ASSESSMENT OF THE IMPACT OF HEALTHCARE SYSTEM INDICATORS ON THE COUNTRY'S ECONOMY

ОЦІНКА ВПЛИВУ ІНДИКАТОРІВ СИСТЕМИ ОХОРОНИ ЗДОРОВ'Я НА ЕКОНОМІКУ КРАЇНИ

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Abstracts

The purpose of the article is to determine the impact of healthcare system indicators on a key measure of economic performance – GDP by type of economic activity in «Healthcare and Social Assistance» for further policy-making on preserving and improving the health of the population.

Material and Methods. Analytical, mathematical (regression analysis method), statistical (summary and grouping of observation data; calculation of summary indicators and their analysis) research methods, method of system approach and epidemiological analysis are used in the work. The information base for the epidemiological analysis was the express issues of the State Statistics Service of Ukraine and the World Bank data.

Results. The study evaluates the changes in the volume of Ukraine's GDP and GDP by type of economic activity in the sector of «Health Care and Social Assistance». The periods are identified when the GDP growth rate by activity in "Health Care and Social Assistance" exceeded the GDP growth rate of Ukraine, which was observed, in particular, during the COVID-19 pandemic. Key healthcare system indicators influencing economic performance, particularly GDP by type of economic activity in «Healthcare and Social Assistance» are determined. A linear regression model is developed, demonstrating that the most significant factors contributing to GDP growth in the type of activity «Health Care and Social Assistance» include indicators of healthy life years, average life expectancy, total healthcare expenditures, and R&D expenditures. Forecasting is conducted based on healthcare system indicators affecting GDP by type economic activity in «Healthcare and Social Assistance» for further development of policies aimed at preserving and improving public health.

Conclusions. The results of forecasting GDP growth by type of activity in «Healthcare and Social Assistance» indicate the need to increase the indicators of total health care expenditures and research and development expenditures, taking into account their average growth rates. By applying this approach and aligning with socio-economic priorities, GDP growth for type of activity in «Healthcare and Social Assistance» sector is expected to grow by 8.44% in the short term while ensuring long-term innovation in the healthcare system.

Key words: healthcare system, macroeconomic indicators, GDP by type of economic activity in «Healthcare and Social Assistance».

Метою статті є визначення впливів індикаторів системи охорони здоров'я на ключовий показник, що характеризує результативність економіки – ВВП за видом діяльності «Охорона здоров'я та надання соціальної допомоги» для подальшого формування політики збереження та зміцнення здоров'я населення.

Матеріал і методи. У роботі використано аналітичний, математичний (метод регресійного аналізу), статистичний (зведення та групування даних спостережень, розрахунок зведених показників та їх аналіз) методи дослідження, метод системного підходу та епідеміологічного

аналізу. Інформаційною базою для епідеміологічного аналізу були експрес-випуски Державної служби статистики України та дані Світового банку.

Результати. Здійснено оцінку зміни обсягу ВВП України та ВВП за видом економічної діяльності «Охорона здоров'я та надання соціальної допомоги». Установлено періоди, коли темп приросту ВВП за видом діяльності «Охорона здоров'я та надання соціальної допомоги» перевищував темп приросту ВВП України, що спостерігалося, зокрема, у період пандемії COVID-19. Визначено індикатори системи охорони здоров'я, що впливають на результативність економіки, зокрема на ВВП за видом діяльності «Охорона здоров'я та надання соціальної допомоги». Побудовано лінійну регресійну модель, яка показує, що найбільш вагомими чинниками зростання ВВП за видом діяльності «Охорона здоров'я та надання соціальної допомоги» є показники років здорового життя, середньої очікуваної тривалості життя, загальних витрат на охорону здоров'я та витрат на R&D. Здійснено прогнозування на основі індикаторів системи охорони здоров'я, які впливають на ВВП за видом діяльності «Охорона здоров'я та надання соціальної допомоги», для подальшого формування політики збереження та зміцнення здоров'я населення.

Висновки. Результати прогнозування зростання ВВП за видом діяльності «Охорона здоров'я та надання соціальної допомоги» вказують на необхідність збільшення показників загальних витрат на охорону здоров'я та витрат на наукові дослідження і розробки з урахуванням їх середніх темпів росту. У результаті застосування даного підходу й урахування соціально-економічних пріоритетів передбачено зростання показника ВВП за видом діяльності «Охорона здоров'я та надання соціальної допомоги» на 8,44% у короткостроковій перспективі та інноваційності системи охорони здоров'я у довгостроковому періоді.

