Evaluation of Health Service Capacity and High-Quality Development Path in China

Guorong Chai[1] and Jiaying Wang[2]
[1]School of Management, Lanzhou University, Lanzhou, Gansu,730000, China
[2]Hospital Management Research Center, Lanzhou University, Lanzhou, Gansu, 730000, China

Keywords: Health Services Capacity, High-Quality Development, Coupling Coordination Degree, Intelligent Healthcare.

Abstract: On the basis of analyzing the connotation of high-quality development of health service capacity, this study collects the medical resource data of 31 provinces (municipalities) in China from 2012 to 2019. The evaluation of China's health service capacity is conducted using the rank-sum ratio method, the coupling coordination degree model, and the cloud model, and relevant optimization paths are put forward. The results show that the inter-regional health service capacity is constantly improving and stabilizing, but regions including Anhui, Hainan, and Heilongjiang still face such problems as uncoordinated development of health service volume, health service efficiency, and human resources. Based on the current development trend of health service intellectualization, this paper puts forward optimization paths for health service capacity at the national, regional, and institutional levels with the aid of digital healthcare.

1 INTRODUCTION

Over the past two years, we have been living under the great impact of the major public health emergencies marked by COVID-19, which also has brought great challenges to the global governance system and governance capacity. Notably, problems such as fragile health service capacity and unreasonable resource allocation were exposed in some countries during the anti-pandemic period (Ilardi, 2020; Patel, 2020). It is undeniable that the lack of a single indicator of health service capacity may be explained by the "hospital runs" during emergencies such as the outbreak of the pandemic and the surge in the number of confirmed cases. However, it also exposes the poor coordination of multi-indicator development of national health service capacity, causing difficulty in forming a strong health service capacity network. As people's health has been put at the center of the world development agenda and becomes a comprehensive measure of economic and social development and people's wellbeing, China has gradually focused on optimizing the high-quality development of health service capabilities (Uner, 2020). To this end, relevant policies issued by China in November 2021 emphasize the need to strengthen health services capacity and benchmarks (General office of the State Council, 2021). Therefore, optimizing and improving health service capacity is an important part of China's high-quality development and an important link to improving national public service capacity.

Currently, the research on high-quality development in China mainly focuses on connotation and measurement. There is no unified definition of high-quality development in the academic circle, nor a unified standard for measurement (Yu, 2019). On the contrary, more attention is paid to the multi-indicator coordinated development state with equal emphasis on development speed and quality, stability, and balance (Shi, 2021; Jin, 2018). The

* Corresponding author
Chai Guorong (1976-), professor, whose main research interests are digital health care and health care management. Wang Jiaying (1993-), doctoral student, whose main research interests are digital health care and health care management.

Chai, G. and Wang, J.
Evaluation of Health Service Capacity and High-Quality Development Path in China.
DOI: 10.5220/0012041600003620
In *Proceedings of the 4th International Conference on Economic Management and Model Engineering (ICEMME 2022)*, pages 663-671
ISBN: 978-989-758-636-1

existing research deems health service capacity as the maximum degree of non-material service that can provide actual medical output, with patients and special groups as the main service objects, and medical technologies, equipment, diagnosis and treatment environment, and information technology as basic service means. It mainly includes hospital resource allocation, technical personnel, work efficiency, diagnosis and treatment, technical level, and other abilities (Wang, 2021). Scholars both in China and abroad have conducted studies on health service capacity. Foreign countries pay more attention to the evaluation of emergency health service provision (Alzahrani, 2021), while most domestic studies are conducted from the perspective of resource allocation and analyze the equalization of health services at provincial, municipal, and primary levels.

Overall, the existing research still has the following shortcomings. First of all, theoretical research is difficult to adapt to the current development trend. The impact of the pandemic has exposed the vulnerability of health service capacity, so we should pay more attention to the formation of a strong health service capacity network rather than the equal allocation of medical resources. Second, the existing research still leans toward the "hard" indicator of facilities and pays little attention to the "soft" indicator of resources. Moreover, the indicator composition mostly chooses individual perception, leaving objectivity doubtful. Finally, the elements of health service capacity are interrelated as a network, but no research regards them as a whole, ignoring the coordination among the elements. The important role of medical institutions in shaping and improving their service capacity is also ignored.

