

Coupling and Coordination between Medical security Services and Regional Economic Development in Beijing, Tianjin and Hebei: A Comparative Analysis for 2020 and 2022

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Abstract. Objective: To assess the coupling coordination interaction between medical security service capacity and regional economic development level in the Beijing-Tianjin-Hebei region, and provide recommendations for medical reform and residents' well-being improvement. Methods: The output was obtained by using comprehensive evaluation, coupling coordination, and relative development degree models to analyze the data collated from 2020 and 2022 statistical yearbooks. Results: Significant regional disparities in coupling coordination status were evidenced in 2020 and 2022, with Beijing in the Intermediate coordination stage ($D=0.754$), while Tianjin ($D=0.574$) and Hebei ($D=0.564$) in dyscoordination. Beijing exhibited lagging type of medical security service capacity (A41), while Tianjin demonstrated coordinated development type between regional economic (A32). And Hebei was a lagging type of regional economic development (A33). In 2022, Beijing's relative development degree increased to 0.781, whereas Tianjin's decreased to 0.849. Development types remained unchanged for Beijing, Tianjin and Hebei. Conclusion: Regional disparities exist in medical security service capacity among Beijing, Tianjin and Hebei in 2020 and 2022, revealing a differentiated development pattern. Future strategies should prioritize the improvement actions: (1) innovating regional coordination mechanisms; (2) optimizing medical resources in Beijing; (3) focusing on elderly medical insurance in Tianjin; and (4) strengthening positive feedback mechanisms in Hebei to foster coordinated development.

Keywords: Beijing, Tianjin, and Hebei; medical security services; coupling coordination; economic development.

1. Background

Medical security stands as one of the most critical factors influencing economic and social development^[1]. It is related to the health of the people, economic development, social stability, and the long-term peace and security of the nation. It is also an essential component of the national governance policy system^[2]. Medical security has played a significant role in addressing the issue of expensive medical care for the public, improving the health level of the people, and maintaining social stability^[3]. Meanwhile, the level of economic development determines the level of basic medical security for residents. Economic support is the strong backing for the basic medical security service system^[4]. Regional economic development is the key to ensure people's quality of life and living standards and further promotes the demand for health-promoting medical services^[5]. The coordination of medical security services and economic development has become one of the key focuses of social coordinated development^[6]. The importance of the coordinated development is implemented in the Article 14 of the Constitution of the People's Republic of China which explicitly states that the state should establish and improve a social security system that is adapted to the level of economic development. The level of medical security service in a country should be adapted to match the regional economic development^[7]. Only when medical security service capacity and regional economic development are coordinated, the basic medical security system can serve people better and improve the overall health level of society^[3].

The relationship between medical security and economic development has always attracted considerable attention. Cooper (1996)^[8] and Wennberg (2002)^[9] argued that narrowing regional disparities within the medical security system hinged on the efficiency of medical resource allocation.

Kujawska (2018)^[10] employed a network data envelopment analysis (DEA) model to evaluate the medical and public health systems of 30 Organization for Economic Co-operation and Development (OECD) countries and found that the ratio of public health expenditure to private health expenditure affects the efficiency of the medical security system. An excessively high proportion of private health expenditure can lead to a decrease in health efficiency. Liu H (2020)^[11], using data from the China Health and Nutrition Survey (CHNS), discovered disparities in the fairness of medical security policy benefits among different income groups. In the research on the relationship between medical security services and economic development, Cha Y (2024)^[7] and Yao H (2024)^[3] found that the overall coupling and coordination degree between China's basic medical security and regional economic development needed to be improved, and that the two systems exhibited spatial agglomeration. Xiao H (2015)^[12] proposed that economic development had a positive promoting effect on the financing and protection capabilities of basic medical insurance. Therefore, only those regions that enhance the capacity of medical security services, improve the level of regional economic development, and achieve mutual promotion and co-evolution between medical security services and regional economic development can achieve a high degree of coordination and realize a win-win development of both^[13].