Ключові слова: система охорони здоров'я, макроекономічні показники, ВВП за видом економічної діяльності «Охорона здоров'я та надання соціальної допомоги».

Introduction. The health status of the population and the functioning of the healthcare sector are key indicators of a country's economic well-being. A high level of health among the economically active population determines the level of labor productivity and production efficiency, while the healthcare system is aimed at preserving and strengthening health by ensuring access to medical care.

Financial resources allocated to the healthcare system and their rational distribution and utilization play a leading role in improving the accessibility and quality of state-guaranteed healthcare services for the population [10; 13]. In the modern conditions, healthcare institutions, as providers of medical (healthcare) services, must operate as economically efficient business models, independently exploring the medical services market, identifying funding sources, implementing innovations, and establishing connections with potential consumers of healthcare services [12; 20].

The COVID-19 pandemic, military and political conflicts between countries, particularly Russia's full-scale invasion of Ukraine, and other factors justify the selection of Ukraine as the research object. All these challenges have highlighted the urgent need for improved accessibility and quality of healthcare services, as well as the necessity for rapid responses to emergencies. From an economic perspective, addressing these issues requires the consolidation of efforts across various sectors both within the country and on an international level. Currently, intersectoral and interagency actions aimed at preserving and strengthening public health remain insufficiently coordinated and demand enhanced collaboration between different sectors and levels of governance to influence the social determinants of health [7]. In the context of a full-scale war, Ukraine's healthcare system was forced to respond to new and emerging needs of the population for medical care that had not been a priority before the war, such as traumatology and orthopedics, intensive care, reconstructive surgery, burns treatment, bullet wounds and minefield injuries, and rehabilitation of war trauma. This process has been extremely complicated by the large-scale destruction of medical infrastructure due to hostilities, a decrease in the number of healthcare professionals caused by migration and mobilization, the massive displacement of people from temporarily occupied territories, and the limited accessibility of medical services for the population remaining these temporarily occupied territories, etc. It should be noted that

wartime challenges have exacerbated problems in the public health system, particularly in epidemiological surveillance, monitoring of environmental factors, vaccination coverage, and disrupted the continuity of treatment of socially significant diseases. Additionally, the ability to prevent non-communicable diseases has significantly declined.

Given the current realities, the priority directions for transforming the healthcare system should include not only ensuring high-quality and timely medical care for the population but also strengthening preparedness for responding to emergencies and threats of various types (military, technological or man-made, biological, etc.) [16].

Analysis of Recent Research and Publications. The issues of state regulation and financing of various types of economic activities, particularly in the "Healthcare and Social Assistance" sector, have been the focus of numerous scientific studies by foreign scholars, including J. Chelsom [3], G. Cometto [4], D. Doiron [5], V. Ivankova [9], E. Fainman [6], S. Nundy [15] and R. Visconti [23]. Among Ukrainian researchers, the works of M. Bilynska [2], Z. Iurynets [8], L. Krynychko [11], V. Lekhan [12], Z. Nadyuk [13], N. Savina [24], A. Serdyuk [17] and H. Slabkyi [18], are noteworthy. However, given the influence of economic, political, and environmental factors on the healthcare system, further research is needed to explore the issue of relationship between the healthcare system and the overall economic performance of the country under such conditions.

The aim of the article is to determine the impact of healthcare system indicators on a key measure of economic performance – GDP by type of economic activity in "Healthcare and Social Assistance" for further policy-making on preserving and improving the health of the population.

Material and methods. Analytical, mathematical (regression analysis method), statistical (summary and grouping of observation data; calculation of summary indicators and their analysis) research methods, method of system approach and epidemiological analysis are used in the work. The information base for the epidemiological analysis was the express issues of the State Statistics Service of Ukraine and the World Bank data.

