r [On Approval of the strategy for socioeconomic development of the Russian Federation with low emissions of greenhouse gases for the period up to 2050: The RF Government Order issued on October 29, 2021 No. 3052-r]. *KonsultantPlus*. Available at: http://www.consultant.ru/document/cons_doc_LAW_399657/ (November 11, 2022) (in Russian).

tial differentiation of the RF regions[7]. Successful implementation of these activities largely depends on a regional context in different RF regions since the country territory is relatively extensive and huge. The current officially acknowledged[7] basic issues related to spatial development of the Russian Federation include high intra- and inter-regional socioeconomic inequality, uncomfortable urban environment, poor quality of the environment in large urban agglomerations (where population exceeds 500 thousand people), negative effects produced by the global climate change etc. Complex and differentiated approaches that consider a specific demographic situation, socioeconomic peculiarities and natural and climatic conditions in different RF regions have been selected as the guidelines[7, 8] for finding solutions to the issues outlined above.

According to the forecasts by the RF Ministry of Economic Development, key trends in the economic policy in the middle term are going to include "spatial development that involves reduction in inter-regional differentiation in the quality of life…" and "development of human capital through raising quality and availability of healthcare, education, culture, environment and safety (considering the higher requirements to the quality of life) by using the most advanced technologies" [8].

Given that, it seems only logical that the information space now provides data on region ratings as per the quality of life[9] and management quality[10] made by using calculated indexes and experts estimates as per indicator groups that describe different spheres in people's activities.

Therefore, there are certain predispositions for new emerging risk factors and more precise definition of the existing ones since they modify the medical and demographic situation on the global scale against the background of all the efforts taken to decrease the global burden of diseases, a regional context considered. These predispositions determine the necessity to accomplish studies that address prediction and assessment of available public health potential in a territorial aspect.

The present study develops methodical approaches to predicting changes in life expectancy at birth given the occurring transformations of socio-hygienic determinants that modify it. Previously, the authors created a list of socio-hygienic determinants (SHDs) of life expectancy at birth[11] based on the results obtained by relevant and topical studies on epidemiology of non-communicable diseases. ANNs were applied to create models within 'SHDs – LEB' system followed by estimating a potential growth in LEB in the Russian Federation as a whole [17] and in a given RF region [18] considering the target indicators outlined as goals within the National and Federal projects aimed at improving the quality of life in the country.

The current research in the sphere and the state projects being implemented at the moment gave grounds for the basic scope of the

[7] Ob utverzhdenii Strategii prostranstvennogo razvitiya Rossiiskoi Federatsii na period do 2025 goda: Rasporyazhenie Pravitel'stva RF ot 13.02.2019 № 207-r (red. ot 30.09.2022) [On Approval of the strategy for spatial development of the Russian Federation for the period up to 2025: The RF Government Order issued on February 13, 2019 No. 207-r (last edited on September 30, 2022)]. *KonsultantPlus*. Available at: http://www.consultant.ru/document/cons_doc_LAW_318094/ (November 12, 2022) (in Russian).

[8] Ob utverzhdenii Osnov gosudarstvennoi politiki regional'nogo razvitiya Rossiiskoi Federatsii na period do 2025 goda: Ukaz Prezidenta ot 16.01.2017 № 13 [On Approval of the Fundamentals of the state policy for the regional development in the Russian Federation for the period up to 2025: The RF President Order issued on January 16, 2017 No. 13]. *KonsultantPlus*. Available at: http://www.consultant.ru/document/cons_doc_LAW_210967/ (November 12, 2022) (in Russian).

[9] Luchshie regiony dlya zhizni. Reiting RBK [The best regions for living. RBK rating]. *RBK*. Available at: https://www.rbc.ru/economics/26/04/2021/6078136e9a7947d0e9e1b1fb (October 26, 2022) (in Russian).

[10] Turovskii R.F., Orlov D.I. IX reiting effektivnosti upravleniya v sub"ektakh Rossiiskoi Federatsii v 2021 godu [IX rating of management efficiency in the RF regions in 2021]. *APEC: the Agency for Political and Economic Communications*. Available at: http://www.apecom.ru/projects/item.php?SECTION_ID=91&ELEMENT_ID=7691 (October 26, 2022) (in Russian).

[11] MR 2.1.10.0269-21. Opredelenie sotsial'no-gigienicheskikh determinant i prognoz potentsiala rosta ozhidaemoi prodolzhitel'nosti zhizni naseleniya Rossiiskoi Federatsii s uchetom regional'noi differentsiatsii: metodicheskie rekomendatsii [MG 2.1.10.0269-21. Identification of socio-hygienic determinants and prediction of a potential growth in life expectancy at birth for the RF population, regional differentiation taken into account: methodical guidelines]. Moscow, 2021, 113 p. (in Russian).

present study and corroborated its relevance. **The aim** was to establish regularities of influence, both at the country and regional levels, exerted by indicators describing sanitary-epidemiological wellbeing and lifestyle-related ones on LEB and to estimate reserves of managing this public health indicator considering activities performed by Rospotrebnadzor and implementation of the national and regional projects in the middle and long term.

