

Forecasting Development of Medical Services Market in the Context of Model-Based Innovation Economy

Sadokat Rakhimova^{1,*}, *Feruza Yusupova*¹, *Iryna Andryushchenko*², *Alexey Yumashev*³ and *Ara Karapetyan*⁴

¹Urgench State University, Hamid Alimdjani Street, 64, 220100, Urgench, Uzbekistan

²National University Zaporizhzhia Polytechnic, Zhukovskoho Street, 64, 69063, Zaporizhzhia, Ukraine

³Sechenov First Moscow State Medical University, Trubetskaya Street, 8-2, 119991, Moscow, Russia

⁴Central Research Institute of Dentistry and Maxillofacial Surgery, Timura Frunze Street, 16, 119034, Moscow, Russia

Abstract. The relevance of the article is due to the current stage of worldwide medical services development. The global nature of innovation development and digital technologies have affected all spheres of human activity, including medicine. On the other hand, the increasing role of social aspects in economic development forms new tasks in the development of healthcare. It should become of a better quality and more accessible. The paper used general scientific and special research methods. Among the special research methods, we used mathematical methods: statistical research, correlation and regression analysis. This article presents the results of forecasting the development of the medical services market in the Khorezm region of the Republic of Uzbekistan in the mid-term perspective. The mathematical model of forecasting the development of the medical services market took into account such factors as the number of private clinics, the number of employees of medical organizations, the real cost of medical services in constant prices, the number of operating hospital facilities, real total income per capita in constant prices of organizations, total income per capita in constant prices. Correlation analysis showed a high, stable relationship between the indicators. Regression analysis allowed to determine the forecast parameters of the market of medical services in the Khorezm region of the Republic of Uzbekistan. The reliability of calculations was checked by Student's t-test and Durbin-Watson statistic test. Increasing the quality of life of the population in the region is the basis for increasing demand for quality health services and will lead to the growth of the private sector of health services.

1 Introduction

Improving the quality of medical services at the global, national, regional and local levels in the world, and attracting foreign investment resources to the health care sector, is considered as a strategic goal of sustainable development in the period until 2030. All over the world,

* Corresponding author: sadoqat8888@mail.ru

medical problems, especially due to the global impact of COVID-19, are increasingly affecting the economies of developed and developing countries. At a time when national economic growth is expected to slow down to 5.5 percent from the pre-pandemic level in developing countries starting with China, Taiwan (86.4), South Korea (82.3), France (80.9), countries such as Japan (80.6), Denmark (79.9), Finland (76.4) are experiencing a decrease in GDP [1].

A more promising model of quality management is a channel model based on systematic analysis and econometric modeling. The strength of this method is that it is possible to test for time-varying factors [2].

It is urgent for the state health care system to protect the health of the population, expand the level of coverage of quality medical services, increase the type and range of offered medical services, and attract new equipment to the medical field by involving the private sector.

For this reason, development of promising indicators for the next years, identifying the development trends of the industry today and the factors affecting the development of the industry, is considered one of the important tasks of this research work [3; 4].

The objective of the article is to identify regularities in the development of the medical services market, to forecast its development and to prepare recommendations to improve the accessibility and quality of medical services for the population. The empirical basis for the realization of this goal will be made up of statistical data on the Khorezm region of the Republic of Uzbekistan. Based on the results obtained, it will be possible to make forecasts for other regions and territories.

2 Literature review

Researchers note a trend towards qualitative development of private medical services [5-16]. Medical services are becoming a competitive advantage for the development of other activities - tourism, travel, promotion of the interests of the territory, investment attraction [17]. In general, this leads to an increase in the investment attractiveness of the territory and the growth of income of the population [18]. The processes of combining two industries - healthcare and tourism - are under study. It is noted that the potential benefits of such a combination exceed the benefits from the development of these industries separately. Healthcare is becoming a connecting element of the socio-economic policy of the region [19].

Currently, there is increasing competition in the healthcare sector. It is manifested both in the private and public sector of medical services. All the tools of classical market competition are used here - advertising, stimulation of consumer demand, development of discount programs for regular clients, maintaining an attractive image of the organization and so on [20].

Lately, researchers have begun to pay attention to the relationship between indicators of healthcare development and those of social and economic well-being of the region. Demographic issues and their dependence on the quality of drug provision are analyzed. Population incomes and their relationship with the dynamics of medical services are considered [21].