Results. The health of the population and the functioning of the healthcare system play a crucial role in achieving an optimal balance between the three pillars of sustainable development – economic, social, and environmental. However, considering the current anthropogenic challenges, the implementation of the Sustainable Development Goals (SDGs), aimed at ensuring peace, prosperity, and well-being of people, has become one of the most significant challenges for Ukraine. Therefore, assessing the impact of healthcare system indicators on economic performance was conducted using Ukraine as a case study.

In order to identify key macroeconomic trends influencing the establishment and development of the national healthcare system, official data from the State Statistics Service of Ukraine were collected and summarized [21]. According to the results of the analysis, an overall trend of GDP growth by UAH 3773.9 billion (from UAH 1465.2 to UAH 5239.1 billion) as well as an increase in GDP by type of economic activity in "Healthcare and Social Assistance" by UAH 102.2 billion (from UAH 48.2 to UAH 150.4 billion) was established. The growth rates of these indicators amounted to 258% and 212%, respectively (Figure 1).

It should be noted that GDP by type of economic activity in "Healthcare and Social Assistance" fluctuated within approximately 3% of Ukraine's total GDP throughout the analyzed period. In particular, in 2022, its share stood at 2.87% of total GDP of Ukraine (Figure 2). The highest recorded value was of 3.29% in 2013, followed by a gradual downward trend. The lowest value of 2.17%, was observed in 2018, which, in our opinion, was influenced by the healthcare system's transformation reform. Specifically, the adoption of the Law of Ukraine "On State Financial Guarantees of Medical Care for the Population" at the end of 2017 introduced changes to the healthcare services financing mechanisms, including the guaranteed package of medical services known as the Medical Guarantees Program.

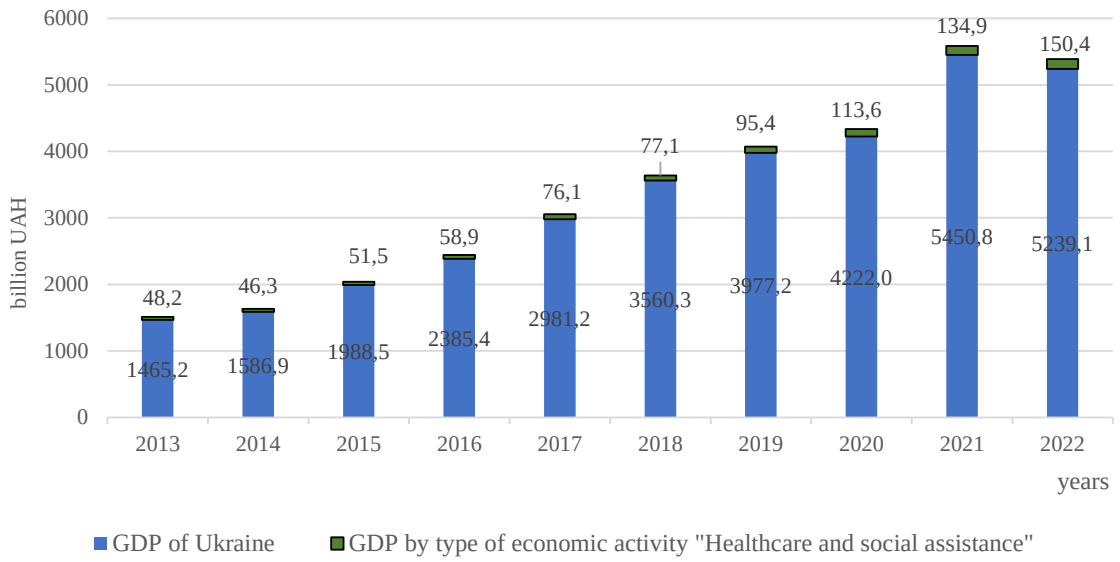

Fig. 1. Ukraine's GDP and GDP by the type of economic activity in "Healthcare and Social Assistance" from 2013 to 2022

Source: compiled by the authors based on data from [21].