Given the above analysis, this study constructs an all-around indicator system for the evaluation of health service capacity in 31 provinces (municipalities) in China and further analyzes the coupling coordination degree among these indicators and the advantageous and disadvantageous indicators of different regions. On this basis, this paper puts forward the optimization path for health service capacity, which provides a theoretical reference for promoting the in-depth and diversified development of health services.

2 CONSTRUCTION AND CALCULATION OF EVALUATION INDICATOR OF HEALTH SERVICE CAPACITY

2.1 Construction of Evaluation Indicator System

Accurately grasping the connotation of high-quality development of health services capacity is the basis of constructing a scientific evaluation indicator system. It is considered that promoting the high-quality development of health service capacity is a major strategic choice for China to shore up weak spots in consumer service industries and improve people's quality of life in the face of the bottleneck of regional resource allocation and complex and changeable emergencies. The high-quality development represents the optimized state of the service capacity structure, which is closely related to service facilities, service quality, human resources, and supportive policies. Health service capacity is affected by multiple internal and external indicators. The service capacity of medical institutions in different provinces is not only influenced by external indicators such as regional economic development and management policies; it is also affected by internal indicators such as service facilities, service efficiency, and human resources; moreover, the development of the regional information technology can also serve as a catalyst (Whitley, 2020). According to the nature of indicators, they can be divided into "hard indicators" and "soft indicators." The former is relatively stable, including the number of visits and the number of facilities; the latter is a supplement to hard indicators and has certain variability (Ni, 2010), including human resources, information technology, etc. The interaction of "hard indicators" and "soft indicators" destabilizes the development of health service capacity, the latter of which causes a huge disparity among different provinces (municipalities). Therefore, this paper, from the perspective of systemic analysis, established an evaluation indicator system for evaluating the coordinated development of "hard indicators" and "soft indicators."

By combing the existing research results, five evaluation dimensions were determined, including the quality, efficiency, scope, and human resources of hardware facilities and business operations. Given the scarce recent research results in this aspect, this paper further tested the rationality of the evaluation indicator using the expert interview method to avoid

omissions. Six administrative staff and nine medical practitioners from the First and Second Hospitals of Lanzhou University and Gansu Provincial People's Hospital were selected for four anonymous questionnaires and interviews, which took two weeks. These interviews mainly introduced the purpose and significance of the research to experts, which in turn let us understand the internal evaluation process and standards of services systematically and draw opinions on indicator selection from professionals. To further ensure the scientific effectiveness of indicator selection, we consulted five administrative staff and medical practitioners from the National Health and Family Planning Commission, Health Commission of Guangdong Province, Huashan Hospital of Fudan University, and the Third Affiliated Hospital of Sun Yat-sen University, and confirmed the final evaluation indicator system (Table 1).

Table 1: Selection of evaluation indicators for health service capacity.

Primary indicator	Secondary indicators	Tertiary indicators	Indicator attribute	Expert interview results
Medical treatment Service capability	Health service volume	Number of outpatient visits (A_1)	+	90% (18 persons)
		Number of emergency visits (A_2)	+	95% (19 persons)
		Number of health examinations (A_3)	+	85% (17 persons)
		Number of discharged patients (A_4)	+	85% (17 persons)
		Number of hospital admissions (A_5)	+	45% (9 persons)
	Health service efficiency	Discharge rate per bed (B_1)	+	100% (20 persons)
		Average number of visits per capita (B_2)	+	85% (17 persons)
		Number of inpatients per doctor per day (B_3)	+	80% (16 persons)
		Average length of stay in hospital (B_4)	+	40% (8 persons)
	Health service facilities	Number of hospital beds per 10,000 population (C_1)	+	100% (20 persons)
		Occupancy rate of hospital beds (C_2)	+	85% (17 persons)
		Number of medical institutions per 10,000 population (C_3)	+	60% (12 persons)
	Health service human resources	Practicing (assistant) physicians per 10,000 population (D_1)	+	100% (20 persons)
		Practicing physicians per 10,000 population (D_2)	+	100% (20 persons)
		Registered nurses per 10,000 population (D_3)	+	90% (18 persons)
		Pharmacists per 10,000 population (D_4)	+	85% (17 persons)
		Technicians per 10,000 population (D_5)	+	75% (15 persons)

