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Development of State Digital Platforms: A Methodological Toolkit for Analysing the Attainment of Regional Health Care Systems' Target Indicators

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Abstract. The introduction of digital healthcare platforms has had a positive impact on the accessibility of the healthcare system among the population and increased the efficiency of state control over the healthcare of society. But like any evolution, this digital progress has a number of imperfections. In particular, digital methods for automated monitoring of the achievement of regional healthcare systems target indicators for the purpose of operational supervision and taking timely measures in the public health maintenance of certain territories are practically absent. The aim of the work is to develop a methodological toolkit for automated analysis of the achievement of regional health systems target indicators across state digital platforms. The proposed methodology is based on the author's system of indicators, the automated calculation of which will allow monitoring the effectiveness of health care systems in selected regions in real-time, as well as to take timely measures to maintain and protect public health, to form strategies in the development of regional health care systems. The object of the study is the regional health care system of the Russian Federation. The application of the proposed methodological tools makes it possible to rank the territories by the level of values of complex standardized indicators, taking into account financial conditions, resources, and markers for achieving target indicators. Automated monitoring of these indicators allows us to determine the types of strategies for the development of the healthcare system in selected regions. The proposed approach to monitoring the performance of regional healthcare systems will facilitate the development and enhancement of strategies for their progress, aiming to ensure high standards of quality of life among the population.

Keywords: Development strategies; Digital platforms; Health care system; Public finance; Regions

1. Introduction

Digital technologies that have been widely adopted in recent years have demonstrated high efficiency in various areas of the economy and society (Yashina *et al.,* 2022; Petrov *et al.,* 2021; Polyanin *et al.,* 2020). The COVID-19 pandemic has propelled the development of digital health platforms (Alharbi, 2021). Digital healthcare platforms are defined as a collection of applications and technologies employed by the government to both facilitate the delivery of healthcare services and oversee the quality of healthcare services and the

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overall development of the healthcare system. The introduction of such platforms has not only improved the accessibility of the population's health care system but also increased the effectiveness of overnment control over health care services to the population (Harzheim *et al.,* 2020; Rodgers *et al.,* 2019). Along the way, a number of developing countries have made significant progress in the digital transformation of the public sector and the health system in particular. However, this progress has been slow and erratic (Harzheim *et al.,* 2020). This is largely due to the lack of a unified approach to the implementation of digital governing methods that involve various integrated information systems (Scupola and Mergel, 2022), including in health care. For example, the Russian Federation is developing the digital information system "Electronic Budget", in which only selected functions of budget administration are subject to automation. However, in certain countries around the world, public authorities are gradually moving towards full or almost full digital transformation of a range of their control functions (Tangi *et al.,* 2020; Mergel, Edelmann, and Haug, 2019; Panagiotopoulos, Klievink, and Cordella, 2019). At the same time, a number of countries face a variety of challenges in the digitalization of the public administration process due to the lack of a unified digitalization strategy and insufficient funding (Dunleavy *et al.,* 2006).

Some researchers suggest that the introduction of digital technologies in all public administration systems, despite the great opportunities, often does not lead to the results anticipated (Paul *et al.,* 2023). In particular, scholars have particular concerns about the digitalization of the health care system (Kwiatkowska and Skorzewska-Amberg, 2019). On the one hand, digital technologies in the field of health care systems are mainly aimed at tracking the spread of various infectious diseases, supplying medicines, integrating data on the causes of increased mortality and decreased fertility of the population, etc. For this purpose, technologies such as blockchain, artificial intelligence, neural networks, machine learning, and cloud technologies are widely used (Popov *et al.,* 2022; Yu and Park, 2022). They allow the healthcare sector to process and analyze patient data and ensure that this information is protected (Kruse *et al.,* 2017). Digital technologies in healthcare have a major impact on the entire health service. In this regard, the process of data management is the main focus of the digitalization of healthcare (Paul *et al.,* 2023; Dash, 2020). On the other hand, digital methods of automated monitoring of the attainment of regional health systems' target indicators, which allow for prompt decision-making and the development of timely measures to maintain public health in selected territories, are practically absent. This reduces the effectiveness of state control in the field of public healthcare.