To achieve this aim, several tasks were set and then solved: 1) to identify different types of RF regions and distribute them into specific groups as per these types considering sanitary-epidemiological wellbeing (SEW for short) and lifestyles; 2) to set scenario changes in socio-economic determinants in the middle term (up to 2024) according to the existing trends and targets outlined in the Federal and regional projects; 3) to calculate predicted LEB levels in RF regions (by 2024) with different SEW and lifestyles as per preset scenarios; 4) to establish available reserves for LEB management as regularities and peculiar effects produced on the indicator by regionally differentiated SEW indicators and lifestyle-related ones.

Materials and methods. Life expectancy at birth and factors that can modify it, both environmental and lifestyle-related ones, were selected as our research objects. Official statistical data over the period in 2010–2018 on all the RF regions were taken from the open sources and applied as initial data in socio-hygienic determinants and LEB levels. In conformity with the Methodical guidelines MR 2.1.10.0269-21 'Identification of socio-hygienic determinants and prediction of a potential growth in life expectancy at birth for the RF population, regional differentiation taken into account'[11], the list of the examined indicators included 148 socio-hygienic determinants that were conditionally aggregated into 6 groups: sanitary-epidemiological wellbeing (53 indicators), socio-demographic indicators (34), lifestyle-related indicators (30), economic indicators (14), public healthcare (9 indicators), nature and climate (8 indicators).

We performed k-means clustering to identify what RF regions were comparable as per SEW indicators and lifestyle-related ones; the analysis relied on 2018 data. Each examined group of determinants was divided into 4 clusters. Next, all the RF regions were compared as per their belonging to specific clusters in the analyzed groups of socio-hygienic determinants.

Analysis as per groups of SEW indicators and lifestyle-related ones was performed with these factors viewed as potentially manageable by activities performed by the sanitary-epidemiological service in accordance with its authority and considering the existing trends and additional effects produced by activities accomplished within the projects being implemented in the country.

Clusters were ranked from conditionally 'the best' to 'the worst' ones within the analyzed groups of socio-hygienic determinants; this was done by ranking average cluster values in these groups and the resulting biggest sum of all the ranks in a given group was considered 'the worst'. To perform comparative assessments, we ranked the RF regions as per ultimate effects on LEB produced in clusters of the analyzed indicator groups.

Available reserves for managing LEB through predicting its potential growth were identified in accordance with the algorithm described in the MR 2.1.10.0269-21[11], with using a neural network model (a four-layer perceptron with two internal layers containing 8 and 3 neurons accordingly, the determination coefficient (R^2) of the ultimate model was equal 0.78); analyzing cause-effect relations between environmental factors and lifestyle-related ones (socio-hygienic determinants) and LEB; the next stage involved identifying the ultimate predicted LEB level based on scenario changes in either all the socio-hygienic determinants or some specific ones.

In accordance with the algorithm described in the MR 2.1.10.0269-21[11], scenario changes in socio-hygienic determinants (independent variables) were set within the baseline scenario as equal to their values that were actually registered in 2018 (a pre-COVID period); the data on 2018 were taken from open official statistical sources. To achieve the aim of the study and

solve tasks set within it, we parameterized predictive scenarios only as regards SEW indicators and lifestyle-related ones; all the other indicator groups were considered background characteristics of the analyzed territories. Target values set for two analyzed groups of socio-hygienic determinants (sanitary-epidemiological wellbeing and lifestyle) were specified in accordance with the target indicator levels outlined in the National and Federal projects[12] and calculated (predicted) indicator levels as per linear / logarithmic trends by 2024 (the highest value of the determination coefficient R^2 was used as the criterion).

Predicted LEB levels (by 2024) were calculated and reserves for managing this indicator in RF regions with different sanitary-epidemiological wellbeing and lifestyles were identified using an algorithm that included several stages. First, baseline and target scenarios were created to describe changes in indicators characterizing socio-hygienic determinants for different types of the analyzed territories. Next, predicted LEB levels were calculated for different types of territories in accordance with baseline and target scenarios. Last, we calculated a potential growth in LEB for different territories (as difference in model LEB levels as per a baseline and target scenario) followed by identifying reserves for managing this indicator.

We analyzed reserves for managing life expectancy at birth relying on predicted estimations of a growth in this indicator (potential LEB growth). The analysis considered scenario changes in the analyzed socio-hygienic determinants, all-country regularities and regional peculiarities as well as the existing unrealized potential due to targeted management of priority SEW indicators and lifestyle-related ones.

Mathematical modeling and statistical analysis of the initial data with subsequent analysis and visualization of its results were accomplished in software packages for mathematical computations and statistical data analysis (Statistica 10, RStudio, MS Excel 2010).

Results and discussion. K-means clustering gave an opportunity to distribute the RF regions into different clusters within the analyzed groups of socio-hygienic determinants (Figure 1).