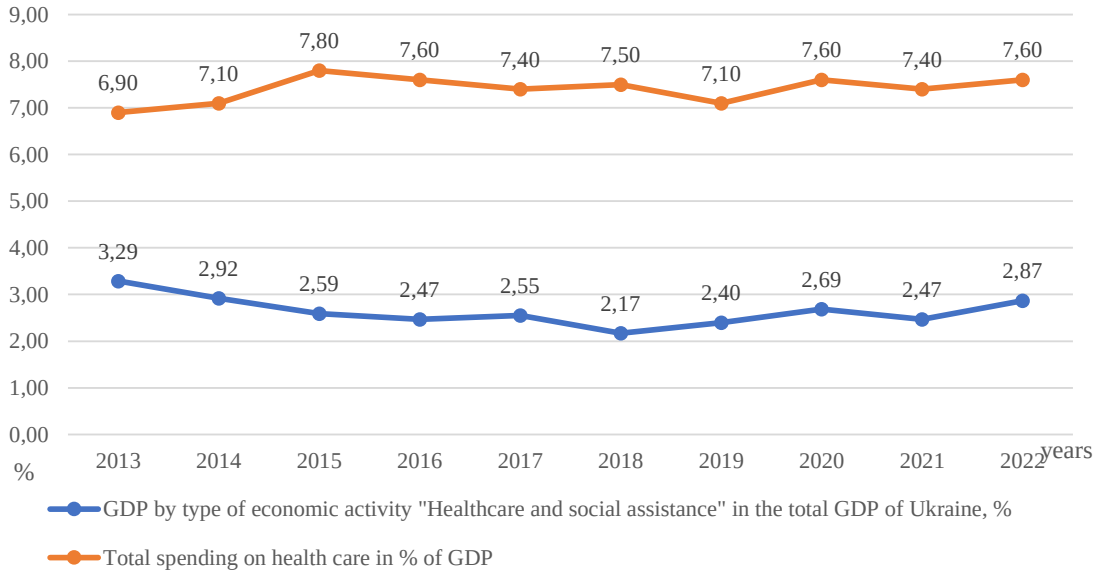

Fig.e 2. Share of GDP by type of economic activity in "Healthcare and Social Assistance" in Ukraine's total GDP and total healthcare expenditures as a percentage (%) of GDP

Source: compiled by the authors based on data from [21].

At the same time, total healthcare expenditures as a percentage of GDP fluctuated between 7.0% and 7.8% (Figure 2). In comparison, healthcare spending accounts for 16.7% of GDP in the United States (with a GDP of USD 21.3 trillion), 11.1% in Germany (GDP – USD 3.8 trillion), 4.86% in Poland (with a GDP of USD 592 billion), 7.4% in the Czech Republic (with a GDP of USD 414 billion), 9.8% in the United Kingdom (with a GDP of USD 2,830 billion), and 7.4% in Hungary (with a GDP of USD 161 billion) [19].

Taking into account the identified key macroeconomic trends influencing the formation and development of the national healthcare system, three groups of factors have been proposed, in particular: those characterizing the healthcare system, the economic and innovative (innovation capacity) potential of the country. The health care system indicators that detail the content of public health and affect the GDP by type of economic activity in "Health Care and Social Assistance", which is chosen as a summarizing (aggregate) indicator (Y), are presented in Table 1.

The choice of these indicators is based on their significance in achieving the objectives of Sustainable Development Goal 3 "Good Health and Well-Being", in particular, the number of maternal and child mortality rates. Indicators such as average life expectancy, healthy life years, and overall mortality rates are key public health metrics among the countries of the European region and are integrated into the unified statistical database Eurostat. This enables making comparative assessments of these indicators between different countries and helps determine the effectiveness of healthcare systems as a whole.

Other groups of factors relate to the country's economic and innovation potential. The choice of parameters characterizing them from the organizational point of view was related to the possibility of providing official statistical data. From a substantive perspective, the selection of parameters focused on the indicators listed in Table 2.

When analyzing factors for the further construction of a linear regression model, only those with the highest correlation with the dependent variable Y (the main factor) were taken into account. By examining the pairwise correlation matrix, it was established that the dependent variable was significantly influenced by factors $X1_1$, $X1_2$, $X1_4$, $X1_5$, $X2_1$, $X2_2$, $X2_7$, $X2_8$, $X3_1$, $X3_2$, and $X3_3$. Thus, the correlation analysis of all parameters presented in Tables 1 and 2 allowed us to identify only 11 of them, while the influence of the others was considered insignificant.