The aim of the work is to develop methodological tools for automated analysis of the attainment of regional healthcare systems' target indicators for state digital platforms. It is proposed to form a system of indicators for such monitoring, the automated calculation of which will make it possible to track the healthcare functional effectiveness in selected regions in real-time and take timely measures to maintain and protect public health and form strategies for the development of regional healthcare systems in the face of internal and external challenges. As an example, the regional healthcare system of the Russian Federation will be reviewed using two blocks of indicators characterizing different financial conditions, resource endowment, and obtained target results. The regional healthcare system includes medical organizations and territorial executive authorities in the field of healthcare, whose competence includes planning and implementing the health of citizens. The determination of the types of strategies for the development of regional healthcare systems is based on the definition of integral standardized indicators reflecting financial-resource support and markers of goal achievement in state programs and national projects.

2. Methods

Healthcare system development strategy is a model of healthcare system management based on the choice of the most appropriate way of its formation with consideration of financial-resource support to achieve the goals, which are characterized by markers of target indicators, taking into account internal and external opportunities. Strategy implies readiness for change, uncertainty, and risk and adaptation to constantly changing external and internal challenges. Inherent characteristics of the strategy for the development of the healthcare system are reliance on human potential as the main value of the healthcare system; focus on medical care for the population; implementation of flexible response to changes; orientation of the entire complex of measures to the long-term achievement of the objectives of the healthcare development in the regions. Strategies for the development of regional healthcare systems in Russia can be classified into types oriented to different financial conditions and to resources at the disposal of the Russian Federation subjects, as well as to obtain target results.

The methodological toolkit is based on the database of the Russian Treasury, the Ministry of Finance of the Russian Federation, and the Federal State Statistics Service and can be integrated with the digital platform "Electronic Budget". This toolkit is based on the generated system of indicators characterizing financial conditions, resources at the disposal of Russian regions, and the level of achievement of target indicators (Table 1).

Table 1 System of indicators characterizing financial conditions, resources and markers of goal achievement

Notations	Indicators
Indicators Characterizing Financial Conditions and Resources at the Disposal of Constituent Entities of the Russian Federation (**IFCR**)	
IFCR 1.1	Share of completed expenditures on healthcare
IFCR 1.2	Share of assigned expenditures on healthcare
IFCR 1.3	Ratio of completed healthcare expenditures per capita
IFCR 1.4	Ratio of assigned healthcare expenditures per capita
IFCR 1.5	Ratio of executed national project expenditures per capita
IFCR 1.6	National projects' assigned expenditure per capita ratio
IFCR 1.7	Execution rate of expenditures of the national project "Demography"
IFCR 1.8	Ratio of executed expenditures of the national project "Demography" per capita
IFCR 1.9	Coefficient of assigned expenditures of the national project "Demography" per capita
IFCR 1.10	Execution rate of expenditures of the national project "Health Care"
IFCR 1.11	Coefficient of executed expenditures of the national project "Health Care" per capita
IFCR 1.12	Coefficient of assigned expenses of the national project "Health Care" per capita
IFCR 1.13	hospital organisations availability ccoefficient
IFCR 1.14	Outpatient and polyclinic organizations availability coefficient
IFCR 1.15	Hospital bed availability ratio
IFCR 1.16	Medical and obstetric stations availability coefficient
IFCR 1.17	Load factor per doctor
Target Indicators Achievement Markers (TI)	
TI 1.2	Pregnancy termination rate
TI 1.3	Birth rate
TI 1.4	Mortality rate
TI 1.5	Share of citizens leading a healthy lifestyle
TI 1.6	Life expectancy at birth
TI 1.7	Infant mortality rate

