EXPLORING THE SCENARIOS OF NATIONAL ECONOMY TRANSFORMATION IN CONDITIONS OF HEALTH DESTABILIZING FACTORS[1]

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Introduction. To develop scenarios for the transformation from the existing format of the national economy in Ukraine to an optimal one, it is necessary to take into account the experience of countries that have succeeded in achieving a certain level of resistance to the pandemic and demonstrated a high level of flexibility in various spheres of society in critical conditions. That is why it is expedient to form a sample of the world's countries to investigate the correspondence of the level of development of medical resilience and such spheres as political-institutional, financial-budgetary, and economic to the pandemic, which determined the primary goal of this research.

Literature review. The works of some scientists are devoted to researching issues of various kinds of transformation of the country. The authors of the work [1] proved

[1] This research was funded by the Ministry of Education and Science of Ukraine. Grant number: 0122U000781

that socio-economic development, well-being, and sustainable development significantly influence the transformation of the country. In contrast, political factors have little influence on the success of the restructuring process. In several works, the issues of digital transformation of countries due to technical improvements and the advantages they provide to an individual state over other countries are considered [2-4]. In [5], the authors focus on the scientific discussion of crucial economic, social, political, innovative, and technological factors affecting the country's transformation and brand. The authors of the work [6] define the factor of population migration as a critical factor in the formation of a resilient environment for the country's development and the factor that determines the pace of transformation of the national economy. Various aspects of the influence of public health factors on the country's growth are studied in works [7-9]. Very few works have been devoted to the quantitative study of the influence of public health factors on transformations in the national economy and the development of possible scenarios of this process, which determined the relevance of this study.

Results. The statistical base of the study was made up of 78 countries of the world, the choice of which is due to the availability of statistical data from open sources of information. It should be noted that even though specific indicators are also available for countries not included in the sample, they were rejected to avoid their inconsistency for further comparison due to the use of different calculation methods by the analytical agencies that publish them. Also, in the absence of at least one of the indicators' values included in the analysis for a particular country, it was excluded from the study. In the absence of indicator values in 2023 in open sources, the values of 2023 were calculated by extrapolation based on the available indicator values for the previous ten years, taking into account the trend of their change (linear, quadratic, or exponential).

To consider the state of development of the political-institutional, financial-budgetary, and medical spheres, integral indicators available in the consolidated statistics by country are considered. The level of development of the political and institutional sphere is determined by the International Property Rights Index (IPRI) [10], which evaluates the level of development of property rights institutions. This index measures such essential criteria of the country's growth as the level of independence of the judicial system, the level of corruption, the availability of loans, etc. Data on the development of the studied countries according to this index are presented in Table 1.

To assess the level of development of the financial and budgetary sphere of the country, the Total reserves indicator was chosen, which demonstrates the property status of the state at the end of the year, effectively describing the work of national monetary institutions (table 2).

To assess the medical field's development level, the Health Index Score by [12] is included in the analysis. This indicator measures how people are healthy and have access to the necessary services to maintain good health, including health outcomes, health systems, illness and risk factors, and mortality rates. The calculation considers the rank values according to this rating for each country, which are included in the analysis (table 3). To assess the level of development of the economic sphere of countries, there is no unified integral indicator that would fully describe the state of this sphere and would not correlate with previous indicators. Therefore, an integral indicator was built to evaluate the economic sphere. Key indicators of the country's economic development, such as Foreign direct investment, Gross national income, Inflation, and Unemployment, were chosen to construct the integral indicator. At the same time, we will consider Foreign direct investment and Gross national income as stimulators and Inflation and Unemployment as destimulants. The analysis of input data indicates the need for data normalization because for the "Foreign direct investment" indicator, the spread of statistical data is more than 700 billion USD dollars, and for "Inflation" – 70.