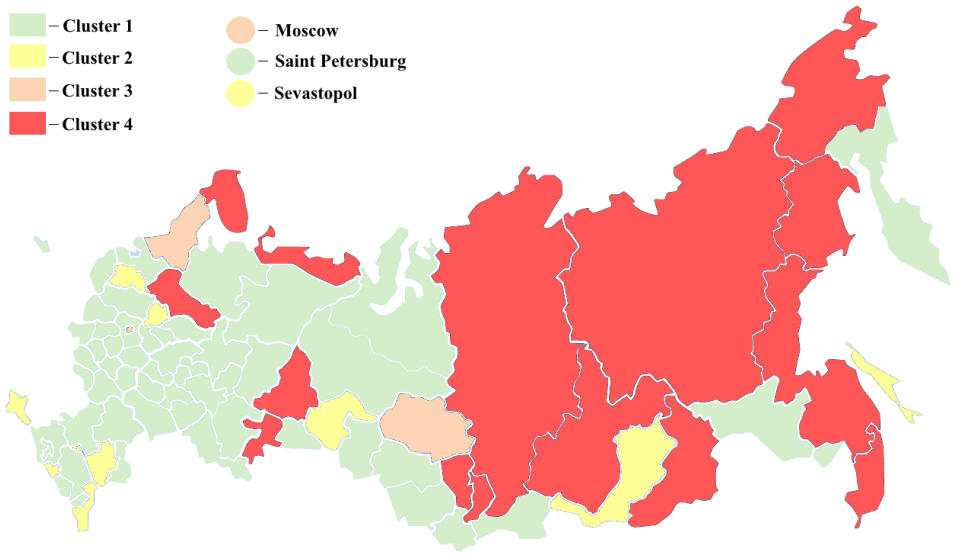
Since there was significant differentiation of the RF regions, we ranked the clusters within each of the analyzed groups of socio-hygienic determinants (Table 1).

Conditionally ‘the best’ and ‘the worst’ clusters (Table 1) were identified by ranking average cluster values of indicators in the RF regions as per clusters within the analyzed groups of socio-hygienic determinants.

Clusterization of the RF regions within the group comprising **indicators of sanitary-epidemiological wellbeing** (Figure 1a) has revealed that the RF regions that were assigned to the **first cluster** have comparatively higher levels of sanitary-epidemiological wellbeing against other clusters (Table 2).

This cluster has the greatest number of the RF regions, namely 57 (the Leningrad region, Tula region, Belgorod region, etc.). The regions in this cluster typically have the lowest share of drinking water sources that do not conform to the sanitary standards and rules (10.6 % of centralized water supply sources; 11.7 %, non-centralized ones; 14.6 % of surface sources and 10.0 % of underground ones). Also, the share of soil samples deviating from the standards is the lowest in this cluster and equals 3.6 % as regards sanitary-chemical indicators and 2.7 % as regards levels of heavy metals. The cluster has the greatest share of population provided with qualitative drinking water (95.3 % of the urban population and 79.3 % of the rural population). Also, the cluster has the lowest share of food samples that do not conform to the existing sanitary-epidemiological requirements as per sanitary-chemical (0.4 %) and microbiological indicators (3.5 %). The cluster has the lowest share of working population who has to work under conditions deviating from the hygienic standards (34.9 %) including exposure to such

[12] Natsional'nye proekty [The National projects]. *The Russian Government*. Available at: http://government.ru/rugovclassifier/section/2641/ (October 16, 2022) (in Russian).



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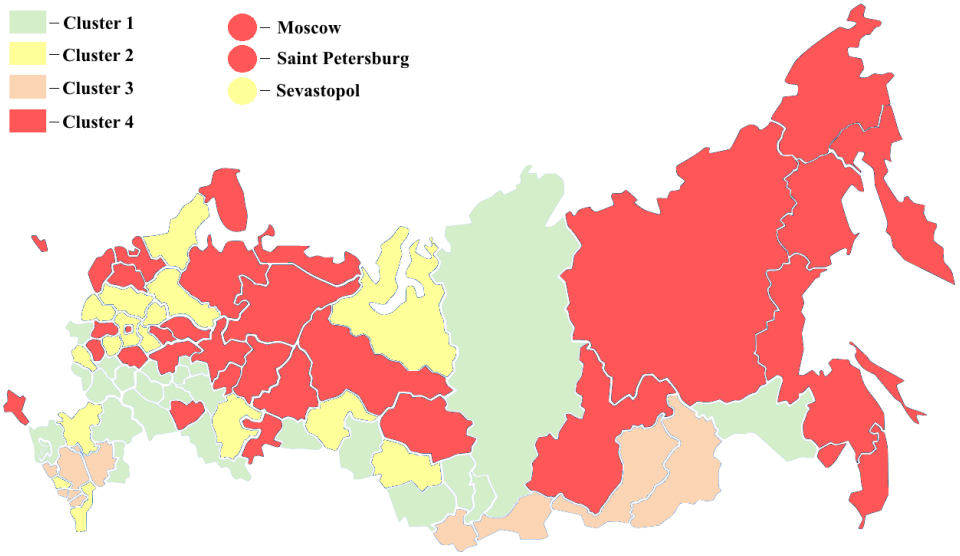

b

Figure 1. Results of clusterization in groups of SEW indicators (a); lifestyle-related indicators (b)

Table 1

Cluster ranking within groups of socio-economic determinants

A group of socio-economic determinants	Number of a cluster*	Rank sum	Number / share of regions in a cluster **
Indicators of sanitary-epidemiological wellbeing	1	120	57 (67.1 %)
	2	147	10 (11.8 %)
	3	149	3 (3.5 %)
	4	174	15 (17.6 %)
Lifestyle-related indicators	1	43	24 (28.2 %)
	2	57	17 (20.0 %)
	3	57	10 (11.8 %)
	4	63	34 (40.0 %)

N o t e : * means that coloring matches the qualitative attribute of ‘the best’ (green) and ‘the worst’ (red) cluster as per the quantitative attribute ‘Rank sum’; the higher the sum, the ‘worse’ (conditionally) the cluster is within the analyzed group of socio-hygienic determinants; ** means that a share of the regions in a cluster out of the total number of RF regions is given in brackets.