While establishing the indicator system, in an effort to eliminate the influence of the regional population base as much as possible and reduce the preference of medical workers in the interview, we treated these indicators as relative indicators and used the data from 2012 to 2019 to test the validity of the system. The chronological data showed that the dimensions of the overall evaluation indicator system were set reasonably, but some indicators were still required to be adjusted or deleted. Based on the integration of expert interview results and the validity test of the indicator system, indicators A_5, B_4, and C_3 were removed in this paper. The reasons for deletion are as follows: The hospitalization rate (A_5) is considered to be related to the discharge rate (A_4), both indicating the sickness rate and the facility carrying capacity of medical institutions. The average length of stay in a hospital (B_4) is more relevant to

the specific conditions of the patient, and the number of medical institutions per 10,000 population (C_3) is not explanatory enough as there may be big differences in the level of medical institutions. As such, the above indicators have a low degree of interpretation of service efficiency and have not passed the validity test, so they are not considered for selection. The final indicator system comprises 14 evaluation indicators selected from four dimensions: health service volume, service efficiency, medical facilities, and human resources.

2.2 Analysis of Data Sources

This paper takes China's 31 provincial administrative regions as the research object (except Hong Kong, Macao, and Taiwan) within the period of 2012-2019. The data involved in the research indicators come from the National Population Health Data Center and China Statistical Yearbook. Based on the research topic, the author checked, screened, and integrated the data, supplemented the missing data to ensure the integrity of the sample, and carried out an equivalent performance of indicators to ensure the validity and accuracy of the data.

2.3 Construction of Evaluation Model

Rank-sum ratio (RSR) was used to measure the ranking and grading of health service capacity in 31 provinces (municipalities). The RSR method integrates the advantages of classical parametric statistics and modern nonparametric statistics, and the errors of objective weighting and method simplification can be offset among regions. Moreover, using the non-integer rank-sum ratio method in the rank ordering can address the defects of easy loss of quantitative information of original indicator values, thus improving the reliability of results (Li, 2019). For benefit indicators, the rank ordering was made according to Formula (1), and RSR distribution was determined by Formula (2). After the RSR correction values were output through regression validation, the ranking and evaluation results were obtained.

$$R_{ij} = 1 + (n-1)\frac{X_{ij} - \min(X_{1j}, X_{nj}, ..., X_{nj})}{\max(X_{1j}, X_{nj}, ..., X_{nj}) - \min(X_{1j}, X_{nj}, ..., X_{nj})} \quad (1)$$

$$RSR_i = \frac{1}{n}\sum_{j=1}^{m} w_j R_{ij} \quad (2)$$

The coupling coordination degree model was used to measure the correlation degree and coordinated development level among multiple interactive indicators of regional health service capacity. The four functions in Formula (3) are the comprehensive evaluation indicators of health service capacity, and C is the coupling degree. In Formulas (4) and (5), T is the coordination indicator, and D is the coupling coordination degree (Kong, 2021).

$$C = 4 \times \{f(x) \times g(y) \times h(z) \times l(w) / [f(x) + g(y) + h(z) + l(w)]^4\}^{1/4} \quad (3)$$

$$T = af(x) + \beta g(y) + \lambda h(z) + \omega l(w) \quad (4)$$

$$D = \sqrt{C^* T} \quad (5)$$

The cloud model was used to measure the imbalance degree of health service capacity development in vulnerable areas and provides path guidance for optimizing service capacity. The model is an uncertain transformation model between qualitative concepts and their quantitative representations based on traditional fuzzy mathematics and probability statistics. It overcomes the shortcoming of randomness in the existing evaluation and realizes the effective evaluation of objects. Generally, the cloud model sets U as the domain of X, C as a qualitative concept of U, and sample x a random representation of qualitative concept C, then the certainty of X to C is a random number with stable tendency (Li, 2014), as expressed in Formula (6).

$$\mu: U \to [0,1], \forall x \in U, x \to \mu(x) \quad (6)$$

3 EVALUATION OF HEALTH SERVICE CAPACITY

3.1 Comprehensive Evaluation of Health Service Capacity

According to the designed evaluation principle, we first made a preliminary analysis of the overall evolution of health service capacity in 31 provinces (municipalities) in China from 2012 to 2019. The analysis results showed that the regression equation had a good fitting effect, with $R^2 > 0.95$ and $P < 0.001$. In the fitted critical value, the corresponding critical value of each grade was increasing continuously. The critical value of the fifth grade (optimal grade) rose from 0.686 in 2012 to 0.732 in 2019, and that of the first grade (lowest grade) rose from 0.130 to 0.153. This indicated that the overall health service capacity among regions was enhanced in fluctuation, but it still showed a large difference in the level of health service capacity among different regions (Table 2).