Researchers pay special attention to the financial provision of the healthcare system. This is especially true for countries with a state budget deficit. In this situation, public health care organizations are forced to optimize financial activities and seek alternative sources of financing. In such countries, high quality private medical services may be beyond the access of a significant proportion of the population. The research issue is to find ways to increase accessibility of medical services through the development of competition and reduction of prices for the population [22].

The scientific literature provides an in-depth analysis of the statistics of economic indicators of the medical services market [23-28]. The review includes parameters of demand, supply, prices for medical services depending on their complexity and quality, breadth and depth of assortment and other market indicators. It applies both desk and field research, surveys of employees of medical organizations and consumers of their services [29]. Thus, the healthcare sphere and especially its private sector become the object of classical market research. In this regard, we can assert that the use of correlation and regression analysis methods, is as promising for the application in the healthcare field, as it is in classical market research.

Researchers note that improving the quality of medical services at the stages of disease prevention in the population allows saving resources to provide medical care at later stages of the diseases. This allows us to conclude that there is an effective model for the development of the regional medical services market, based on an optimal combination of economic factors such as the number of medical organizations, the number of medical personnel, the cost of various medical services and the ratio of this cost to the population income level [29]. Mandatory and voluntary health insurance is also considered a promising area of research. Countries apply different insurance models. Researchers note that the potential of insurance in healthcare is not yet fully utilized. The formation of an insurance fund through voluntary contributions of all market participants to finance the current needs of health care is promising to develop [31-32].

It is also worth noting the impact of globalization on the market of new medical technologies [33-37]. This applies to digital technologies for monitoring human health [38]. Competition in this market has global dimensions. As studies in the BRICS countries (Brazil, Russia, India, China, South African Republic) have shown, health care expenditures have a stable tendency to increase [39]. Here we can also study the dependence between the market of medical services and tourism, as well as the influence of population income on the dynamics of consumption of these services.

Thus, according to the review of scientific publications on the topic of the study, we can say that application of mathematical methods in research of the regional market of private medical services is very promising. The reviewed sources do not contain the results of the study of mathematical models of the regional market of private medical services. This paper can fill this gap.

3 Materials and Methods

The Khorezm region of the Republic of Uzbekistan was chosen as the empirical and statistical base of the study. This satisfies the purpose of the study - to consider the specifics of the regional market of private medical services.

There are 396 private medical workers in Khorezm region of the Uzbekistan, 333 of them provide qualified medical services to the population in outpatient and 63 inpatient conditions, in 62 specialties. There are 1,327 treatment beds, 232 personal care employees, 836 staff members, 726 nurses and 740 staff members. 142 private medical institutions were established in Khorezm region, only 7 of them providing inpatient medical services. Outpatient medical services were provided in 133 of them, and there were only 232 treatment beds. In 2000, 0.2 percent of patients in the region worked in private clinics, and today, 19 percent are providing medical services to the population in private financial healthcare institutions.

The number of existing private clinics and the number of medical workers in them can be seen as important indicators of the development of the medical field in the region. Because, in 2010-2021, both indicators increased by 7.9 percent and 15.7 times, respectively. As a result, it was possible to increase the real volume of healthcare services by 11.2 times.

Taking the above data, we focused on their selection for the regression model of the health care market. Analysis, prediction and correlation of the results are important for the problem of increasing the density of dependence, that is, the problem of multicollinearity.

From the results of correlation analysis, it is known that it has a high degree of correlation with all the indicators selected for health care services. In addition, they are highly correlated and it was found that identifying them into one model leads to an autocorrelation problem.

A 2.2-fold increase in the number of hospital institutions considered to be important from the point of view of provision of comprehensive medical services, attended by a large part of the population, has been ensured, with a positive trend observed. Taking into account the above indicators, it is necessary to pay attention to the results of the correlation analysis in order to select the factors for the model and evaluate the density of the relationship between them, that is, to avoid the problem of multicollinearity (Table 1).

Table 1. Correlation analysis results in Khorezm region

	PE	WPG	HSG	H	PCRINR	PCTINR
PE	1.00					
WPG	0.98	1.00				
HSG	0.96	0.93	1.00			
H	0.96	0.97	0.93	1.00		
PCRINR	0.91	0.87	0.98	0.84	1.00	
PCTINR	0.99	0.98	0.98	0.96	0.95	1.00

Here: PE – the number of available private clinics in the region (unit); WPG - number of medical workers working in private clinics (person); HSG- Real value of health care services at constant prices (billion soums); H - the number of operating hospital institutions (unit); PCRINR – real total income per capita at constant prices (thousand soums); PCTINR – total income per capita at constant prices (thousand soums).