Table 2

Cluster ranks within the groups of indicators that describe sanitary-epidemiological wellbeing

Groups of indicators describing sanitary-epidemiological wellbeing	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Ambient air quality	2	3	1	4
Drinking water quality	1	4	3	2
Soil quality	1	3	2	4
Physical factors in urban settlements (noise, EMR)	2	1	4	3
Quality of non-foods	2	4	1	3
Quality of foods	1	2	4	3
Quality of workplaces	2	1	3	1
Typical categories of objects as per their sanitary-epidemiological profiles	2	2	1	2
Economic entities as per risk categories	2	1	1	1
Working conditions deviating from the existing hygienic standards	1	1	2	3
Rank sum	19	22	24	27

Note: different colors of the table cells correspond to average cluster values as per priorities where red means the worst attributes and green means the best ones.

harmful factors as vibration (4.1 %), non-ionizing radiation (0.9 %), work hardness (17.4 %) and intensity (4.3 %). Still, the cluster holds the second rank place as per emissions from stationary sources (157 thousand tons per year) and the first rank place as per the share of soil samples that do not conform to the existing standards as per parasitological indicators (1.5 %). In 2018, LEB levels varied between 66.47 and 82.41 years in the regions in this cluster.

The second cluster as per sanitary-epidemiological wellbeing includes 10 RF regions (the Novgorod region, the Yaroslavl region, Republic of Crimea, etc.). Emissions of pollutants are lower in this cluster, both from stationary and mobile sources (55.6 thousand tons and 98.2 thousand tons per year accordingly). But the share of drinking water sources that do not conform to the sanitary standards and rules is the highest in this cluster (39.5 % of centralized water supply sources and 44.9 % of non-centralized ones; 50.7 % of surface sources and 36.9 % of underground ones). The cluster has a relatively high share of soil samples that deviate from the hygienic standards as per sanitary-chemical indicators and levels of heavy metals (7.0 % and 7.2 % accordingly) but the share of samples deviating from the standards as per microbiological indicators is quite low (3.5 %). The share of working people who have to work under conditions not conforming to the existing hygienic standards is relatively lower than in other clusters (35.1 %); the lowest shares were identified as regards exposure to such occupational factors as noise (15.4 %), biological factors (0.5 %), and adverse microclimate (2.9 %); but the share of working people exposed to chemical factors at their workplaces was rather high (6.9 %). The cluster has the high share of ambient air samples with chemical contents exceeding MPC in rural areas (3.9 %). In 2018, LEB levels varied between 69.92 and 78.69 years in the regions in the second cluster.

The third cluster includes three RF regions (Moscow, Republic of Karelia and the Tomsk region). Just like other clusters, this one has several indicators of sanitary-epidemiological wellbeing with relatively higher average cluster values. In this cluster, there are higher shares of food raw materials and food products deviating from the existing sanitary-epidemiological requirements as per sanitary-chemical and microbiological indicators (0.68 % and 6.5 % accordingly); the cluster also has the highest share of workplaces that do not conform to the existing hygienic requirements as per noise and vibration (29.0 % and 47.3 % accordingly). In 2018, LEB levels varied between 70.56 and 77.84 years in the third cluster.

The fourth cluster includes 15 RF regions (the Chelyabinsk region, the Irkutsk region, Trans-Baikal territory, etc.). The sanitary-epidemiological situation is comparatively unfavorable there. This cluster has the highest average cluster values of emissions that pollute ambient air, both from stationary and mobiles sources (475.8 and 650.6 thousand tons accordingly); the share of ambient air samples with chemical contents exceeding MPC in urban areas is the highest (3.2 %). Drinking water quality is also relatively poor since the share of centralized water supply sources, including underground ones, which do not conform to the sanitary standards and rules, is high (22.8 % and 21.9 % accordingly). There are high shares of soil samples in the regions included into this cluster that do not conform to the hygienic requirements as per sanitary-chemical and microbiological indicators and levels of heavy metals (11.9 %, 11.4 % and 10.9 % accordingly). The cluster has the highest shares of food samples with levels of antibiotics deviating from the hygienic standards, namely 1.2 %, as well as the highest shares of non-foods deviating from the standards as per sanitary-chemical indicators, 10.1 %. The cluster has the highest share of working people who have to work under conditions not conforming to the existing hygienic standards, both as a whole (51.7 %) and as per specific factors (noise, 28.9 %; vibration, 10.3 %; work hardness, 27.7 % etc.). In 2018, LEB levels varied between 63.58 and 72.72 years. It is noteworthy, that most cities included into the 'Clean Air' Federal project (9 cities or 75 %) are located in the regions included into this cluster.

Clusterization of the RF regions within the group comprising **lifestyle-related indicators** (Figure 1b) revealed that the **first cluster** included 24 RF regions (the Orenburg region, the Volgograd region, Republic of Tatarstan, etc.). Just as it was the case with the group of indicators describing sanitary-epidemiological wellbeing, this cluster has a relatively more favorable situation as regards the analyzed group of indicators (Table 3). In this cluster, consumption of basic foods, including vegetables (23.4 %) and fruits (26.3 %) deviates from the recommended standards[13] only slightly; ethanol consumption per capita is comparatively low (7.5 liters per year per an adult person); the share of population who do sports or physical exercises is comparatively high (44.7 %). In 2018, LEB levels in the first cluster as per lifestyle-related indicators varied between 69.11 and 74.35 years.