Table 1. The level of development of the political and institutional sphere of the analyzed countries according to the index IPRI

Country	IPRI	Country	IPRI	Country	IPRI	Country	IPRI	Country	IPRI	Country	IPRI
Chad	3.084	Colombia	4.562	Panama	5.098	Romania	5.786	Qatar	6.36	Japan	7.583
Nigeria	3.371	Kenya	4.614	Bulgaria	5.138	Slovakia	5.88	Portugal	6.385	Switzerland	7.619
Bangladesh	3.73	Dominican Republic	4.627	Greece	5.173	Chile	5.947	Israel	6.388	Austria	7.632
Pakistan	3.824	Mexico	4.627	Montenegro	5.174	Cyprus	5.975	Spain	6.502	Australia	7.688
Ukraine	4.011	Kazakhstan	4.64	Croatia	5.191	Slovenia	6.025	Czech Republic	6.577	Germany	7.748
Albania	4.119	Serbia	4.669	South Africa	5.192	Italy	6.038	Korea, Rep	6.685	Luxemburg	7.767
Ecuador	4.213	Moldova	4.72	Kuwait	5.23	Oman	6.081	France	7.056	Sweden	7.771
Turkey	4.243	Thailand	4.778	Armenia	5.246	Malta	6.089	Iceland	7.196	Norway	7.772
Egypt	4.355	Sri Lanka	4.836	China	5.336	United Arab Emirates	6.162	Belgium	7.341	New Zealand	7.793
Peru	4.37	Georgia	4.918	Rwanda	5.393	Malaysia	6.174	Ireland	7.418	Denmark	7.812
Philippines	4.396	Indonesia	4.996	Hungary	5.422	Latvia	6.183	Canada	7.42	Netherlands	7.853
Vietnam	4.414	India	5.072	Poland	5.458	Uruguay	6.347	United Kingdom	7.489	Singapore	7.958
Brazil	4.467	Azerbaijan	5.095	Saudi Arabia	5.714	Lithuania	6.36	United States of America	7.525	Finland	8.09

Source: built by the authors based on [10]

Table 2. The level of development of the financial and budgetary sphere of countries based on the Total reserves indicator (TR)

Country	TR	Country	TR	Country	TR	Country	TR	Country	TR	Country	TR
Chad	0.21	Lithuania	5.37	Finland	16.04	Hungary	41.22	Spain	92.91	Thailand	216.50
Malta	1.20	Iceland	5.89	Oman	17.61	Belgium	41.27	Philippines	96.04	Italy	224.58
Cyprus	1.67	Panama	6.88	Serbia	20.68	Qatar	47.39	Denmark	96.07	France	242.42
Rwanda	1.73	Kenya	7.97	Ukraine	28.51	Kuwait	52.46	Canada	106.95	Germany	293.91
Montenegro	2.04	Ecuador	8.46	Croatia	29.73	Romania	55.81	Malaysia	114.66	Singapore	296.63
Slovenia	2.27	Pakistan	9.93	Egypt, Arab Rep.	32.14	Australia	56.70	Turkiye	123.74	Brazil	324.67
Luxembourg	2.87	Slovak Republic	10.28	Portugal	32.23	Colombia	56.70	Indonesia	137.22	Korea, Rep.	423.37
Sri Lanka	3.14	Azerbaijan	11.29	Austria	33.08	South Africa	60.55	United Arab Emirates	138.43	Saudi Arabia	478.23
Armenia	4.11	Greece	12.06	Bangladesh	33.75	Netherlands	63.35	Czechia	139.98	India	567.30
Latvia	4.46	Ireland	13.04	Kazakhstan	35.08	Sweden	64.29	Poland	166.66	United States	706.64
Moldova	4.47	New Zealand	14.40	Nigeria	35.56	Norway	72.08	United Kingdom	176.41	Switzerland	923.63
Georgia	4.89	Dominican Republic	14.52	Chile	39.10	Peru	74.78	Israel	194.23	Japan	1227.57
Albania	5.27	Uruguay	15.13	Bulgaria	40.99	Viet Nam	86.54	Mexico	201.12	China	3306.84

Source: built by the authors based on [11]

Table 3. The level of development of the medical field of countries based on the Health Index Score indicator (HIS)