Conducting multifactor regression studies requires large sample sizes. Since, in our case, we analyze data only for the period from 2013 to 2022, constructing an effective regression mathematical model is possible while considering a maximum of five factors. Moreover, there should be a weak correlation between individual factors. Therefore, we construct a pairwise correlation coefficient matrix and conduct a detailed analysis of all factors and their potential interrelationships (Table 3).

Table 1

Health system indicators, (X1)

Indicators		Years									
		2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
$X1_1$	The average expected life expectancy, years	71,37	71,37	71,38	71,68	71,98	71,76	72,01	71,35	69,77	69,89
$X1_2$	Years of healthy life (HALE), years	63,13	63,03	63,67	63,93	64,60	64,66	64,32	64,78	64,45	64,3
$X1_3$	Total mortality, thousand persons	662,4	632,3	594,8	583,6	574,1	587,7	581,1	616,8	714,3	725,2
$X1_4$	Infant mortality (up to 1 year), thousand persons	4030	3656	3318	2955	2786	2397	2189	1988	1971	1980
$X1_5$	Maternal mortality, per 100 thousand live births	16,0	12,0	15,1	12,6	9,1	12,5	14,9	18,7	42,7	41,3

Source: compiled by the authors based on data from [21; 22].

Table 2

Indicators of economic (X2) and innovation potential (X3)

Indicators		Years									
		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Economic potential											
$X2_1$	Disposable income per person, UAH	26719	26782	31803	37080	47270	58442	69140	74688	90036	94125
$X2_2$	Total healthcare spending, million UAH	132453,0	144231,0	155219,5	181594,9	223726,6	264121,4	293 024,6	329 341,4	356432,1	374231,0
$X2_3$	Total healthcare spending, % of GDP	6,9	7,1	7,8	7,6	7,4	7,5	7,1	7,6	7,4	7,6
$X2_4$	Household spending on health care in total spending, %	47,3	46,7	48,8	52,3	47,5	49,7	49,2	46,4	48,7	49,7
$X2_5$	Public spending on healthcare, % of GDP	3,3	3,5	3,7	3,6	3,5	3,5	3,2	3,8	3,9	4,0
$X2_6$	Current spending on health care per capita, USD	280,6	212,6	157,4	157,1	186,7	221,5	246,9	269,7	274,5	287,6
$X2_7$	Capital investments by type of economic activity "Health care", million UAH	1746,2	1223,9	2367,2	4479	6708,3	8138,8	9484,6	14835,6	21779,2	17412,9
$X2_8$	Number of business entities by type of economic activity "Health care", units	18048	21114	21683	21583	22085	24961	30994	37583	34574	35107
Innovation potential											
$\mathbf{X3_1}$	R&D expenses, total, UAH million	10248,5	9487,5	11003,6	11530,7	13379,3	16773,7	17254,6	17022,4	20923,1	17117,8
$\mathbf{X3_2}$	Share of R&D expenses, % of GDP	0,7	0,6	0,55	0,48	0,45	0,47	0,43	0,41	0,38	0,33
$\mathbf{X3_3}$	Number of employees involved in R&D, persons	155386	136123	122504	97912	94274	88128	79262	78860	68488	53221
$X3_4$	Number of doctors with a higher qualification category, persons	56784,0	58765,0	60515,0	61124,0	63211,0	62441,0	63144,0	60607,0	61146,0	56584,0

Source: compiled by the authors based on data from [21; 22].

To obtain the least squares estimates of the regression model, we use the well-known Markov-Gauss theorem [1]:

Theorem. Let:

1. $y = X\beta + \varepsilon$; where X – is the data matrix of observations, β – is the vector of model (regression) coefficients, ε – is the vector of errors

2. X – is a deterministic matrix of size $n \times k$, with rank k;

3. $M\varepsilon = 0, D\varepsilon = M\varepsilon\varepsilon^T = \sigma^2 I_n$.