The second cluster includes 16 RF regions (the Kursk region, the Novosibirsk region, the Yamal-Nenets Autonomous Area etc.). The cluster has the most optimal food consumption (close to the recommended standards with relatively smaller deviations) as regards vegetables (-18.1 %), fruits (-15.8 %), potato (-26.2 %), milk products (-10.2 %), and eggs (-4.2 %); still, some products are consumed in excessive quantities, namely meat and meat products (+37.3 %), sugar (+53.4 %) and butter (+13.8 %). Alcohol consumption is higher in this cluster than in the first or third one but lower than in the fourth one. In this cluster, the total number of sport objects and facilities is lower than in other clusters, in

Table 3

Cluster ranks within the groups of lifestyle-related indicators

A group of lifestyle-related indicators	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Quantitative attributes of food consumption by population	1	2	4	3
Quantitative attributes of retail alcohol sales to population	2	3	1	4
Population's physical activity	1	3	4	2

Note: different colors of the table cells correspond to average cluster values as per priorities where red means the worst attributes and green means the best ones.

[13] Ob utverzhdenii Rekomendatsii po ratsional'nym normam potrebleniya pishchevykh produktov, otvechayushchikh sovremennym trebovaniyam zdorovogo pitaniya: Prikaz Ministerstva zdravookhraneniya RF ot 19 avgusta 2016 g. № 614 [On Approval of the Recommendation on rational food consumption that meet the healthy diet requirements: The Order by the RF Public Healthcare Ministry issued on August 19, 2016 No. 614]. *GARANT: information and legal portal*. Available at: https://www.garant.ru/products/ipo/prime/doc/71385784/ (November 15, 2022) (in Russian).

particular, there are not enough gymnasiums and stadiums; still, the share of people who do sports or physical exercises is quite high in the cluster (42.24 % or the second rank place). The minimum and maximum LEB levels were 70.47 and 78.69 years accordingly in the regions in this cluster in 2018.

The **third cluster** as per lifestyle-related indicators includes 10 RF regions (Karachay-Cherkess Republic, the Altai Republic, Trans-Baikal territory, etc.). The cluster has the lowest retail alcohol sales (3.8 liters of ethanol per year per an adult person); still there are some deviations in food consumption, which is lower than the recommended standards as regards some foods (vegetables, -35.9 %; fruits, -41.4 %; milk products, -27.4 %; fish and sea foods, -37.1 %). The share of population who do sports or physical exercises is rather low (40.1 %). In 2018, LEB levels in the third cluster as per lifestyle-related indicators varied between 66.47 and 82.41 years.

The fourth cluster includes 34 RF regions (the Kirov region, the Orel region, the Sverdlovsk region, etc.) and the situation there as per lifestyle-related indicators could be described as 'less favorable' in comparison with three other clusters. Retail alcohol sales are the highest in this cluster (10.7 liters per year per an adult person). Some products are consumed in quantities lower than the recommended standards[14] (vegetables, -34.6 %, fruits, -32.8 %, etc.); the share of population who do sports or physical exercises is also low, 39.7 %, despite quite well-developed sport infrastructure (237 sport facilities per 100 thousand people). The minimum and maximum LEB levels were 63.58 and 77.84 years accordingly in the regions in this cluster in 2018.

We relied on the results obtained by clusterization to estimate a potential growth in LEB considering the existing trends and additional influence exerted by the National and Federal projects being implemented now. The estimation revealed significant differentiation of effects produced on LEB by specific sub-groups of SEW indicators and life-style related ones as well as the whole indicator groups in regions that belonged to different types (clusters).

In the RF as a whole, at present we can expect variable effects produced by indicators describing **sanitary-epidemiological wellbeing** by 2024 considering the current trends, from -289 days to +1398 days. Negative effects on LEB as per the current trends are detected in some regions in the 3rd and 4th clusters where deviations from the sanitary standards as per specific SEW indicators are the greatest and / or there are negative short-term trends (by 2024) in determinants included in this group.

The **fourth type** (cluster) is characterized with effects on LEB within the range between (-289) and +220 days due to changes in sanitary-epidemiological determinants by 2024 according to the current trends. Positive effects that predict a LEB growth are produced by improved working conditions, better quality of non-foods, and better drinking water quality (Figure 2b). On average, the smallest effects on LEB according to the current trends are produced in this cluster by soil quality, quality of foods, and risk categories of economic entities as regards possible violations of sanitary-epidemiological requirements. A negative effect on LEB is produced in this cluster, according to the current trends, by soil quality.

Implementation of the 'Clean Air', 'Clean Water' and some other Federal projects in the regions included in this cluster can produce additional positive effects on LEB within the range from 9 to 420 days. These variations occur due to other significant trends in indicators of sanitary-epidemiological wellbeing and internal relations between specific determinants in this group. Still, we have a significant reserve for a LEB growth due to improvement of other sanitary-epidemiological indicators even if changes in them would not lead to significant improvement in the sanitary-epidemiological situation in the regions in this cluster by 2024 (Figures 2a and 2b). Thus, implementation of the National projects and achieving 'better'

[14] Ob utverzhdenii Rekomendatsii po ratsional'nym normam potrebleniya pishchevykh produktov, otvechayushchikh sovremennym trebovaniyam zdorovogo pitaniya: Prikaz Ministerstva zdravookhraneniya RF ot 19 avgusta 2016 g. № 614 [On Approval of the Recommendation on rational food consumption that meet the healthy diet requirements: The Order by the RF Public Healthcare Ministry issued on August 19, 2016 No. 614]. *GARANT: information and legal portal*. Available at: https://www.garant.ru/products/ipo/prime/doc/71385784/ (November 15, 2022) (in Russian).