According to the forecast, the number of private clinics and the number of people employed in them will grow at a high rate in the next years, respectively, private clinics will make up 15.9 percent and those employed in them will make up 19.1 percent. The fact that the number of jobs in the private sector is higher than the growth rate of clinics shows that clinics will increase not only in quantity, but also in quality. At the same time, the number of operating hospitals will also be steadily growing. Growth rates of real per capita income and total income are estimated to be 4.8 percent and 12.2 percent, respectively.

Thus, we have prepared statistics and pre-processed it to make a mathematical model for forecasting the growth of the market of healthcare services in the Khorezm region of the Republic of Uzbekistan.

4 Results

From the results of the correlation analysis, it can be seen that health care services have a high degree of correlation with all the indicators selected for analysis. In addition, it was found that the correlation between the given indicators is high, and their inclusion in one model creates the problem of autocorrelation [40].

Real and total income per capita was also considered as an important social factor. There are two reasons for this, firstly, the increase in the income of the population increases their ability to comply with and use medical standards, and secondly, the increase in the share of the private sector makes the price of the service and the income of the population one of the important factors in the use of medical services.

Taking into account the results of the above analysis, the impact of these factors on the volume of medical services provided in the region was assessed using quantitative indicators based on the regression analysis method.

The existence of a strong correlation between the factors indicates that it is not possible to use the multifactor regression equation. Because, due to the problem of multicollinearity, the opposite signs of the coefficients were determined in the equation. Therefore, the influence of each factor was considered separately. A logarithmic function was used for this, because the parameter representing the effect of the factor in the equation of this form is equal to the elasticity coefficient.

The results of three important criteria for justifying the adequacy of the developed models were mentioned, that is, if the adequacy of the determined parameters based on the Student's t-test was justified, the coefficient of determination and the MAPE indicator were used to justify the suitability and reliability of the model.

According to the obtained results, it was determined that the number of private clinics has a positive effect on health services quality. However, the coefficient of elasticity between the two indicators is 0.7, which is the smallest value among the parameters determined by the selected factors.

On the other hand, all criteria excluding MAPE indicate that the influence of this factor is higher than that of the others. The same situation can be observed in terms of the number of items in private clinics, that is, the coefficient of elasticity for this factor is 0.74. It is important to pay special attention to the effect of the change in the number of operating hospitals. Because the coefficient of elasticity determined by this factor has the highest value and is 2.54. It is observed that the Student t-test cited to justify the adequacy of this parameter is at the required level.

However, the coefficient of determination is 0.68, indicating that this factor accounts for 68% of the variation in the volume of health care services excluding other factors and interactions. This is the smallest value among the specified coefficients of determination. In addition, the MAPE indicator has the highest value, which shows a low reliability of this model as compared to other models. To find out why, we consider the relationship between changes in population income and the demand for health services. Incomes of the population were considered in two ways, i.e. real and total incomes per capita. With an elasticity coefficient of 2.48 representing the effect of real income per capita, it appears as the factor with the highest effect after the number of operating hospital facilities.

It should be noted that all the criteria cited for the justification of the adequacy and reliability of this model and its parameters have a high value. In particular, the MAPE indicator of 2.95 justifies the reliability of this model as 97 percent. The coefficient of elasticity determined by total income per capita is almost twice as small. It can be observed that the model representing the influence of this factor, as well as the real per capita income, has a high degree of adequacy and reliability of its parameters.

The results of the analysis show that the highest elasticity coefficient corresponds to the number of operating hospitals, but the adequacy and reliability of the model and its parameters are low. On the other hand, it has been found that the effect of real and total income per capita is high. To conclude, a large volume of health care services is provided by the operating hospital institutions, only the increase in the income of the population causes an increase in the demand for the services provided by private clinics. As a result, although the effect of the number of hospital facilities in operation is high, the majority of the change in health services is accounted for by private clinics.

Based on the results of the above analysis, the volume of health care services in the region and the factors influencing it were developed for the next years. For this, the necessary model was developed using regression analysis. First of all, we will focus on the results of the regression analysis, which was carried out on the development of the necessary model to calculate the forecast values of the change of healthcare services in the region in the next five years.

A graphical method was used to select the type of the model, and when connecting the points, two views correspond to their shape, i.e. a straight line and a parabola (Figure 1). According to the results of the implemented graphic method, it is appropriate to use a two-view model to develop a prognosis. In both cases, the coefficient of determination is close to one. But the results obtained using this method are not enough to justify the adequacy of the models and their parameters, so we found it appropriate to carry out additional analysis to choose the most optimal model [40].