Then, the ordinary least squares (OLS) estimate is the best linear unbiased estimator (BLUE) that is, the estimator that has the smallest variance among all linear unbiased estimators (those

Table 3

Pairwise Correlation Coefficient Matrix
(for visualization purposes, only one decimal place is displayed)

	y	$X1_1$	$X1_2$	$X1_3$	$X1_4$	$X1_5$	$X2_1$	$X2_2$	$X2_3$	$X2_4$	$X2_5$	$X2_6$	$X2_7$	$X2_8$	$X3_1$	$X3_2$	$X3_3$
y	1,0																
$X1_1$	-0,7	1,0															
$X1_2$	0,7	-0,1	1,0														
$X1_3$	0,6	-0,9	-0,1	1,0													
$X1_4$	-0,9	0,4	-0,9	-0,2	1,0												
$X1_5$	0,8	-1,0	0,2	0,9	-0,5	1,0											
$X2_1$	1,0	-0,6	0,7	0,5	-0,9	0,8	1,0										
$X2_2$	1,0	-0,6	0,8	0,5	-1,0	0,7	1,0	1,0									
$X2_3$	0,3	-0,2	0,5	-0,1	-0,4	0,2	0,3	0,3	1,0								
$X2_4$	0,1	0,0	0,2	-0,1	-0,2	0,1	0,1	0,1	0,4	1,0							
$X2_5$	0,7	-0,8	0,3	0,6	-0,5	0,7	0,6	0,6	0,7	0,1	1,0						
$X2_6$	0,6	-0,6	0,2	0,7	-0,4	0,6	0,6	0,6	-0,4	-0,4	0,2	1,0					
$X2_7$	1,0	-0,7	0,7	0,6	-0,9	0,8	1,0	1,0	0,3	0,1	0,7	0,6	1,0				
$X2_8$	0,9	-0,5	0,7	0,4	-0,9	0,7	0,9	0,9	0,3	-0,1	0,6	0,6	0,9	1,0			
$X3_1$	0,9	-0,5	0,8	0,4	-0,9	0,7	0,9	0,9	0,2	0,1	0,4	0,6	0,9	0,9	1,0		
$X3_2$	-0,9	0,4	-0,8	-0,2	1,0	-0,6	-0,9	-0,9	-0,5	-0,3	-0,6	-0,2	-0,8	-0,8	-0,8	1,0	
$X3_3$	-0,9	0,4	-0,8	-0,2	1,0	-0,6	-0,9	-0,9	-0,5	-0,3	-0,6	-0,3	-0,9	-0,8	-0,9	1,0	1,0
$X3_4$	-0,1	0,5	0,6	-0,7	-0,4	-0,4	0,1	0,1	0,2	0,2	-0,3	-0,5	0,0	0,0	0,3	-0,3	-0,3

that are unbiased and linear in the observed output variables).

$$\hat{\beta} = (X^T X)^{-1} X^T y \quad (1)$$

It is important to note that our analysis assumes that the error matrix satisfies all the conditions of the Gauss-Markov theorem, namely:

1. The errors ε_i, $i=1,...,k$ are independent, identically distributed random variables following a normal distribution:

$\varepsilon \sim N(0, \sigma^T)$

2.$E(\varepsilon)=0$; $V(\varepsilon) = E(\varepsilon\varepsilon^T) = \sigma^T I$.

A matrix of numerical values of the corresponding factors is constructed over the years.

To satisfy the conditions of the Gauss-Markov theorem in the four-factor case, the rank of the observation data matrix *X* must be equal to 4. We determine the rank of this matrix. It is easy to verify that rang X = 4, meaning our matrix meets the conditions of the theorem (the minor formed by the first four rows is nonzero). Therefore, we can proceed to determine the coefficient matrix of the linear regression equation using formula (1).

Thus, according to formula (2):

$$B := \left(X^T \cdot X\right)^{-1} \cdot X^T \cdot Y, \quad (2)$$

The calculations performed in Excel yield the following values:

X=	71,37	63,13	132453	10248,5
	71,37	63,03	144231	9487,5
	71,38	63,67	155219,5	11003,6
	71,68	63,93	181594,9	11530,7
	71,98	64,6	223726,6	13379,3
	71,76	64,66	264121,4	16773,7
	72,01	64,32	293024,6	17254,6
	71,35	64,78	329341,44	17022,40
	69,77	64,45	356432,12	20923,1
	69,89	64,3	374231	17117,8

Vector Y:	48247
	46250
	51480
	58858
	76140
	77130
	95435
	113642
	134883
	150430

B=	-10460,80
	12123,97
	0,42
	-3,39

As a result, the obtained linear regression model is:

$$Y = -10460{,}8X1_1 + 12123{,}97X1_2 + 0{,}42X2_2 - 3{,}39X3_1 \quad (3)$$

Note: $X1_1$ – average life expectancy; $X1_2$ – years of healthy life; $X2_2$ – total healthcare expenditures; $X3_1$ – expenditures on R&D.