Country	HIS	Country	HIS	Country	HIS	Country	HIS	Country	HIS	Country	HIS
Singapore	1	Denmark	16	Thailand	31	Hungary	46	Albania	66	Moldova	93
Japan	2	Italy	17	Canada	32	Sri Lanka	47	Armenia	68	Philippines	96
Korea, Rep	3	Belgium	18	United Arab Emirates	33	Poland	48	United States of America	69	Ukraine	101
China	4	Malta	19	United Kingdom	34	Chile	51	Mexico	71	Montenegro	103
Israel	6	France	20	Uruguay	35	Peru	52	Romania	72	Bangladesh	106
Norway	7	Australia	21	Colombia	36	Croatia	53	Kazakhstan	77	Egypt	107
Iceland	8	Austria	22	Qatar	38	Oman	55	Serbia	80	India	112
Sweden	9	Ireland	23	Portugal	40	Saudi Arabia	56	Ecuador	82	Kenya	114
Switzerland	10	Slovenia	24	Greece	41	Panama	57	Brazil	83	Rwanda	116
Netherlands	11	New Zealand	25	Malaysia	42	Latvia	59	Azerbaijan	85	Pakistan	124
Luxemburg	12	Spain	26	Kuwait	43	Lithuania	61	Indonesia	87	South Africa	129
Germany	13	Czech Republic	28	Vietnam	44	Turkey	63	Dominican Republic	89	Nigeria	157
Finland	15	Cyprus	29	Slovakia	45	Bulgaria	65	Georgia	90	Chad	165

Source: built by the authors based on [12]

To bring the indicators to a comparable form, normalization according to the Harrington method was applied for each indicator (1):

$$e_j^* = \frac{2 \cdot e_j - \left(\max_c e_j + \min_j e_j\right)}{\max_j e_j - \min_j e_j} \qquad (1)$$

where e_j^* – the normalized value of the characteristics of the economic sphere for the *j*-th country; e_j – the actual value of the characteristics of the economic sphere for the *j*-th country; $\max_j e_j$ / $\min_j e_j$ – the maximum / minimum value of the characteristics of the economic sphere for the *j*-th country.

Thus, by applying data normalization, a comparable form of variables was achieved, namely their inclusion in the interval [-1;1]. To apply the integral index, a simple additive convolution was used, taking into account the stimulators and destimulants of the sphere (stimulators fall into the convolution with a "+" sign, and destimulants with a "-") sign because the data contain negative values, the weight of which is canceled during multiplicative convolution. The results of integral values of the development of the economic sphere are presented in Table 4.

Analysis of the level of development of countries in four spheres makes it possible to identify outsider countries in 3-4 studied spheres at once: Chad, Nigeria, Bangladesh, Pakistan, Ukraine, Albania, Ecuador, Turkey, Egypt, South Africa, Rwanda, Kenya, Montenegro, Moldova, Sri Lanka, Armenia, Georgia, Greece. On the contrary, according to the most investigated indicators, the leading countries are Singapore, Denmark, Norway, Germany, Australia, Switzerland, Japan, Korea, China, Israel, the USA, the United Kingdom, France, and Thailand. This makes it possible to assume that the development of these areas is interconnected and affects the country's ability to counter emergencies, such as pandemics. Therefore, in the study, the index of resilience to the pandemic was chosen to classify countries. As a target value for the future classification of countries and verification of correlation with medical, political-institutional, economic, and financial-budgetary spheres, the Global Health Security Index (GHS) was chosen as an integral indicator reflecting the preparedness of countries to counter epidemics and pandemics as destabilizing factors of national development. Among other indicators, it includes assessing the quality of work of relevant departments in preventing the spread of viral diseases, transparency of reporting, speed of response of the health care system to threats to public health, etc.

Table 4. Integral values of the level of development of the economic sphere of the studied countries (E)

Country	E	Country	E	Country	E	Country	E	Country	E	Country	E
Turkey	-1.70	Serbia	0.04	Bulgaria	0.25	Slovenia	0.45	Norway	0.64	Oman	0.80
South Africa	-1.18	Pakistan	0.05	Hungary	0.28	Brazil	0.46	Kazakhstan	0.66	Korea, Rep	0.82
Ukraine	-0.86	Spain	0.07	Cyprus	0.29	Iceland	0.48	Malaysia	0.70	Qatar	0.84
Sri Lanka	-0.86	Moldova	0.09	Panama	0.33	Netherlands	0.49	Philippines	0.70	Australia	0.84
Rwanda	-0.58	Armenia	0.13	Finland	0.35	Bangladesh	0.50	Israel	0.71	India	0.85
Montenegro	-0.46	Chile	0.15	Dominican Republic	0.36	Ireland	0.51	Kuwait	0.72	France	0.85
Luxemburg	-0.43	Azerbaijan	0.18	Kenya	0.37	Poland	0.51	Canada	0.72	Vietnam	0.86
Georgia	-0.17	Uruguay	0.20	Portugal	0.38	Peru	0.52	United Arab Emirates	0.73	United Kingdom	0.87
Greece	-0.13	Croatia	0.20	Belgium	0.39	Denmark	0.55	Chad	0.73	Singapore	0.97
Albania	-0.02	Egypt	0.20	Sweden	0.41	New Zealand	0.58	Switzerland	0.74	Germany	1.04
Lithuania	0.00	Slovakia	0.20	Austria	0.42	Malta	0.61	Mexico	0.74	Japan	1.27
Latvia	0.01	Nigeria	0.21	Czech Republic	0.44	Saudi Arabia	0.61	Indonesia	0.77	China	2.50
Colombia	0.02	Romania	0.25	Italy	0.44	Ecuador	0.62	Thailand	0.80	United States of America	3.58