Recent research in China mostly focuses on the capacity of medical security services at the national level, with few scholars concentrating on the coupling coordination between regional medical security services and regional economic development. The coordinated development of the Beijing-Tianjin-Hebei region has become an important national development strategy, and the construction of medical security services is an important part of promoting the integration of the Beijing-Tianjin-Hebei region^[14]. This study, starting from the coordinated development of medical security service capacity and economic development level in the Beijing-Tianjin-Hebei region, uses relevant data collated in the Beijing-Tianjin-Hebei region in 2020 and 2022 to compare the coordinated development status of medical security service capacity and economic development in the three areas. This study aimed to provide a comprehensive understanding of the current development and coordinated development level of the two systems in the Beijing-Tianjin-Hebei region, offer options for deepening healthcare service reform, solving the problems of "difficult and expensive access to medical care," and further improving residents' sense of happiness.

2. Methods

2.1. Data Sources

The data used in this study were sourced from the 2021 and 2023 editions of China Health Statistical Yearbook and China Health and Family Planning Statistical Yearbook. Regional economic development indicators originated from the Beijing Statistical Yearbook, Tianjin Statistical Yearbook, and Hebei Statistical Yearbook. All datasets extracted from official websites of the Beijing-Tianjin-Hebei regional governments and their respective statistical bureaus contained complete records without missing values.

2.2. Selection of Evaluation Indicators and Weight Determination

Based on principles of representativeness, comparability, scientific rigor, and operational feasibility, and previous studies by ZHOU Maojun^[15] and ZHOU Jinman^[16], this research selected indicators including Basic Medical insurance Enrollees to evaluate medical service resource supply within the medical security system. China's basic medical insurance comprises two primary schemes: urban employee-based insurance and urban-rural resident-based insurance. Following existing research practices^[16], these two programs were consolidated for the statistical analysis. Basic Medical insurance Enrollees and related metrics were adopted to assess the developmental status of basic medical insurance. For the regional economic system, indicators such as Regional Gross Domestic Product(GDP) were selected as evaluation criteria (Table 1). The magnitude of the coupling degree was estimated based on the level of interdependent development between medical security service capacity and regional economic development^[13]. Indicators were categorized as positive or inverse:

higher expenditures resulted in increased pressure on spending in medical insurance funds and lower medical security, while increased personal health expenditures corresponded to diminished medical security; both were therefore designated as inverse indicators. All other indicators were treated as positive. The entropy method was employed to calculate indicator weights influencing the medical security service and regional economic development.

Table 1. Description of indicators influencing medical security service capacity and regional economic development

Indicator Layer	Primary Indicator	Secondary Indicator	unit	qualities of the indicator
medical security service capacity	levels of healthcare service resource supply	Number of healthcare institutions per 10,000 population	individual	Positive
		Number of health professionals in healthcare institutions per 10,000 population	Person	Positive
		Number of hospital beds in healthcare institutions per 10,000 population	Beds	Positive
	Basic medical insurance	Basic Medical insurance Enrollees	per 10,000 population	Positive
		Basic Medical insurance Fund Income	Million yuan	Positive
		Basic Medical insurance Fund Expenditure	Million yuan	Negative
Economic Development Level	Service Efficiency	Basic Medical insurance Per Capita Income	Yuan	Positive
		Regional GDP	Million yuan	Positive
	Economic Output	Regional GDP per capita	Yuan	Positive
		GDP Growth Rate		Positive

2.3. Analytical Methods

Utilizing the assigned indicator weights, comprehensive evaluation scores were derived through a comprehensive evaluation model. The coupling coordination function between medical security service and regional economic development was subsequently employed to compute the coupling degree, coupling coordination degree, and relative development degree.

2.3.1. Comprehensive Evaluation Model

Fuzzy comprehensive evaluation constitutes a multi-criteria decision-making method characterized by non-binary outcomes, designed to assess objects influenced by multiple factors. This model was employed to calculate comprehensive scores for medical security service capacity and economic development in the Beijing-Tianjin-Hebei region.