The analysis of the linear regression model reveals that the most significant factor contributing to GDP growth by type of activity in the "Healthcare and Social Assistance" sector is healthy life years (β=12123,97), meaning the economically active period of life during which individuals remain in good health without disabilities. Accordingly, an increase in healthy life expectancy is accompanied by an extension of the active working life of the population and contributes to GDP growth. Conversely, the value of the coefficient for average life expectancy has a negative sign (β=-10460,8), indicating that an increase in average life expectancy is not always accompanied by a healthy period of life in which the population can continue working. This indicates that people may live longer but not necessarily remain able to work and increase production efficiency.

It is an undeniable fact that human health represents a critical socio-economic value, and therefore requires investments (spending) for its preservation and improvement. The level of healthcare expenditures in a country serves as an integrated indicator of both individual healthcare spending and public expenditures in particular. Changes in this indicator depend on the funding and organizational mechanisms of the health care system, as well as on demographic trends, social and economic factors. The value of the β coefficient for total healthcare expenditures is 0.42, and therefore total health care expenditures can be considered as an investment in one's own health, which will further contribute to increased labor productivity, increased production output, and national income growth. Low healthcare costs lead to a significant increase in social security costs due to early mortality (death in the working age), an increasing ratio of retirees to workers or the so-called working population, and rising early disability rates. Conversely, an increase in total health care expenditures (public and private expenditures, including out-of-pocket expenditures (formal and informal direct payments by the population)) leads to an increase in GDP by the type of activity in "Healthcare and Social Assistance".

Today, innovations are a key prerequisite for building a competitive economy and ensuring higher living standards for citizens. However, the share of R&D expenditures in Ukraine's total GDP remains one of the lowest in Europe. The negative value of the coefficient for R&D expenditures (β=-3.39) indicates that funding for access to innovative treatment can only be provided within the available budget through reallocation of expenditures.

To verify the adequacy of the regression model, we apply the following inequality [23]:

$$F = \frac{R^2(n-k-1)}{(1-R^2)k} > F(\alpha, n-1, n-k) \quad (4)$$

where R^2 – coefficient of determination; F-F statistics;

$$R^2 = 1 - \frac{\frac{1}{n-k}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\frac{1}{n-1}\sum_{i=1}^{n}(y_i - \bar{y})^2}, \quad (5)$$

n – number of observations, k – number of model parameters.

In the numerator of the fraction of R^2 is the unbiased estimate of the error variance, while in

the denominator is the unbiased estimate of the variance of the observations of the underlying parameter (dependent variable) takes values from the interval [0,1]. The coefficient of determination R^2 indicates the quality of the regression model's fit to the observed value of $y_{i..}$ If ^{R2}= 0, then regressing y on $_{x1}$.,$_{xk}$ does not improve the quality of the prediction of $_{yi}$. In the other extreme case, ^{R2}= 1 means a perfect fit, i.e., all observed points satisfy the regression equation.

We calculate the coefficient of determination (R^2) using formula (5). It is equal to 0,96 which is quite high. Its value means that the variation in GDP by type of activity in "Healthcare and Social Assistance' is 96% due to the variation in the factors included in our model, and 4% is due to factors not included and considered in the model. The fact that the coefficient of determination differs from zero allows for further adequacy testing.

Taking a significance level of α = 0.05, the Fisher distribution critical value (point) at this significance level is 0.29 (this value was calculated in Excel using the built-in F.DIST function). The F-statistic is calculated by substituting the coefficient of determination into the formula for the F-statistic: F=35,44. Since 35.44 > 0.29, the inequality holds, thus confirming that our regression model (3) is adequate.

To further assess the model's accuracy, we calculate the mean approximation error using the formula:

$$E = \frac{1}{n}\Sigma\left|\frac{y-\hat{y}}{y}\right|100\% \qquad (6)$$

where y –is the actual dependent variable; $\hat{y}$– is the estimated value,

n – is the number of observations.