Source: calculated by the authors

The Covid-19 pandemic has forced a review of priorities in the field of health care at the national level. Even some countries-world leaders turned out to be outsiders in the speed of reaction to new extraordinary circumstances. That is why, when considering the health index indicator, it became necessary to introduce a linguistic assessment of the level of health. Taking into account the statistical data on the studied countries, Chad has the minimum value of 23.3, and the USA has the maximum value of 75.9; that is, the data spread is 52%, and it is enough to divide them into 3 levels: high, medium, and low. The results of such a breakdown are presented in Table 5.

Table 5. Health levels of the studied countries

Level	Low	Medium	High
Country	Chad, Egypt, Pakistan, Rwanda, Sri Lanka, Dominican Republic, Azerbaijan, Bangladesh, Kuwait, Nigeria, Kenya, Ukraine, Oman, United Arab Emirates, Malta, Uruguay, Moldova, Cyprus, India, Vietnam, Montenegro, Saudi Arabia	Albania, Serbia, Philippines, Romania, South Africa, Kazakhstan, Israel, China, Luxemburg, Iceland, Qatar, Croatia, Turkey, Indonesia, Ecuador, Brazil, Greece Italy, Georgia, Czech Republic, Colombia, Panama, Hungary, Slovakia, Portugal, Peru, Ireland, Poland, Chile, Malaysia, Austria, Mexico, Singapore, Switzerland, Belgium, Lithuania, Bulgaria	Norway, Japan, Spain, Armenia, France, Latvia, New Zealand, Denmark, Netherlands, Sweden, Korea, Rep, Germany, United Kingdom, Slovenia, Thailand, Canada, Finland, Australia, United States of America
Quantity	19	37	22

Source: calculated by the authors

To verify the authors' assumption made above about the correspondence of the level of development of the political-institutional, economic, medical, and financial-budgetary spheres of the countries to the speed of reaction to extraordinary epidemiological threats, it is suggested to apply the elements of intellectual analysis - the construction of a neural network. The neural network model of the correspondence of the country's health level to its overall development in four different directions will be presented in the form of a multilayer perceptron MLP using the Broyden–Fletcher–Goldfarb–Shanno (BFGS) algorithm and the use of logistic and hyperbolic activation functions. The neural network model of the multilayer perceptron MLP of country development correspondence can be formalized using the formula:

$$GHS(x) = F\left(\sum_i v_{ij} \dots F\left(\sum_i v_{ij} F\left(\sum_i v_{ij} x_{ij} - \varepsilon_j\right)_1 - \varepsilon_j\right)_2 \dots - \varepsilon_j\right)_k \quad (2)$$

where $F\left(\sum_i v_{ij} x_{ij} - \varepsilon_j\right)_1$ – first layer; $F\left(\sum_i v_{ij} F\left(\sum_i v_{ij} x_{ij} - \varepsilon_j\right)_1 - \varepsilon_j\right)_2$ – second layer; $F\left(\sum_i v_{ij} \dots F\left(\sum_i v_{ij} F\left(\sum_i v_{ij} x_{ij} - \varepsilon_j\right)_1 - \varepsilon_j\right)_2 \dots - \theta\varepsilon_j\right)_k$ – *k*-th layer; *i* – entry number; *j* – neuron number in the layer; x_{ij} – input signal of the corresponding input, neuron and layer; v_{ij} – input, neuron, and layer weights; ε_j – threshold level of the neuron.