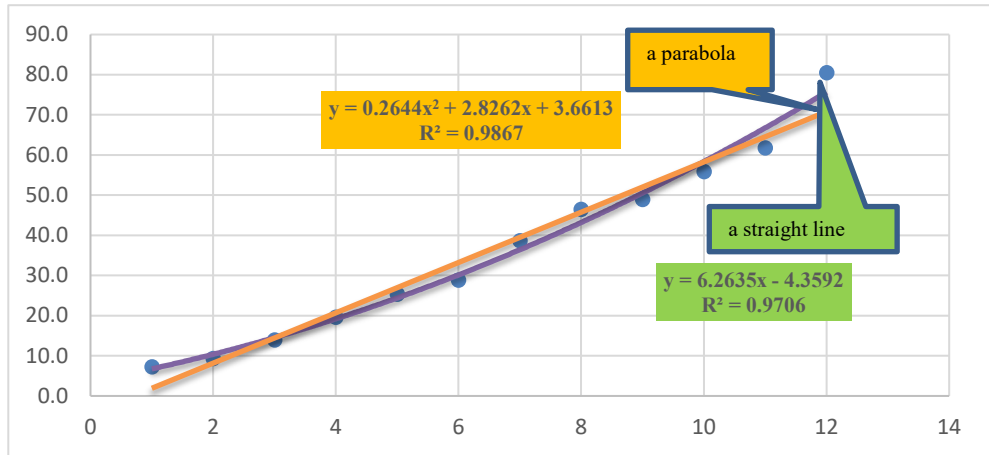


Fig. 1. The results of the graphical method for the selection of the necessary model for the development of forecast values of the volume of health services in Khorezm region

The Gretl program was used to perform the comparative regression analysis, and as a result of developing the mentioned linear model, the free term was found to be inadequate according to Student's t-test. All other criteria are at the required level, indicating the adequacy of the model. However, it was found that the MAPE indicator representing the reliability of the model is 12.3 and has a slightly higher value (Appendix 1). The results of the model determined by excluding the free term are adequate for almost all criteria, except for the decrease of the Durbin-Watson index and the almost unchanged MAPE index. Taking into account the results of the above analysis, an alternative option, i.e. a comparative analysis of the results of the parabola, was carried out. Similarly, when the model presented in the graph was developed using Gretl, it shows that the free term is not adequate according to the Student's t-test, but other parameters are adequate. In addition, the remaining factors justify the high level of the model. In particular, the value of MAPE was found to be equal to 5.6. Therefore, we found it appropriate to use the following model to calculate the forecast indicators of the real value of healthcare services provided in the region.

$$HSC = 3,99 * t + 0,19 * t^2 \tag{1}$$

Here: HSC - Real value of health care services at constant prices (billion soums); t – the trend starts from 2010.

Adequacy of this model was judged by a number of criteria and it was proved that the model is adequate and reliable in all of them (Table.2). The results of the model developed to calculate the forecast indicators of the real value of health services provided in Khorezm region [40].

Table 2. (Model 7: OLS, using observations 2010-2021 (T = 12) Dependent variable: HSC)

	Coefficient	Std. Error	t-ratio	p-value
Time	3.99465	0.470951	8.482	<0.0001

time2	0.186511	0.0487307	3.827	0.0033
Mean dependent var	36.35353	S.D. dependent var	22.92323	
Sum squared resid	89.37712	S.E. of regression	2.989601	
Uncentered R-squared	0.995870	Centered R-squared	0.984537	
F(2, 10)	1205.554	P-value(F)	1.20e-12	
Log-likelihood	-29.07501	Akaike criterion	62.15002	
Schwarz criterion	63.11983	Hannan-Quinn	61.79096	
Rho	-0.200290	Durbin-Watson	1.796001	

Thus, we have succeeded in making a mathematical model of forecasting the development of the medical services market in Khorezm region of the Republic of Uzbekistan for the medium term perspective. The validity of the model was checked by Student, Schwartz, Akaike, Hanan-Quinn, Durbin-Watson criteria. According to the obtained data, we can say that the model we have developed has an acceptable level of reliability.