Substituting the relevant values into formula (6), we obtain E=5,94. This is a pretty good result. After all, a good result [1]; [14] is considered to be when the error does not exceed 8-10%. The closer to zero the average approximation error is, the closer the model is to reality and the more accurate the forecasts based on it will be.

At the next stage, we use the resulting linear regression model (3) to determine the potential for GDP growth in the "Healthcare and Social Assistance" sector. Given that the key factors are average life expectancy ($X1_1$), healthy life years ($X1_2$), total healthcare expenditures ($X2_2$), and R&D expenditures ($X3_1$), the choice and ensuring their optimal ratio becomes an important task for the state regulation of the healthcare system. Since average life expectancy and healthy life years depend on numerous factors, including economic, social and environmental ones, it is extremely difficult and challenging to directly influence and regulate their change. However, the state can influence the economic aspect of the healthcare system, particularly by adjusting the level of total healthcare expenditures and R&D expenditures, for example, through the reallocation or redistribution of funding from other sectors of the economy. Therefore, when selecting regulatory solutions, we proposed to use the indicators of total healthcare expenditures ($X2_2$) and R&D expenditures ($X3_1$). To ensure the feasibility of the proposed solutions, the change in the values of the indicators is proposed to be considered in accordance with the growth rates of these indicators, namely the growth rate of the previous year and the average growth rate over the entire period. At the same time, the indicators of average life expectancy ($X1_1$) and healthy life years ($X1_2$) should remain unchanged.

At the stage of implementing the proposed approach, substituting the forecast values of indicators $X2_2$ and $X3_1$, considering their growth rates for the previous 2022/2021 (1.05 and 0.82, respectively) into the linear regression model (3), the forecast values of GDP by type of activity in "Healthcare and Social Assistance" were calculated and amounted to UAH 166016.3 billion. That is, the calculation determined that under the given condition, the absolute increase in GDP by the type of activity in "Healthcare and Social Assistance" would be UAH 15586.3 billion, or 10.36% (Table 4). If the state's regulatory decision is based on the application of the average growth rate approach for the entire period, which for indicator $X2_2$ has a growth rate of 1.12, and for indicator $X3_1$ a growth rate of 1.07, the absolute GDP increase by type of activity in "Healthcare and Social Assistance would be UAH 12691.1 billion, or 8.44%.

In terms of the economic approach, the most attractive option is the first one, which provides

Table 4

Forecasting Trends in Ukraine's Healthcare System Development

Indicators	Base value of indicators, UAH million	Indicator change	Forecast value of the indicator	Value of Y in GDP		Absolute GDP growth, UAH million	GDP growth rate, %
				basic	forecast		
The nature of changes corresponds to growth rates 2022/2021							
$X2_2$ – total healthcare spending	374231,0	1,05	392918,7	150430	166016,3	15586,3	10,36
$X3_1$ – R&D expenses	17117,8	0,82	14004,6				
The nature of changes corresponds to average growth rates							
$X2_2$ – total healthcare spending	374231,0	1,12	420517,5	150430	163121,1	12691,1	8,44
$X3_1$ – R&D expenses	17117,8	1,07	18277,9				

Source: compiled by the authors based on data from [21].

for an increase in total healthcare expenditures by 1.05 while reducing research and development expenditures to 0.82. Under this approach, GDP growth is expected to be 10.36%. Taking into account social perspective, including the impact of military aggression on public health, as well as the fact that the future of medicine is associated with innovative technologies and tools, it is recommended to pay attention to the second option, which provides for an increase in total healthcare expenditures with an index of 1.12 and research and development expenditures with an index of 1.07. This approach will not only ensure an increase in GDP by type of economic activity in "Healthcare and Social Assistance" sector by 8.44%, but will also foster the innovative development of medical technologies and the long-term healthcare system efficiency.

Conclusions. The key indicators of the impact on GDP by type of activity in "Healthcare and Social Assistance" are indicators of average life expectancy, healthy life years, total health care expenditures and research and development expenditures. The results of forecasting GDP growth by type of activity in "Healthcare and Social Assistance" indicate the need to increase the indicators of total health care expenditures and research and development expenditures, taking into account their average growth rates. By applying this approach and aligning with socio-economic priorities, GDP growth for type of activity in "Healthcare and Social Assistance" sector is expected to grow by 8.44% in the short term while ensuring long-term innovation in the healthcare system.

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