The BFGS algorithm is a standard method that bypasses the step of calculating the Hessian of the function to find the optimal value by evaluating it. This iterative quasi-Newtonian method is used mainly for a convex nonlinear function without constraints. Briefly, the BFGS algorithm involves the implementation of the following sequence of steps and cyclical actions until reaching the required critical value [13]:

1) calculation of the weighting factors υ and the initial value of the Hessian H; 2) grad gradient calculation; 3) calculation of the correlation of the obtained weighting coefficients R and estimation of network learning speed parameters σ; 4) gradient recalculation and changes compared to the previous value Δgrad; 5) finding the inverse Hessian H^{-1}; 6) assessment of changes in weighting factors compared to previous ones and evaluation of the direction of adjustment if necessary; 7) if there is no adjustment, the optimal value has been found. In the opposite case, the actions are looped starting from the fourth step of the gradient precalculation.

To build a high-quality neural network with the help of a multilayer perceptron MLP, the Statistica application program package, the "Neural Networks" module, was used, using automated neural network classification methods with the following input parameters: the number of hidden neurons from 5 to 15, the error function – sum of squares or cross-entropy, activation functions for both secret and output neurons – logistic or hyperbolic, the training sample will be 70%, and the control and test samples will be 15% each.

The neural network modeling conducted using the multilayer perceptron MLP of the dependence of the level of health in the country on the level of development of the political-institutional, economic, financial-budgetary, and medical spheres is presented in Table 6.

Table 6. The results of building models of neural networks of the dependence of the level of health in the country on the level of development of the political-institutional, economic, financial-budgetary, and medical spheres

N	Architecture	Learning productivity	Control productivity	Test productivity	Learning algorithm	Error function	Activity function of hidden neurons	Activity function of output neurons
1	MLP 4-15-3	71.42857	72.72727	54.54545	BFGS 14	Entropy	Logistical	Softmax
2	MLP 4-5-3	64.28571	63.63636	54.54545	BFGS 7	Sum of squares	Hyperbolic	Hyperbolic
3	MLP 4-5-3	71.42857	72.72727	54.54545	BFGS 13	Entropy	Logistical	Softmax
4	MLP 4-5-3	51.78571	63.63636	63.63636	BFGS 6	Sum of squares	Logistical	Hyperbolic
5	MLP 4-5-3	73.21429	72.72727	45.45455	BFGS 27	Sum of squares	Hyperbolic	Logistical
6	MLP 4-7-3	69.64286	63.63636	45.45455	BFGS 10	Entropy	Hyperbolic	Softmax
7	MLP 4-5-3	75.00000	81.81818	54.54545	BFGS 28	Sum of squares	Logistical	Logistical
8	MLP 4-9-3	57.14286	72.72727	63.63636	BFGS 5	Entropy	Logistical	Softmax
9	MLP 4-11-3	67.85714	63.63636	45.45455	BFGS 16	Sum of squares	Logistical	Hyperbolic
10	MLP 4-5-3	67.85714	63.63636	45.45455	BFGS 8	Entropy	Hyperbolic	Softmax

Source: calculated by the authors

The analysis of the obtained results makes it possible to conclude that all 10 built models have more than 50% productivity for the training sample. However, for further analysis of the dependence of the country's health level on the level of development of the political-institutional, economic, financial-budgetary, and medical spheres, we will choose only those models with a productivity of more than 70%, which confirms the authors' assumption. So, the following models were selected for further research: 1) model with MLP 4-15-3 architecture, performance of training sample 71.4%, control -72.7%, test 54.5%; 2) model with MLP 4-5-3 architecture, performance of training sample 71.4%, control -72.7%, test 54.5%; 3) model with MLP 4-5-3 architecture, performance of training sample 73.2%, control -72.7%, test 45.5%; 4) the model with the MLP 4-5-3 architecture, the performance of the training sample is 75%, the control sample is 81.8%, and the test sample is 54.5%. Optimization of the complexity of building a neural network was based on the criterion of minimizing the percentage of incorrectly classified countries. Table 7 shows the sensitivity analysis of indicators for the highest-quality neural network models.