Indicators subject to automated monitoring and characterizing financial conditions, resources, and markers of achievement of goals are brought to a single interval of measurement from 0 to 1. based on the requirement to minimize or maximize them. In

particular, the following standardization formulas are used for minimizing indicators (1) or maximizing indicators (2) characterizing financial conditions and resources (IFCR):

$$IFCR_{ij}^{*} = \frac{IFCR_{ij} - IFCR_{imin}}{IFCR_{imax} - IFCR_{imin}}, \quad (1)$$

$$IFCR_{ij}^{*} = \frac{IFCR_{imax} - IFCR_{ij}}{IFCR_{imax} - IFCR_{imin}}, \quad (2)$$

where $IFCR_{ij}^{*}$ is the standardized IFCR indicator of the index *i* in the region *j*, $IFCR_{ij}$ is an estimated value of the proposed index *i* of IFCR indicator in the region *j*, $IFCR_{imax}$ is the highest estimated value of the *i* index among all analyzed territories, $IFCR_{imin}$is the lowest estimated value of the *i* index among all analyzed territories.

At the next stage, in relation to each region, the summary standardized indicators are determined for the two groups specified in Table 1. For example, for the group of financial conditions and resources by the formula (3):

$$CIFCR_{j}^{*} = \sum_{i=1}^{n} IFCR_{ij}^{*}, \quad (3)$$

where $CIFCR_{j}^{*}$ is a complex standardized indicator characterizing the financial conditions and resources of the regions. Similarly, a complex standardized indicator is calculated by markers of target achievement indicators.

Further, the strategies for developing regional healthcare systems in Russia are classified using cluster analysis (Table 2).

Table 2 Classification of strategies for the development of regional health care systems in Russia

Types	Level combinations	Zones
1 type	IFCR 1 – TI 1	Zone No. 7
2 type	IFCR 1– TI 2	Zone No. 8
3 type	IFCR 2 – TI 1	Zone No. 4
4 type	IFCR 1 – TI 3	Zone No. 9
5 type	IFCR 2 – TI 2	Zone No. 5
6 type	IFCR 3 – TI 1	Zone No. 1
7 type	IFCR 2 – TI 3	Zone No. 6
8 type	IFCR 3 – TI 2	Zone No. 2
9 type	IFCR 3 – TI 3	Zone No. 3

Let us characterize the types of health system development strategies by taking into account financial conditions, regional resources, and markers of target indicators achievement (Figure 1). The first type (*IFCR 1 – TI 1*) characterizes the zone of high sustainability of the regional health care system. The second type (*IFCR 1 – TI 2*) reflects the zone of moderate sustainability of the regional health system. The third type (*IFCR 2 – TI 1*) shows the zone of weak sustainability of the regional health system functioning. Regions that are categorized in strategy types 1-3 differ from each other in terms of financial and resource endowment and markers of target indicator achievement. However, they have sufficient resources and good fulfillment of healthcare target indicators.

The fourth type (*IFCR 1 – TI 3*) characterizes the zone of weak sustainability of the regional healthcare system. The fifth type (*IFCR 2 – TI 2*) demonstrates a neutral state ("point of indifference") of the regional healthcare system. The sixth type (*IFCR 3 – TI 1*) reflects a moderately unstable state of the regional health system. Regions categorized as types 4-6 of strategies have excellent financial and resource endowment and different markers of target indicators achievement. They are characterized by a satisfactory level and average level of achievement of target health indicators. However, there is often a shortage of resources to achieve the planned values of the control figures of the target indicators.

The seventh type (*IFCR 2 – TI 3*) demonstrates the significant fragility of regional health systems. The eighth type (*IFCR 3 – TI 2*) reflects high volatility in the functioning of regional health systems. The ninth type (*IFCR 3 – TI 3*) indicates the presence of crisis conditions and high barriers to developing regional health systems. Regions classified as types 7-9 of strategies differ from each other by the level of financial and resource provision and markers of achievement of target indicators but are characterized by insufficient resource provision and low level of achievement of target indicators.