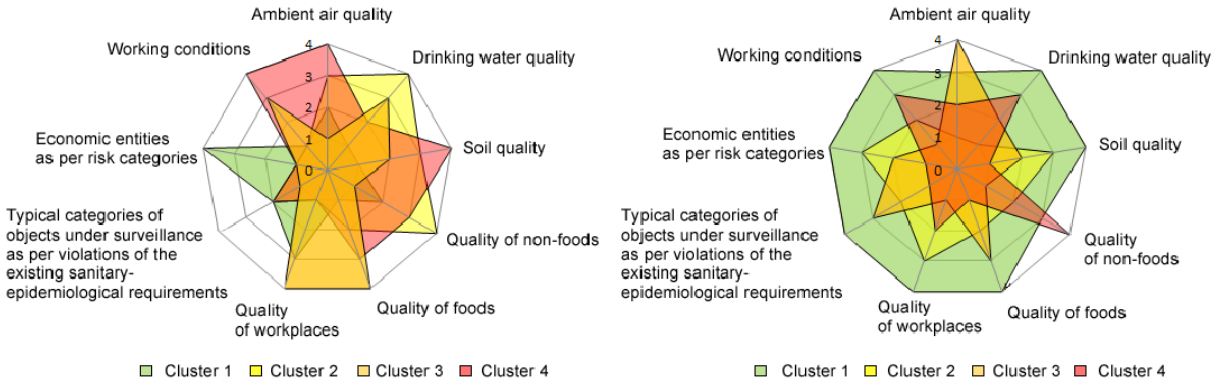

Figure 2. Cluster ranking in the group of indicators that describe sanitary-epidemiological wellbeing: (a) as per rank values of indicators in 2018; (b) as per aggregated effects produced on LEB by indicator sub-groups by 2024 (the 1st rank means the most favorable situation / the smallest effect on LEB; the 4th rank means the least favorable situation / the greatest effect on LEB)

levels of indicators that do not conform to the existing sanitary-epidemiological requirements (achieving levels that are as close to the hygienic standards and requirements as possible) can secure a growth in LEB in this cluster that at best would reach 740 days.

In **the 3rd cluster,** effects produced on LEB by 2024 as per the existing trends vary between -191 days and +1398 days. In the short term, the greatest positive effect on LEB is expected to be produced by better ambient air quality, better quality of foods, and typical categories of objects under surveillance as per violations of the existing sanitary-epidemiological requirements. The smallest effects are expected to be produced by changes in working conditions, quality of workplaces, and quality of non-foods. The current trends in drinking water quality produce negative effects on a potential LEB growth in some regions in the cluster. Implementation of the existing Federal projects can secure an additional growth in LEB up to 42 days. Improved working conditions, quality of workplaces and drinking water quality might be considered additional reserves for a LEB growth by 2024 (Figures 2a and 2b).

The current trends in sanitary-epidemiological determinants in the **2nd cluster** can produce effects on LEB by 2024 that vary between -39 and +853 days. A potential growth in LEB in this cluster is largely expected due to better soil quality, better quality of working places, and risk categories of economic entities. Negative effects on LEB are produced by the current trends in ambient air quality and drinking water quality. Implementation of the National and Federal projects in the regions included in this cluster will secure an additional 10 % growth in effects produced on LEB given the existing trends in sanitary-epidemiological indicators. Besides, there is an additional reserve for a LEB growth due to further improvement of drinking water and ambient air quality.

The regions in the **1st cluster** have a comparatively more favorable sanitary-epidemiological situation against other clusters. According to the current trends, a potential LEB growth by 2024 equals 100–318 days in this cluster. The regions in this cluster have managed to achieve a LEB growth most successfully; this became possible largely due to managing most sanitary-epidemiological indicators that are priority ones in this cluster. They include drinking water quality, soil quality, working conditions etc. Implementation of the Federal projects, in case their targets are achieved as regards relevant indicators, will secure an additional positive effect on LEB by 2024 that will vary between 6 and 57 days. Reserves for an additional LEB growth include minimization of negative effects produced on public health due to further improvement of working conditions, ambient air quality and quality of non-foods.

An expected change **in lifestyle-related indicators** by 2024, considering additional influence exerted by the National and Federal projects being implemented now, can lead to a LEB growth that will vary between 107 and 659 days in the country as a whole. Differences between regions as per effects on LEB occur due to both baseline levels of the ana-

lyzed lifestyle-related indicators and registered trends in these determinants (Figure 3a).

The regions in the **1st cluster** have the most favorable levels of lifestyle-related indicators; a potential LLEB growth there varies between 1070 and 280 days. Potentially, the greatest growth in LEB may occur due to achieving targets stipulated by the 'Public Health Improvement' Federal project[15] and 'Sport as a Standard of Life' Federal project[16], namely, a decline in alcohol consumption and greater physical activity in accordance with the regional targets. Potentially, a further LEB growth might be achieved in this cluster as per this indicator group due to even greater decline in alcohol consumption.