Table 7. Analysis of the sensitivity of indicators

	HIS	IPRI	E	TR
1.MLP 4-15-3	1.369287	1.382210	1.025736	1.022636
3. MLP 4-5-3	1.628043	1.458623	1.095058	1.045061
5. MLP 4-5-3	2.065960	1.878895	1.413041	1.222856
7.MLP 4-5-3	1.669880	1.341052	1.047896	1.103800
Average	1.683293	1.515195	1.145433	1.098588

Source: calculated by the authors

The sensitivity of indicators makes it possible to assess the importance of each input factor, and the greater the value of sensitivity, the greater the importance of the studied factor. The analysis of Table 7 makes it possible to conclude that, according to all relevant models, the health indicator has a more significant influence, which is logical. However, the confirmation of the assumption that the country's health level also depends on the political-institutional, financial-budgetary components is that the sensitivity of these indicators according to the selected models differs by an average of 0.4, which is not significant enough for the weighting coefficients. In addition,

Table 8 shows the confidence intervals of the predicted value of the health level to the input level according to the results of the best-performing neural network.

Table 8. Confidence levels of country-level health membership for a layered perceptron with MLP 4-5-3 architecture

	Samples	Input	Output	high	low	medium
Albania	Training	medium	medium	0.205085	0.321168	0.473747
Armenia	Test	high	*medium*	0.233237	0.299374	0.467389
Australia	Training	high	high	0.517153	0.225065	0.257782
Austria	Training	medium	*high*	0.466769	0.241810	0.291421
Azerbaijan	Training	low	*medium*	0.236148	0.359646	0.404206
Bangladesh	Training	low	low	0.236034	0.502888	0.261079
Belgium	Training	medium	*high*	0.430974	0.246631	0.322395
Brazil	Training	medium	medium	0.229505	0.332063	0.438432
Bulgaria	2	medium	medium	0.233757	0.286061	0.480182
Canada	Training	high	high	0.475615	0.240728	0.283657
Chad	Training	low	low	0.224534	0.554086	0.221381
Chile	Training	medium	medium	0.255346	0.274944	0.469710
China	Training	medium	medium	0.255188	0.220008	0.524804
Colombia	Training	medium	medium	0.213958	0.242344	0.543698
Croatia	Training	medium	medium	0.230173	0.263192	0.506635
Cyprus	Training	low	*medium*	0.260882	0.253100	0.486018
Czech Republic	2	medium	medium	0.327922	0.261270	0.410808
Denmark	Training	high	high	0.504835	0.228042	0.267123
Dominican Republic	Training	low	*medium*	0.235240	0.382152	0.382608
Ecuador	2	medium	medium	0.237943	0.350605	0.411453
Egypt	Training	low	low	0.231952	0.486879	0.281169
Finland	Training	high	high	0.507005	0.229585	0.263410
France	Training	high	high	0.460416	0.234086	0.305498
Georgia	Training	medium	*low*	0.217782	0.402580	0.379638
Germany	Training	high	high	0.534105	0.217439	0.248456
Greece	Training	medium	medium	0.219665	0.251182	0.529152
Hungary	Test	medium	medium	0.238244	0.256067	0.505689
Iceland	2	medium	*high*	0.428410	0.239405	0.332186
India	Training	low	low	0.270099	0.405148	0.324753
Indonesia	Training	medium	medium	0.262752	0.337558	0.399690
Ireland	2	medium	*high*	0.454485	0.244046	0.301469
Israel	Training	medium	medium	0.336983	0.239093	0.423924
Italy	Training	medium	medium	0.271613	0.242765	0.485623
Japan	Training	high	high	0.521919	0.213793	0.264288
Kazakhstan	Training	medium	medium	0.243072	0.312808	0.444121
Kenya	Training	low	low	0.240250	0.487790	0.271960
Korea, Rep	Training	high	high	0.390722	0.232217	0.377061
Kuwait	2	low	*medium*	0.247719	0.250976	0.501305
Latvia	Training	high	*medium*	0.261871	0.295944	0.442184
Lithuania	Training	medium	medium	0.270193	0.304339	0.425468
Luxemburg	Test	medium	medium	0.361241	0.267526	0.371233
Malaysia	Training	medium	medium	0.310431	0.269663	0.419905
Malta	Training	low	*medium*	0.294971	0.248871	0.456157
Mexico	Training	medium	medium	0.239530	0.283598	0.476872
Moldova	Training	low	low	0.226922	0.412305	0.360773
Montenegro	Test	low	low	0.219602	0.457613	0.322786
Netherlands	Training	high	high	0.504388	0.226988	0.268624
New Zealand	Training	high	high	0.498043	0.233935	0.268021
Nigeria	2	low	low	0.221611	0.557219	0.221170
Norway	2	high	high	0.510851	0.223197	0.265952
Oman	Training	low	*medium*	0.309106	0.285733	0.405161
Pakistan	Training	low	low	0.224390	0.543943	0.231666
Panama	Test	medium	medium	0.233422	0.268280	0.498298
Peru	Training	medium	medium	0.221461	0.252782	0.525757
Philippines	2	medium	*low*	0.250350	0.402476	0.347175
Poland	Training	medium	medium	0.248345	0.257361	0.494294
Portugal	Training	medium	medium	0.297151	0.274277	0.428572
Qatar	Training	medium	medium	0.351962	0.265035	0.383003
Romania	Training	medium	medium	0.259377	0.311905	0.428718
Rwanda	Training	low	low	0.226324	0.493719	0.279957
Saudi Arabia	Training	low	*medium*	0.265365	0.266993	0.467642
Serbia	Test	medium	medium	0.217634	0.353930	0.428436
Singapore	Training	medium	*high*	0.538613	0.215152	0.246235
Slovakia	Training	medium	medium	0.253557	0.265983	0.480460
Slovenia	Training	high	*medium*	0.275131	0.251282	0.473588
South Africa	2	medium	*low*	0.218982	0.532567	0.248450
Spain	2	high	*medium*	0.280686	0.260303	0.459011