For the purposes of the ongoing cluster analysis of regional healthcare systems, it is proposed to provide an integral characterization by groups of strategies.

Financial Conditions and Resources				
	IFCR 3 rd level	№1 Sixth type *IFCR* 3 – *TI* 1	№2 Eighth type *IFCR* 3 – *TI* 2	№3 Ninth type *IFCR* 3 – *TI* 3
	IFCR 2 nd level	№4 Third type *IFCR* 2 – *TI* 1	№5 Fifth type *IFCR* 2 – *TI* 2	№6 Seventh type *IFCR* 2 – *TI* 3
	IFCR 1 st level	№ 7 First type *IFCR* 1 – *TI* 1	№8 Second type *IFCR* 1 – *TI* 2	№9 Fourth type *IFCR* 1 – *TI* 3
		TI 11 st level	*TI* 2 nd level	*TI* 3 rd level
		Target Indicator Achievement Markers		

Figure 1 Matrix of strategies for the development of healthcare systems based on complex standardized indicators, taking into account the financial conditions and resources of the regions and by markers of achievement of target indicators

Types 1-3 of healthcare system development strategies are characterized by a high degree of financial and resource centralization, and resource efficiency is linked to the implementation of market mechanisms in healthcare. As a rule, such healthcare systems operate in large industrial regions. Paid services in private medical institutions are characterized by high quality, and working conditions for doctors are much better. These types of strategies are also characterized by better values of goal achievement markers: birth rate, mortality rate, number of citizens leading a healthy lifestyle, life expectancy, and infant mortality rate.

In the regions, there should be a system of fund distribution that enhances state control over the targeted use of allocated funds, ensuring the effective functioning of the public healthcare system. The introduction of market mechanisms in the healthcare system may lead to increased costs due to unjustified appointments. The system of motivation of medical staff should restrain the growth of costs of the health care system. The system should include tools to ensure social protection and accessibility of medical care for low-income groups of the population. Increased accessibility of medical care and doctors' qualifications allow the regions to promptly use new scientific knowledge and technical discoveries and the Russian pharmaceutical industry to produce and supply new-generation medicines to medical institutions.

For regions belonging to the 4-6 types of healthcare system development strategies, it is necessary to increase the role of the state in healthcare financing and introduce mechanisms of financial planning and payment for medical care that stimulate the increase in the efficiency of resource use. It is necessary to form a sustainable financial base for the implementation of the program of state-guaranteed free medical care. It is necessary to introduce a system of financial incentives for regions that fall into a moderate risk zone associated with insufficient financial and resource support and the risk of fulfilling the

strategic objectives of Russia's development: population growth and increased life expectancy.

Functionality issues of the healthcare system in the regions were attributable to 7-9 types of healthcare development strategies are characterized by insufficient funding, shortage of qualified specialists, low salaries of doctors and other medical workers, short duration of appointments with specialists, lack of new equipment, the prevalence of old technologies, high cost and inaccessibility of medicines. The decline of specialists in state polyclinics and hospitals providing free healthcare is due to both low salaries and a lack of incentives for quality work. Patients often give up on waiting for appropriate aid or receive it too late, which sometimes leads to disappointing consequences.

These strategies for healthcare systems development are associated with three areas of transition: financial, infrastructural, and human resources. Public funding needs to be at least doubled. The overall target is for public funding to reach 5% of gross domestic product (GDP) by 2025.

The implementation of the proposed methodological tools is possible through its implementation in the state digital platform “Electronic Budget” (Figure 2).