Table 2: RSR fitting thresholds and number of classifications.

Grade	2012	2013	2014	2015	2016	2017	2018	2019	Number
1	< 0.13	< 0.11	< 0.09	< 0.07	< 0.08	< 0.08	< 0.11	< 0.15	1
2	0.13~	0.11~	0.09 ~	0.07~	0.08~	0.08~	0.11~	0.15~	7
3	0.32~	0.30~	0.28~	0.27~	0.28~	0.29~	0.30~	0.35~	14
4	0.50~	0.48~	0.48~	0.47~	0.49~	0.49~	0.50~	0.54~	7
5	0.69~	0.66~	0.67~	0.67~	0.70~	0.69~	0.70~	0.73~	2

3.2 Difference Evaluation of Coordinated Development of Health Service Capacity

The coordinated development of the indicators of health service capacity is the premise and key to optimal development, so the coordination of multiple indicators should not be ignored during the evaluation. The coupling coordination degree analysis can further measure the coordinated development level of multiple interactive indicators of inter-regional health service capacity. This paper subdivided the coupling coordination degree into ten levels, as shown in Table 3, in accordance with the overview classification of Cong et al. (2019). (Cong, 2019)

Table 3: Criteria for the classification of coupling coordination level.

Coupling coordination *D*-value interval	Grade	Degree of coordination	Coupling coordination *D*-value interval	Grade	Degree of coordination
(0.0~0.1)	1	Extreme disorder	(0.5~0.6)	6	Barely Coordinated
(0.1~0.2)	2	Severe disorder	(0.6~0.7)	7	Primary coordination
(0.2~0.3)	3	Moderate disorder	(0.7~0.8)	8	Intermediate coordination
(0.3~0.4)	4	Mild disorder	(0.8~0.9)	9	Good Coordination
(0.4~0.5)	5	Nearly dysfunctional	(0.9~0.10)	10	Quality coordination

The analysis results showed that the difference in coupling coordination degrees of health service capacity in the study areas was shrinking year by year, China's health service capacity was improving year by year, and the evolution path was steadily optimized. Provinces (municipalities) with a high coordination level of health service capacity include Beijing, Shanghai, Zhejiang, etc., in contrast to other regions such as Xizang, Shanxi, and Anhui. However, the coupling coordination of regional health service capacity changed little, which generally remained at about two degrees(Figure 1). The research results of coupling coordination degree of health service capacity in 31 provinces (municipalities) in 2019 are shown in Table 4, in which the *C* value of each place is high, with the maximum value reaching 0.99 and most around 0.8. It can be seen that the multi-indicators of health service capacity are closely related and require coupling coordinated development. Only in areas with their coupling coordination degree at a primary level and above, the coordination indicator $T \geq 0.60$; in most other areas, the *T* value is relatively small due to poor coordination development.

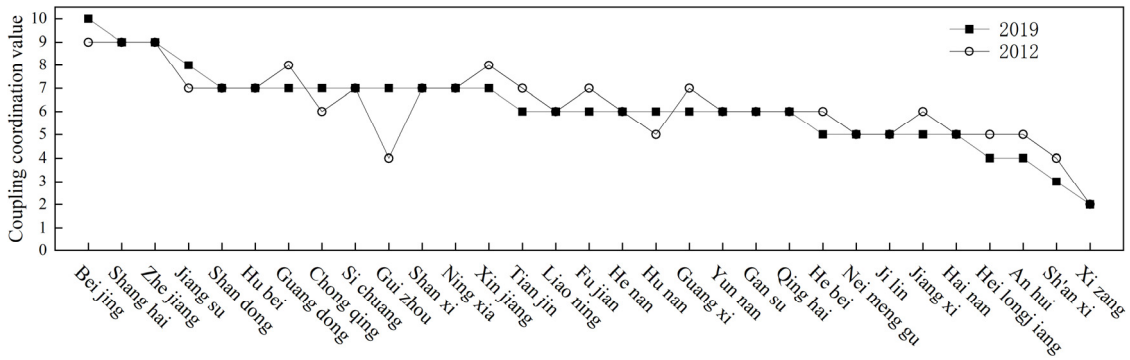

Figure 1: Differences in coupling and coordination scores of medical service capacity among 31 Chinese provinces (municipalities) in 2012 and 2019.