Sri Lanka	Training	low	*medium*	0.196158	0.298127	0.505715
Sweden	Training	high	high	0.489887	0.229832	0.280281
Switzerland	Test	medium	*high*	0.499895	0.220432	0.279673
Thailand	Training	high	*medium*	0.230558	0.232973	0.536469
Turkey	Training	medium	medium	0.167706	0.397180	0.435114
Ukraine	Test	low	low	0.207152	0.514189	0.278660
United Arab Emirates	Training	low	*medium*	0.315084	0.259232	0,425684
United Kingdom	Test	high	high	0.497951	0.233733	0,268315
United States of America	Training	high	high	0.569131	0.212374	0,218495
Uruguay	Training	low	*medium*	0.279151	0.267671	0,453178
Vietnam	Test	low	*medium*	0.227806	0.240303	0,531891

Source: calculated by the authors

In Table 8, those countries where the input value did not coincide with the predicted (output) are highlighted in italics. The confidence intervals for each level are also indicated as low, medium, and high. For this level, the observation probability is more significant. The neural network will assign the country to that level. In general, 25 such countries were identified for this architecture. For example, Armenia has a high input level, but the neural network classifies it as average. Yes, Latvia has a high input level, but the neural network classified it as average. The total number of errors for each level and each selected neural network is presented in Table 9.

Table 9. Error matrix with classification results for training, control, and test samples

		high	**low**	**medium**	**All**
7.MLP 4-5-3	All	19.00000	22.00000	37.00000	78.00000
	Right	14.00000	11.00000	28.00000	53.00000
	Wrong	5.00000	11.00000	9.00000	25.00000
	Right (%)	73.68421	50.00000	75.67568	67.94872
	Wrong (%)	26.31579	50.00000	24.32432	32.05128
1.MLP 4-15-3	All	19.00000	22.00000	37.00000	78.00000
	Right	14.00000	11.00000	30.00000	55.00000
	Wrong	5.00000	11.00000	7.00000	23.00000
	Right (%)	73.68421	50.00000	81.08108	70.51282
	Wrong (%)	26.31579	50.00000	18.91892	29.48718
5. MLP 4-5-3	All	19.00000	22.00000	37.00000	78.00000
	Right	14.00000	11.00000	33.00000	58.00000
	Wrong	5.00000	11.00000	4.00000	20.00000
	Right (%)	73.68421	50.00000	89.18919	74.35897
	Wrong (%)	26.31579	50.00000	10.81081	25.64103
3. MLP 4-5-3	All	19.00000	22.00000	37.00000	78.00000
	Right	14.00000	14.00000	26.00000	54.00000
	Wrong	5.00000	8.00000	11.00000	24.00000
	Right (%)	73.68421	63.63636	70.27027	69.23077
	Wrong (%)	26.31579	36.36364	29.72973	30.76923

Source: calculated by the authors

The analysis of Table 9 makes it possible to conclude that according to all four selected models, the largest percentage of incorrectly classified countries at the "low" level is 36-50%; for the "high" level, all models equally incorrectly classified 26.3% of countries; and at the average level in the range from 10.8 to 24.3%. Also, to analyze the study results, ROC curves were constructed to demonstrate the dependence of the number of correctly classified countries on three categories of health levels, Figure 5.