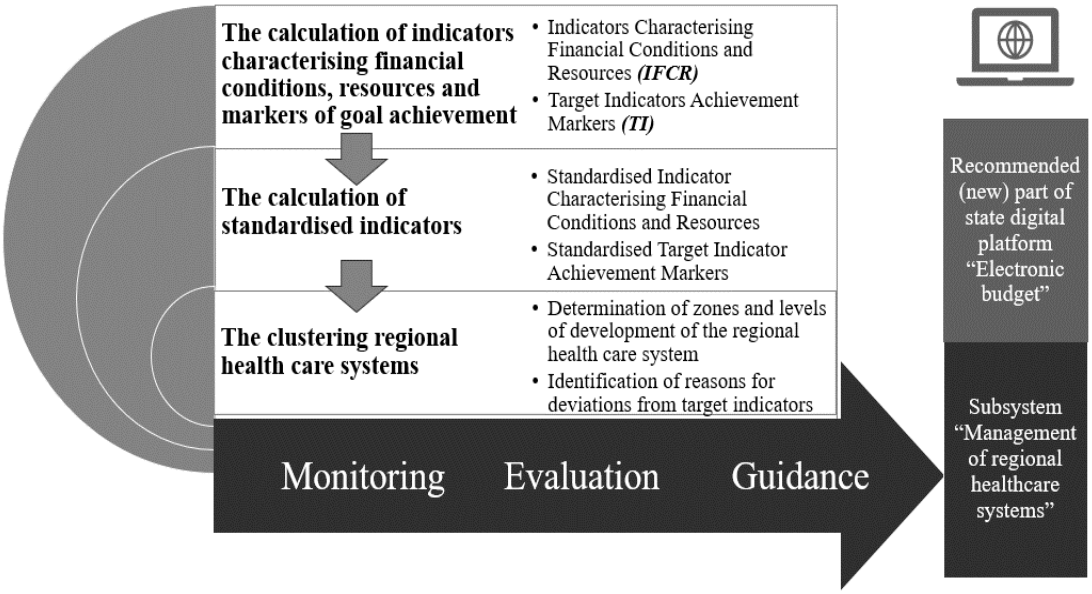

Figure 2 Stages of implementation of the proposed methodological tools for automated analysis of the attainment of regional health care systems' target indicators for state digital platform

The proposed methodological tools will improve the efficiency of both financial and organizational mechanisms for implementing state policy in the field of healthcare.

3. Results and Discussion

The results of the methodological toolkit trial for automated analysis of the target indicators achievement in regional healthcare systems for state digital platforms are presented in Table 3.

Based on the results of calculations, the Russian regions were distributed according to the levels of values of complex standardized indicators, taking into account financial conditions, resources and markers of goal achievement, and the types of strategies corresponding to the classification (Tables 2-3, Figure 1) of healthcare system development in 2021 were determined.

Table 3 Results of regional clustering by levels and zones of healthcare system development based on a set of standardized indicators that take into account financial conditions, resources, and markers for achieving target indicators, 2021 (fragment)

Regions	$CIFCR_j^*$	Level in $CIFR_j^*$	CTI_j^*	Level in CTI_j^*	Type
Yamal-Nenets Autonomous Area	9.39	1 IFCR	3.08	1 TI	1
Chukotka Autonomous Area	6.89	1 IFCR	3.34	1 TI	1
Nenets Autonomous Area	8.66	1 IFCR	3.66	2 TI	2
Republic of Crimea	9.27	1 IFCR	3.78	2 TI	2
Sakhalin Region	9.49	1 IFCR	3.95	2 TI	2
Magadan Region	8.99	1 IFCR	4.30	2 TI	2
Kabardino-Balkarian Republic	12.71	2 IFCR	2.74	1 TI	3
Republic of Tuva	11.61	2 IFCR	3.04	1 TI	3
…	…	…	…	…	…
Moscow City	11.36	2 IFCR	3.59	1 TI	3
Republic of Ingushetia	14.18	3 IFCR	2.04	1 TI	4
Chechen Republic	14.59	3 IFCR	2.37	1 TI	4
Republic of Daghestan	14.12	3 IFCR	2.56	1 TI	4
Chuvash Republic	12.28	2 IFCR	3.65	2 TI	5
Republic of Altai	11.90	2 IFCR	3.65	2 TI	5
Republic of Sakha (Yakutia)	11.88	2 IFCR	3.66	2 TI	5
Jewish Autonomous Region	11.81	2 IFCR	3.69	2 TI	5
…	…	…	…	…	…
Nizhny Novgorod Region	12.93	2 IFCR	4.42	3 TI	7
Amur Region	11.83	2 IFCR	4.44	3 TI	7
Orel Region	12.39	2 IFCR	4.44	3 TI	7
Republic of Karelia	11.55	2 IFCR	4.45	3 TI	7
…	…	…	…	…	…
Stavropol Territory	13.61	3 IFCR	3.77	2 TI	8
Perm Territory	13.48	3 IFCR	4.12	2 TI	8
Omsk Region	14.66	3 IFCR	4.27	2 TI	8
Khabarovsk Territory	14.58	3 IFCR	4.33	2 TI	8
Ivanovo Region	14.37	3 IFCR	4.63	3 TI	9