Table 4: 2019 Healthcare Service Capacity Coupling Coordination Values.

Region	*C* value	*T* value	*D* value	Coordina-tion level	Region	*C* value	*T* value	*D* value	Coordination level
Beijing	0.99	0.82	0.90	10	Fujian	0.88	0.35	0.55	6
Shanghai	0.95	0.83	0.89	9	Guangxi	0.75	0.40	0.55	6
Zhejiang	0.97	0.77	0.86	9	Qinghai	0.97	0.29	0.53	6
Jiangsu	0.96	0.53	0.71	8	Gansu	0.82	0.32	0.51	6
Shanxi	0.98	0.47	0.68	7	Liaoning	0.96	0.27	0.51	6
Sichuan	0.87	0.51	0.67	7	Hunan	0.77	0.33	0.51	6
Ningxia	0.97	0.46	0.67	7	Hainan	0.91	0.26	0.48	5
Xinjiang	0.90	0.49	0.67	7	Hebei	0.80	0.26	0.45	5
Guangdong	0.86	0.48	0.64	7	Jiangxi	0.66	0.29	0.44	5
Hubei	0.83	0.48	0.63	7	Neimenggu	0.90	0.21	0.44	5
Chongqing	0.88	0.45	0.63	7	Jilin	0.90	0.21	0.43	5
Shandong	0.96	0.40	0.62	7	Anhui	0.47	0.25	0.34	4
Guizhou	0.89	0.41	0.60	7	Heilongjiang	0.61	0.16	0.31	4
Henan	0.84	0.42	0.59	6	Shanxi	0.52	0.15	0.28	3
Tianjin	0.98	0.35	0.59	6	Xizang	0.37	0.07	0.16	2
Yunnan	0.80	0.39	0.56	6					

(Comments: *C* value=Coupling degree,*T* value=Coordination index, *D* value= Coupling coordination degree)

3.3 Evaluation of Health Service Capacity in Vulnerable Areas

The cloud model evaluation is mainly used to measure the health service capacity of vulnerable areas and provide guidance for improving the health service capacity in the future. Based on the previous research results, the eight provinces (municipalities) with lower rankings in the comprehensive evaluation and poor indicator coupling degrees in 2019 are Anhui, Hainan, Heilongjiang, Jiangxi, Jilin, Neimenggu, Shanxi, and Xizang.