2.3.2. Coupling Coordination Function

Coupling degree denotes the phenomenon wherein two or more systems interact through internal and external forces to mutually influence each other^[17]. A higher coupling degree signifies stronger interdependence between systems. In this study, the comprehensive development value of the medical security system is denoted as S_1 , while that of the economic development system is expressed as S_2 . Since coupling degree solely reflects the magnitude of inter-system association without indicating coordination quality, the coupling coordination degree was introduced to quantify the level of benign coupling interactions and evaluate the efficacy of coupling coordination^[18]. The model is defined as: $T = \alpha F(X) + \beta G(Y)$

where $\alpha = 0.5$ and $\beta = 0.5$, signifying equal importance between the medical security service capacity subsystem and the regional economic development subsystem. Different threshold ranges of the coupling coordination degree correspond to distinct Coupling Coordination Hierarchies and associated Coupling Coordination Levels, with reference standards provided in Table 2.

Table 2. The criteria and grade of the coupling coordination of the comprehensive evaluation index

Coupling Coordination Hierarchy	Range of Values for the Coupling Coordination Degree	Coupling Coordination Level
Low-Level Coordination (Antagonistic Stage)	$0 \leq D < 0.1$	Extreme Dyscoordination
	$0.1 \leq D < 0.2$	Severe Dyscoordination
	$0.2 \leq D < 0.3$	Moderate Dyscoordination
Medium-Level Coordination (Running-in Stage)	$0.3 \leq D < 0.4$	Mild Dyscoordination
	$0.4 \leq D < 0.5$	Marginal Dyscoordination
	$0.5 \leq D < 0.6$	Marginal Coordination
High-Level Coordination (Coordinated Stage)	$0.6 \leq D < 0.7$	Primary Coordination
	$0.7 \leq D < 0.8$	Intermediate Coordination
	$0.8 \leq D < 0.9$	Good Coordination
	$0.9 \leq D < 1.0$	Superior Coordination

2.3.3. Relative Development Degree

While the coupling coordination model captures synergistic interactions between systems, the relative development degree model was introduced to delineate development typologies within coupling coordination. Here, $S < 1$ indicates superior regional economic development, whereas $S > 1$ reflects relatively advanced medical security development. Integrating distribution patterns of coupling coordination degree and relative development degree, as the same as those reported in previous studies^[19, 20], were defined in this study as: synchronized development with $0.8 \leq S \leq 1.2$, medical security service capacity development lag with $S < 0.8$, and economic development lag with $S > 1.2$. Development types were categorized according to interval ranges of coupling coordination degree and relative development degree, with thresholds detailed in Table 3.

3. Result

3.1. Comparison of the Current Status of Healthcare Resource Allocation in the Beijing-Tianjin-Hebei region

The results of the comparative analysis of healthcare resource allocation in the Beijing-Tianjin-Hebei region between 2020 and 2022 are presented in Table 4. The number of healthcare institutions increased from 2020 to 2022 in all three regions, while Hebei had the highest total number of healthcare institutions when compared with Beijing and Tianjin. Similarly, Hebei had the highest number of healthcare institution beds per 1,000 population in both 2020 and 2022. This variable was higher in 2022 than in 2020 in all three regions, although the increasing rates differed among Beijing (5.7%), Tianjin (2.2%) and Hebei (10.6%). However, the hospital bed occupancy rate (%) in Hebei decreased from 2020 to 2022, while the rate for the same period increased in Beijing and Tianjin. The same period evidenced a decrease in the average length of hospital stay in all three regions, although the decrease rates in Beijing (11.1%) and Tianjin (16.7%) were higher in Hebei (2.2%). Furthermore,

health professionals per 1,000 population increased in all three regions from 2020 to 2022, with the highest increase rate in Hebei (12.9%), then Tianjin (11.1%) and the lowest in Beijing (7.3%).