The least number of regions pertain to the 1-2, 4, and 8-9 types of strategies, namely 2, 4, 3, 4, 1 Russian regions, respectively. Most regions fall under strategy types 5 and 7, with no regions associated with strategy type 6. For example, in Nizhny Novgorod Oblast (type 7 of the strategy) such indicators as hospital outpatient and polyclinic organizations, hospital beds, feldsher-midwifery stations, as well as birth rate, mortality rate, workload per doctor, life expectancy at birth have low values. However, the region is actively involved in the implementation of various programs for the development of healthcare. The values of the coefficients of executed and assigned healthcare expenditures per capita, expenditures of national projects per capita, expenditures of the national project "Demography" per capita, and expenditures of the national project "Health Care" per capita showed insufficient and low level of financing.

The integration of the proposed tools for automated online monitoring of regional health systems with digital public administration platforms (for example, "Electronic Budget") allows to identification and prompt elimination of common regional problems (Figure 3).

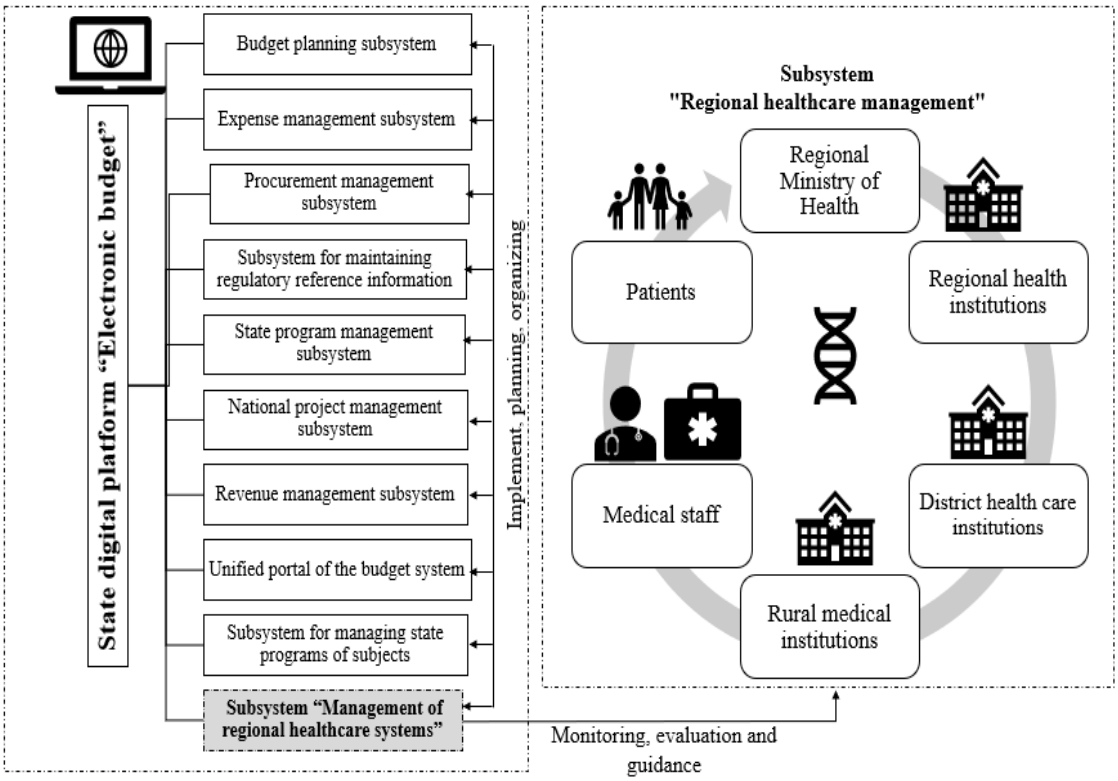

Figure 3 A possible way to integrate the proposed methodological tools by introducing the subsystem "Management of regional healthcare systems" on the state digital platform "Electronic Budget"

The main problems of the regional healthcare system are as follows:

- insufficient quality and accessibility of pre-hospital, medical and sanitary, and primary specialized medical care in rural areas,
- lack of a clear human resources policy to address the staff shortage in the health care system, including programs for the social protection of health workers,
- lack of systematic planning to strengthen the material and technical base of medical institutions,
- underdeveloped public-private partnership network in the regional healthcare system,
- deficit of financing and, as a consequence, insufficient implementation of high-tech treatment methods,
- insufficient level of awareness of the population on the basics of legislation in the field of healthcare and medical insurance;
- insufficient level of efficiency in interaction between health authorities, etc.

It should also be noted the uneven development of the healthcare system in the regions. In part, a number of regions are characterized by low values of the coefficients of provision of hospital organizations, provision of outpatient clinics, provision of hospital beds, provision of medical and obstetric stations, fertility rate, life expectancy at birth.