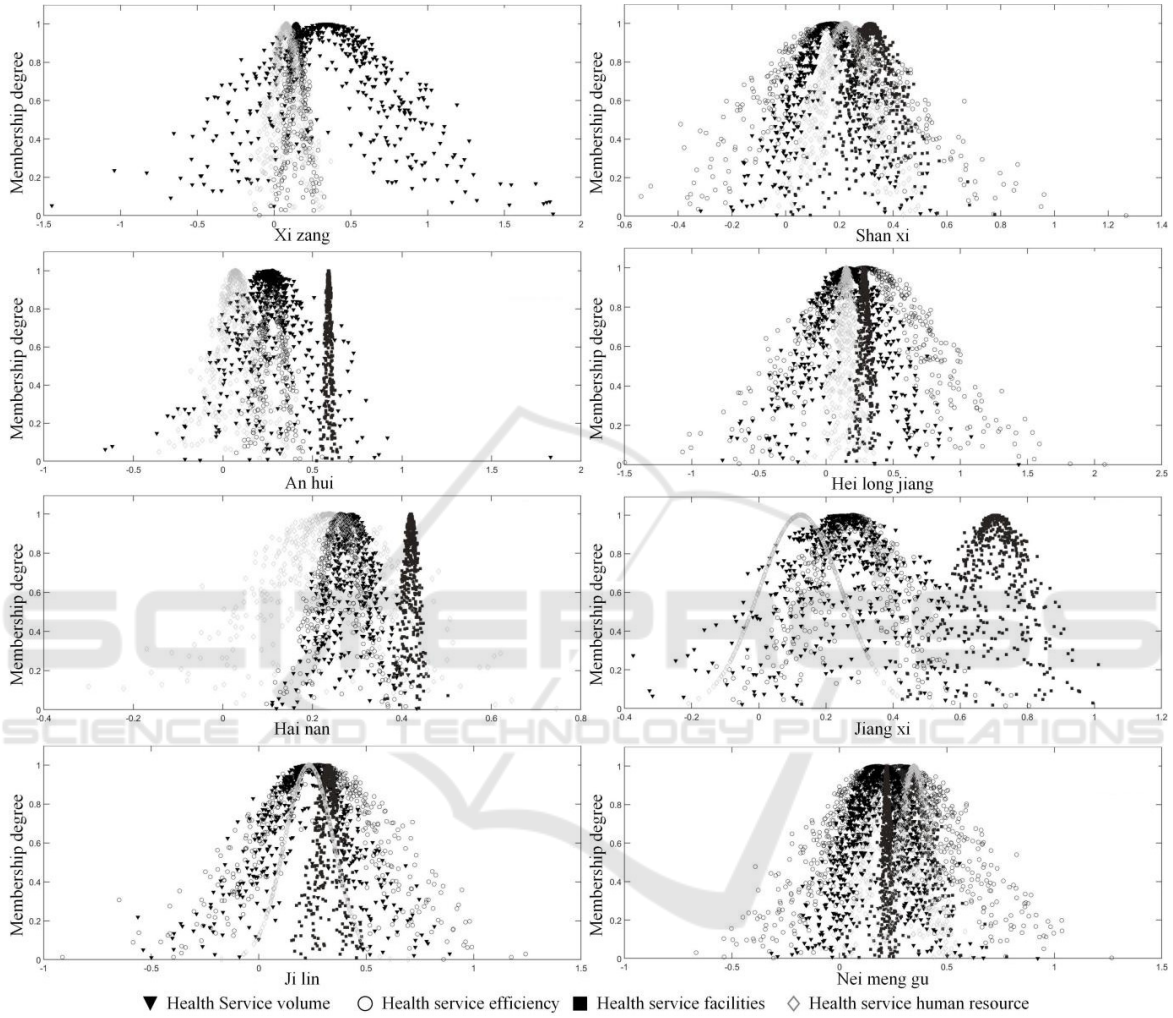

Figure 2: Cloud Model Evaluation in 8 provinces (municipalities) in 2019(Group pictures).

The cloud model evaluation map for the indicators of each place is shown in Figure 2. Among the eight regions, Hainan, Jiangxi, Neimenggu, and Jilin are on the verge of unbalanced development. As shown in the figure, the health service efficiency in Hainan is low and human resources are scarce; the service efficiency and volume in Jiangxi are undesirable, with the shortage of human resources being the most urgent problem to be solved; the service volume, efficiency, and facilities of health service capacity in Neimenggu are poor. The coupling degree of the four indicators in Jilin is high, yet the overall development is interior and close to imbalance. The health service capacity of Anhui and Heilongjiang demonstrates slightly unbalanced development, in which the evaluation results of human resources and service volume in Anhui are less satisfactory. The development status of Heilongjiang and Jilin is similar, which shows balanced yet inferior evaluation results. The health service capacity of Shanxi is moderately unbalanced, with an uncoordinated development of service efficiency, facilities, service volume, and human resources. The development of health service

capacity in Xizang is severely imbalanced at a relatively low overall level.

4 RESULTS DISCUSSION

The evaluation results of health service capacity show the health service capacity of 31 provinces (municipalities) in China from 2012 to 2019 has been gradually enhanced, and the coordinated development level of different indicators has been continuously improved. However, it is clear that although some regions in Northeast China, Northwest China, and Central China have gotten rid of the uneven distribution of basic medical resources, they still face the plight of poorly coordinated development between the soft and hard resources. Therefore, research on health service capacity should comprehensively consider the organic and coordinated development of resources under different development levels. At present, China demands not only high-quality development of service capacity, but also normalized Covid-19 prevention and control. The superposition of multi-level development requirements increases the difficulty of optimizing health service capacity to a certain extent. Therefore, we should also consider the impact of the environment on service capacity in real development. In this context, the research on the effectiveness of resource allocation is insufficient; we should consider improving the hierarchical medical system from the source.