In **the second and third clusters,** the current trends by 2024 and implementation of the relevant projects may secure a LEB growth between 229 and 352 days and 266 and 654 days accordingly. This effect on LEB in these clusters can largely be secured due to achieving optimal levels of food consumption (close to rational food consumption recommended by the RF Public Healthcare Ministry[17]). Greater physical activity by population and food consumption close to its optimal levels (vegetables, fruits, meat products, etc.) can secure an additional growth in LEB in these regions.

A potential LEB growth **in the fourth cluster** can be achieved by expected encompassing improvement of all the sub-groups of lifestyle-related indicators. The greatest effect will occur due to alcohol consumption going down to its target levels[17] and optimal food consumption (meat products, milk products, vegetables, etc.). A potential growth in LEB by 2024 in this cluster would vary between 290 and 659 days in case of positive changes in relevant modifying lifestyle-related factors.

Modifying influence exerted by determinants that are being managed by Rospotrebnadzor activities can provide an additional contribution to achieving target LEB levels by 2024 (COVID-related processes excluded): 8–62 % due to an improved sanitary-epidemiological situation on a given territory and 5–45 % due to spreading healthy lifestyle practices.

It is noteworthy that modifying influence exerted on LEB by indicators of sanitary-epidemiological wellbeing and lifestyle-related ones occurs together with background effects produced by concomitant modifying factors (economic, socio-demographic, public healthcare, etc.). Changes in these factors can lead to changing intensity and direction of influence exerted by the analyzed factors that are being managed by Rospotrebnadzor activities.

a *b*

Figure 3. Cluster ranking in the group of lifestyle-related indicators: (a) as per rank values of indicators in 2018; (b) as per aggregated effects produced on LEB by indicator sub-groups by 2024 (the 1st rank means the most favorable situation / the smallest effect on LEB; the 4th rank means the least favorable situation / the greatest effect on LEB)

[15] Federal'nyi proekt «Ukreplenie obshchestvennogo zdorov'ya» ['Public Health Improvement' Federal project]. *Ministry of Labor and Social Protection*. Available at: https://mintrud.gov.ru/ministry/programms/demography/4 (November 23, 2022) (in Russian).

[16] Federal'nyi proekt «Sport – norma zhizni» ['Sport is a Standard of Life' Federal project]. *Ministry of Labor and Social Protection*. Available at: https://mintrud.gov.ru/ministry/programms/demography/5 (November 23, 2022) (in Russian).

[17] Ob utverzhdenii Rekomendatsii po ratsional'nym normam potrebleniya pishchevykh produktov, otvechayushchikh sovremennym trebovaniyam zdorovogo pitaniya: Prikaz Ministerstva zdravookhraneniya RF ot 19 avgusta 2016 g. № 614 [On Approval of the Recommendation on rational food consumption that meet the healthy diet requirements: The Order by the RF Public Healthcare Ministry issued on August 19, 2016 No. 614]. *GARANT: information and legal portal*. Available at: https://www.garant.ru/products/ipo/prime/doc/71385784/ (November 15, 2022) (in Russian).

In all the RF regions, reserves for a LEB growth include further improvement of a sanitary-epidemiological situation as well as individual and population lifestyles together with using the most optimal model for managing relevant determinants, regional differentiation and trends in the current demographic situation taken into account.

Discussion. The results obtained by scenario prediction of changes in socio-hygienic determinants indicate that greater effects might be secured as regards improvement of a medical-demographic situation due to achieving targets stipulated by the Federal and National projects that are being implemented now. Complex activities (National and Federal projects) can provide an effective tool for improving public health, especially on territories where the sanitary-epidemiological situation is unfavorable.

Complex influence exerted by environmental factors on public health is estimated regularly within varied research spheres and in inter-disciplinary studies that rely on using variable methodical approaches relevant to specific research aims and tasks. T.B. Melnikova with colleagues presented the results of regression and factor analysis that concentrated on cause-effect relations between a relatively small number of independent variables and the results obtained by a sampling observation over public health performed by Rosstat (health self-assessment); they established that sanitary-epidemiological factors and lifestyle-related ones made a significant contribution to people's self-assessment of their health [19, 20]. O.V. Kudelina and M.A. Kaneva comparatively analyzed available statistical indicators in their work (LEB, HALE[18], expenses on public healthcare and some others) in order to identify whether it was possible to apply them as indicators (proxy-variables) of health capital. They concluded that there was not any universal indicator and established that LEB and HALE were the optimal Impact[19] indicators; their ultimate conclusion was that an indicator should be chosen based on actual research tasks [21].

I.P. Shibalkov and O.P. Nedospasova applied several tools in their monograph to simulate cause-effect relations between LEB and environmental factors; in particular, the authors used a regression model, factor analysis and cluster analysis of RF regions. They concluded that considerable efforts should be taken to reduce social inequality as regards health along with developing medical services and technologies [22]. The methodical approach accepted in our studies involves analyzing a wider set of indicators and a greater period of their aggregation; it considers the whole set of factors together with their modifying interactions between each other and makes it possible to obtain quantitative estimations of effects produced on LEB, both aggregated ones and as per each factor independently (considering the background influences).