The analysis shows a significant difference in both financial and organizational mechanisms and tools for the implementation of state policy in the field of healthcare. At the same time, the main goal of the healthcare system of any country is to maintain and improve the health of the population (Panagiotopoulos, Klievink, and Cordella, 2019). The most informative indicator of the state of health, and hence of the achievement of this goal, is the life expectancy of the population at birth. The key factors that will determine the digital health model are:

- the state and pace of development of the region's economy, which determines the possibility of healthcare system development;
- priority of health care development, measured by the share of funding from the budget;
- accessibility of the population to healthcare by guaranteeing every citizen the right to receive medical services in the required volume;
- improving the quality of medical services by promoting and introducing modern forms of service;
- change in the attitude of health care subjects (doctors, patients, population in general) to their health, to preventive measures, readiness to maintain their health, and behavioral strategies in case of illness.

The obtained results of the study are fully consistent with the conclusions made by Mergel, Edelmann, and Haug (2019) and Paul *et al.* (2023). The authors emphasize that addressing the aforementioned challenges and ensuring effective public management of the healthcare system is unattainable without digital platforms. These platforms facilitate the monitoring of target indicator implementation, coordination among all stakeholders, and prompt response measures at the regional (local, district) and national levels.

4. Conclusions

The presented methodology, based on the analysis of target indicators of regional healthcare systems, not only contributes to improving the efficiency of the functioning of this industry but also opens new opportunities for the introduction and development of the latest digital technologies that allow for prompt decision-making and the development of timely measures to maintain public health in individual territories. It will make it possible to quickly make decisions and develop timely measures to maintain public health in certain areas. Automated monitoring of indicators of Russian regional healthcare systems can be integrated into an independent digital platform, "Management of regional healthcare systems," or as a subsystem of the already existing state digital platform, "Electronic Budget." This research can be continued in the direction of expanding the analytical tools of this subsystem, taking into account the individual characteristics of the development of regional healthcare systems and restrictions to ensure the cybersecurity of government platforms. In particular, the system of indicators characterizing financial conditions, resources and indicators of achieving the goals of regional healthcare systems can be expanded.

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