5 OPTIMIZATION PATH FOR HEALTH SERVICE CAPACITY

A holistic approach should be adopted to promote high-quality development in the healthcare industry through high-quality services. Advantaged areas should continue to explore and optimize new ways of health services; stable areas should learn from the experience of advantageous areas to optimize their service capability; vulnerable areas should focus on the coordinated distribution of resources to improve the service level in the region. Overall, health service capacity is still in a complex social system and affected by multiple indicators, so we should choose the optimization path according to various indicators and reality. Currently, the "intelligence" transition of medical institutions can not only improve service quality and efficiency, but also further upgrade refined medical management, which can optimize the allocation of medical resources and improve the public's experience of medical care. Therefore, this study put forward specific optimization paths from national, regional, and institutional levels: (1) The country should pay attention to the intelligent evaluation of medical institutions and ameliorate relevant policies, so as to moderately promote the high-quality development of Internet medical services and "Internet + nursing services" and enhance the effectiveness of macro-guidance policies. (2) Regions should increase financial investment, establish integrated operation management system, intelligent resource management system, etc. to implement fine management of resources so as to avoid blind investment and optimize the allocation of disadvantaged resources. (3) Medical institutions should step up the construction and strengthen internal and external management to improve health service quality and efficiency.

FUND PROJECT

A major project of the National Social Science Foundation of China, "*Research on China's Digital Power Strategy and Implementation Path in the New Era*" (21&ZD163).

REFERENCES

Alzahrani FA, Ahmad M, Nadeem M, et al. (2021) Integrity Assessment of Medical Devices for Improving Hospital Services *J. Computers Materials & Continua*, 67: 3619-3633.

Cong X N. (2019) Expression and mathematical property of coupling model, and its misuse in geographical science *J. Economic Geography*, 39: 18-25.

General office of the State Council. (2021) General Office of the State Council forwarding notice of national development and reform commission on promoting customer service industry to strengthen weak links and improve people's quality of life [EB/OL] http://www.gov.cn/zhengce/content/2021-11/02/content_5648192.htm.

Ilardi A, Chieffi S, Iavarone A, et al. (2020) SARS-CoV-2 in Italy: Population Density correlates with Morbidity and Mortality *J. Japanese journal of infectious diseases*, 71: 61-64.

Jin B. (2018) Economics research on "high-quality development" *J. China Industrial Economics*, (04): 5-18.

Kong Y, Liu J. (2021) Sustainable port cities with coupling coordination and environmental efficiency *J . Ocean & Coastal Management*, 205 :1-13.

Li M, Sun H, Singh V P, et al. (2019) Agricultural Water Resources Management Using Maximum Entropy and Entropy-Weight-Based TOPSIS Methods *J. Entropy*, 21 :1-17.

Li D, Du Y. (2014) Artificial Intelligence with Uncertainty 2nd Edition *M. National Defense Industry Press*, Beijing.

Ni X, Li J Y. (2010) Public service performance evaluation model of government performance: effective or ineffective? — Review on controversy over validity of public service performance evaluation *J. Journal of Renmin University of China*, 24: 108-116.

Patel R J, Kejner A, Mcmullen C. (2020) Early institutional head and neck oncologic and microvascular surgery practice patterns across the United States during the SARS-CoV-2(COVID19) pandemic *J.Head And Neck*, 42: 1168-1172.

Shi D, Zhao J B, Deng Z (*Economic Daily)*, 2021.Understanding the connotation of high-quality development from three aspects [EB/OL].. http://theory.people.com.cn/n1/2019/0909/c40531-31343036.html.

Uner M M, Cetin B, Cavusgil S T, et al. (2020) On the internationalization of Turkish hospital chains: A dynamic capabilities perspective *J. International Business Review*, 29: 1-11.

Wang Z Q, Jiang W Y, Song X B, Gao Y and Yu S. (2021) High-quality development and comprehensive evaluation of China's macro accounting information quality *J. Accounting Research*, (04): 39-48.

Whitley G A, Hemingway P, Law G R, et al. (2020) The predictors, barriers and facilitators to effective management of acute pain in children by emergency medical services: A systematic mixed studies review *J .Journal of Child Health Care*, 25: 481-503.

Yu Y Z, Yang X Z and Zhang S H. (2019) Spatial-temporal transformation characteristics of China's economy from high-speed growth to high-quality development *J. The Journal of Quantitative & Technical Economics*, 36: 3-21.