A.I. Piankova and T.A. Fattakhov performed decomposition analysis to estimate reserves for LEB growth in northern regions in Russia owing to declining mortality rates due to circulatory diseases and external causes [23]. In this study, we applied the systemic approach as regards creating scenarios of predicted changes in socio-hygienic determinants for different types of RF regions. This approach involves using both changing trends in a set of independent variables and target values of indicators stipulated in the National and Federal projects with subsequent determination of priorities and management reserves.

A similar approach to comparative assessment of RF regions as per several indicators related to living conditions and sufficient provision of public healthcare with all relevant reserves was applied by S.A. Boitsov with colleagues [24]. The authors noted in their work that quartile division as per YPLL[20] established that RF regions differed significantly as per their economic and geographical properties within quartiles. This indicated that public health depended on multiple factors, relations between the analyzed variables were not lin-

[18] HALE is healthy life expectancy.

[19] According to LogFrame methodology (the World Bank), the analyzed indicators are distributed as follows: Inputs – Outputs – Outcomes – Impact. The indicators in the Impact category are more efficient for measuring effects produced on certain spheres of human wellbeing.

[20] YPLL means years of potential life lost.

ear, and it was necessary to create multidisciplinary research teams in the field. In our study, an issue related to heterogeneity of the analyzed RF regions with subsequent comparative estimates was solved by identifying different types of regions within the analyzed groups of socio-hygienic indicators and distributing all the regions into different clusters as per these types. Besides, using an ANN model made it possible to consider non-linear interrelations between independent variables.

Extensive data that covered 148 determining indicators over 2010–2018 made it possible to create an optimal neural network model for predicting LEB levels and this is an obvious advantage of our study. But at the same time, the modeling results are limited by these data and it is impossible to make correct predictions of the current LEB levels considering, for example, effects produced by the COVID-19 pandemic, outcomes of economic sanctions and other global processes. Such predictions will require additional training of the ANN model. Indicators were conditionally distributed into groups as per information sources and / or meaning contents of an indicator thereby facilitating data analysis and presentation. However, if the groups are reconfigured, their aggregated effects on LEB might also change. There is one fundamental limitation of this study, namely LEB, the dependable variable we chose. It is considered a hypothetic value that projects the current mortality rates due to all causes onto the next generation. The list of the analyzed independent indicators also can impose certain limitations on the research results concerning effects produced on LEB. More specifically, influence exerted by other modifying factors may be neglected.

There are several promising trends in further development of this research area. They include making more precise lists of independent variables, including other criteria for selecting these independent indicators, standardizing indicator groups (to make them comparable with other studies); adjusting the model or calculating corrections that allow considering effects produced by the COVID-19 pandemic and economic transformations, or creating a new model; examining cause-effect relations between population mortality due to varied causes and socio-hygienic determinants to identify their contributions to final LEB levels and to present more detailed results. Besides, in future we are planning to optimize prediction methods and criteria for determining predictive values of determinants considering their ‘essence’ and rate of changes; we can also suggest certain solutions to the optimization task and an optimal management model.

Conclusions:

1. Activities performed by Rospotrebnadzor within its authority and aimed at providing sanitary-epidemiological wellbeing and spreading healthy lifestyle practices produce positive modifying effects on the integral health indicator, LEB: their contribution, considering significant differences between the RF regions, to achieving target regional LEB levels by 2024 (COVID-related processes excluded) varies between 8 and 62 % for the group of indicators that describe sanitary-epidemiological wellbeing on a given territory and between 5 and 45 % for the group of lifestyle-related indicators.

2. The RF regions differ as per a level of sanitary-epidemiological wellbeing and lifestyle-related indicators and modifying influence exerted by these factors on a potential growth in LEB in the short term are peculiar in different regions. Priority factors with the maximum positive effects on LEB have been identified for each type of regions. The fourth cluster with the least favorable sanitary-epidemiological situation has the following factors that are priority for management: working conditions, quality of non-foods, drinking water quality and ambient air quality. The fourth cluster with the least favorable lifestyle-related indicators has several priority factors that produce the greatest effects on LEB; they include alcohol consumption, rational food consumption and balanced diets, and physical activity by population.

3. Implementation of the National projects aimed at improving sanitary-epidemiological wellbeing and lifestyle-related indicators can secure an additional LEB growth by 2024 that will vary between 6 and 240 days and 107 and 659 days accordingly provided that the project targets have been achieved against the background of the current trends and regional differentiation.

4. Improved working conditions, better quality of drinking water and ambient air are reserves for a LEB growth for all the types of RF regions. They can secure a regionally differentiated positive effect on LEB both in the short and middle term. All the regions have this reserve for a growth in LEB due to improving the initial indicators of sanitary-epidemiological wellbeing on a given territory and lifestyle-related indicators. Effects produced by changes in them by 2024 will not lead to significant improvement of the sanitary-epidemiological situation in the country and population lifestyles without additional managerial decisions.

5. Indicators that describe a sanitary-epidemiological situation on a given territory and lifestyle-related indicators produce modifying effects on LEB against the background influence exerted by other factors (economic, socio-demographic, public healthcare, etc.); changes in these background factors can lead to changing intensity and direction of influence exerted by factors that are managed by Rospotrebnadzor activities. Differences in effects on LEB between the RF regions occur due to both initial (baseline) values and registered trends in the analyzed determinants.

6. The identified country and regional determinants should be considered when creating an optimization model of LEB management considering all available reserves for its growth.

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