5 Discussion

Consider the scientific publications that have similar conclusions and recommendations to our study. First, scientists note the important role of health care in the socio-economic system of the region. They note the need to use not only market instruments in the organization of medical care for the population of the region [41]. Our study confirms this conclusion and the need to develop the social function of health care through increasing the accessibility of medical services, reducing their cost by developing competition and improving the quality of life of the population in the territory [42]. Secondly, scientists note a radical change in the quality of the health care system due to new innovative technologies. New medical solutions make it possible to increase the efficiency of preventive and hospital medical treatment and extend the average life span of a person [43]. Also, emphasis should be placed on the integration of new technological medical solutions into the overall management system of the region [44]. In our study, we also propose to forecast the growth parameters of the private medical services market in coordination with the forecast of social and economic growth of the region. Third, researchers note that to overcome market imperfections and high cost of medical services, it is necessary to apply various forms of organization of economic relations, such as cooperatives [45]. Our study also focuses on increasing the accessibility of medical services through various forms of organization of economic relations. This will lead to an increase in the number of private medical organizations and improvement of the health services quality. Fourth, the scientific literature describes a new quality of the health care system due to the processes of globalization. Competition in the market of medical services has a global nature [46]. Although our study focuses on the regional health care system, we also emphasize the need to be guided by the best global practices of health care services and advanced ways of financing health care organizations in the territory. Fifth, scientists point to the need to develop public-private partnership in the field of health care. New and expensive innovative medical technological solutions should be supported by the state together with market institutions. There is an experience of such interaction and it requires further application [47]. The mathematical model of the development of the regional market of private medical services presented in our study provides for state support using various methods to stimulate supply and demand [35; 48-49].

Next, we consider the results of studies by other authors, which have the most debatable aspect and high potential for further research. First, the reforms in the health care system carried out in the countries with transition economies, focused on purely market mechanisms, led to a decrease in the accessibility of medical services against the background of a general

decline in the quality of life [50]. In our study, we propose not to be restricted to market-based management methods, but to expand the toolkit of interaction with all participants of the health care system. Second, the use of new innovative medicines and treatment methods sometimes encounters many bureaucratic obstacles and does not reach the end user. It is necessary to improve mechanisms for accelerating and bringing new innovative medicines and treatments to the market [51]. Our study with the development of a mathematical model for forecasting the development of the regional market of medical services provides for certain time parameters. Accordingly, it can be used to test the processes of bringing new innovative medicines and treatment methods to the market with maximum benefit to the end user. Thirdly, healthcare organizations are trying to implement business models based on digital technologies and organizational innovations. On the one hand this expands the range of healthcare services, but on the other hand it may have a high initial cost. The authors note that the digitalization of medicine may take decades. However, it is an objective process of optimizing medical care with the help of digital technologies [52]. It is also important to ensure the security system of the medical organization and secure access to individual medical data [53]. Our study did not put digital technology in medicine as the main object of research. However, our study indicates that the private sector of medical services has the ability to improve the quality of medical services, including with the help of new, digital technologies [54-55]. This area is promising for further research. We agree with this thesis. Fourthly, scientists note that the retail segment of medical services requires breakthrough innovative solutions that will make medical services for consumers more accessible, high-quality and not expensive. In many countries, there is a huge proportion of the population that does not have health insurance. This is a problem that needs to be addressed via breakthrough innovation thinking [56]. Our study confirms this thesis, as in the considered private medical sector consumers have little opportunity to use medical insurance mechanisms. The high quality of medical services in the private sector faces the problem of low accessibility and high prices. This aspect requires further research. It is necessary to investigate the composition and structure of possible breakthrough innovations in the retail segment of medical services. Fifth, addressing the problems of the poorest countries in health services is promising research sphere. Poor countries face problems in the power supply of their hospitals and generally poor material, technical and drug supply [57, 58]. This is a social problem that threatens the population decline of the poorest countries. The world should help to solve these problems [59]. We agree with this thesis and also call for attention to this problem. Our study examined the relationship between population income and growth performance of the private health care sector. The results show a strong direct relationship. The state should work on increasing the population's income and development of public medical organizations.

6 Conclusions and suggestions

According to the results of the research, the demand for services in the market of medical services in Khorezm region will increase in the following years. At the same time, it shows the necessity of conducting medical examinations of residents in the region. As a result, increasing the income of the population, making them adhere to medical standards, and increasing the demand for services in this field. In order to meet this demand, it is necessary to increase the amount and scope of services, and the share of the private sector in the field will be further increased. Based on socio-economic parameters, the provision of quality medical services will be radically improved due to the advantages of the private sector share in the context of market relations [32]. Thus, the analysis of the medical service delivery system shows that the main indicator of the effectiveness of medical services, which is

specific to the social sphere and socially oriented, and affects all sectors with the significant participation of the state, is the increase in the quality of life of the population.

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