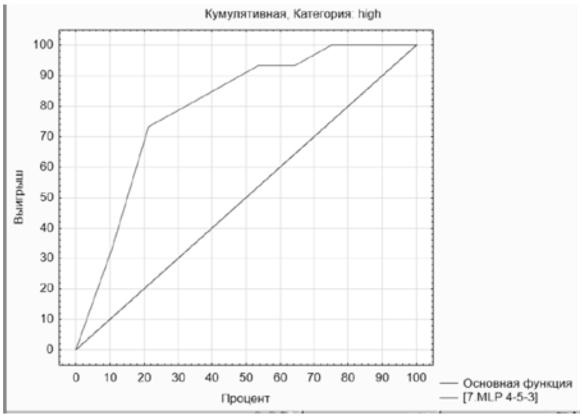

Figure 5. ROC curves for the "low", "medium" and "high" categories of the multilayer perceptron with the MLP 4-5-3 architecture

Source: built by the authors

Analysis of ROC curves of the level of health indicates that even for 20% of "high" category observations, more than 70% will be predicted correctly. It is also worth noting that the best quality is precisely for the "high" category because under it the most significant area remains, and the worst for "medium".

Conclusions. Since it is the countries of the "high" category that are best classified among the other categories, this gives grounds for a more justified sorting of countries and the selection of those that can be benchmarks in the field of countering the impact of destabilizing factors on the health care sector and other areas of national development. Fourteen countries are included in the cluster of countries with a high level of health security, taking into account the verification of confidence levels of belonging to a multilayer perceptron of a defined architecture: Australia, Canada, Denmark, Finland, France, Germany, Japan, South Korea, the Netherlands, New Zealand, Norway, Sweden, United Kingdom, and USA. This approach to classifying countries according to the level of health according to the methodology is fundamentally different from the ones available in the scientific literature and proposed by the authors of such works. The author of [14] used the center of mass estimation method to build a profile of countries according to four determinants (social, economic, behavioral, and health level). The authors declared that this approach to creating a profile of countries according to the level of health makes it possible to assess the country's actual prerequisites for countering the negative impact of threats to public health. In [15], the authors compared different approaches to assessing the level of health of a country, in particular, the availability of resources of the health care system, as health care costs are a percentage of GDP per population. The authors single out for analysis such components of the country's health profile as provision of human resources of the health care system, medicines and medical equipment, and financial resources. The scientists tested the methodology using examples from countries such as Denmark, France, Germany, Sweden, the United Kingdom, and the USA. The classification methodology proposed by the World Health Organization [16] is based on the indicators of the financing of the countries' healthcare systems. Some of the studies are focused more on studying the medical characteristics of the population. The authors of [17] analyzed the health profiles of the population of 20 countries, highlighting their demographic characteristics and risk factors for the occurrence of diseases. There are entirely non-standard approaches to building a country's health profile, for example, within the framework of marketing campaigns that research their consumers, as in the work [18], regarding the population's social security [19]. During the COVID-19 pandemic, much research has been devoted to building a health profile of countries and regions to determine their ability to counter the spread of the coronavirus. Such works were [20], in which the authors classified countries according to their level of risk for the spread of fatal cases of the coronavirus disease, which was mainly based on the age structure of the population and the available health indicators of the population, as well as [21], which assessed the leadership capacity and effectiveness of public administration in overcoming the consequences of the coronavirus pandemic to achieve resilience in the field of national security, and in [22], in which regions were the unit of study.

The approach to the classification of countries by the level of health described in this article allows not only to cluster them according to the actual indicators of the development of the health care system but also to check the extent to which their national systems can function effectively under the influence of destabilizing factors about the economic, financial-budgetary and political-institutional determinants of the country's development. In the future, the selection of countries that, after verification within the framework of neural network modeling, have shown the highest effectiveness in resisting the impact of pandemic threats allows for the formation of promising roadmaps for the development and improvement of the systems of medical care for the population, provision of social services, strengthening of infrastructure support in the field of health care, etc. Benchmarking analysis will allow the development of stabilizing and preventive mechanisms for the transition from the existing formats of national medical and social security systems to optimal ones with the maximum potential and opportunities to resist and level the effects of destabilizing factors on various spheres of society.

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