Table 3. Relative development degree and level of medical security service capacity and regional economic development

D-value range	S-value range	Type of development	
	$S < 0.8$	Type of Impaired Regional Economic Development	A11
$0 < D \leq 0.2$	$0.8 \leq S \leq 1.2$	Co-Impaired Type of Regional Economic Development and Medical security Service Capacity	A12
	$S > 1.2$	Impaired Type of Regional Economic Development	A13
	$S < 0.8$	Impaired Type of medical security service capacity	A21
$0.2 < D \leq 0.4$	$0.8 \leq S \leq 1.2$	Co-Impaired Type of Regional Economic Development and Medical security Service Capacity	A22
	$S > 1.2$	Impaired Type of Regional Economic Development	A23
	$S < 0.8$	Lagging Type of Medical security Service Capacity	A31
$0.4 < D \leq 0.6$	$0.8 \leq S \leq 1.2$	Coordinated Development Type between Regional Economic Development and Medical security Service Capacity	A32
	$S > 1.2$	Lagging Type of regional economic development	A33
	$S < 0.8$	Lagging Type of Medical security Service Capacity	A41
$0.6 < D \leq 0.8$	$0.8 \leq S \leq 1.2$	Coordinated Development Type between Regional Economic Development and Medical security Service Capacity	A42
	$S > 1.2$	Lagging Type of regional economic development	A43
	$S < 0.8$	Lagging Type of Medical security Service Capacity	A51
$0.8 < D \leq 1.0$	$0.8 \leq S \leq 1.2$	Coordinated Development Type between Regional Economic Development and Medical security Service Capacity	A52
	$S > 1.2$	Lagging Type of regional economic development	A53

Table 4. Healthcare Resources in the Beijing-Tianjin-Hebei Region in 2020 and 2022

Year Region	2020				2022			
	Beijing	Tianjin	Hebei	National	Beijing	Tianjin	Hebei	National
Number of Healthcare Institutions (Individual)	10599	5838	86939	103376	10897	6282	90194	1032918
Number of Healthcare Institution Beds per 1,000 Population (Beds)	5.8	4.92	5.92	6.44	6.13	5.03	6.55	6.92
Hospital Bed Occupancy Rate (%)	60.9	61.6	70.8	72.3	67.9	63.3	64.3	71
Average Length of Hospital Stay (Days)	9.9	9.6	9.3	9.5	8.8	8	9.1	9.2
Number of Health Professionals per 1,000 Population (Person)	12.61	8.22	6.96	7.57	13.53	9.13	7.86	8.27

Data Source: China Health Statistics Yearbook 2021 and 2023

3.2. Coupling Analysis of Medical security Service Capacity and Regional Economic Development

The results of the coupling analysis of medical security service capacity and regional economic development are presented in Table 5. The comprehensive evaluation index of medical security service capacity (S1) revealed a tiered gradient in 2020, with Beijing (0.488) demonstrating

significant regional primacy over Hebei (0.399) and Tianjin (0.319). In 2022, the index increased in Beijing and Hebei, with the exception of Tianjin. Conversely, the comprehensive evaluation index of regional economic development (S2) maintained a distinct "Beijing-Tianjin-Hebei" stepwise distribution. In 2020, Beijing's index value (0.663) was 1.89 and 1.99 times than that of Tianjin (0.341) and Hebei (0.254), respectively. In 2022, Beijing's index decreased to 0.640, Hebei's to 0.247, while Tianjin's index increased against the trend to 0.376. Negative gaps between S1 and S2 indicated lagging medical services relative to economic growth across in Beijing and Tianjin. However, Hebei's medical insurance services are better than economic development. Compared to 2020, Hebei showed the most pronounced improvement in coordination in 2022, whereas Tianjin and Hebei experienced a worsened imbalance.

Based on Table 1, composite scores for medical security service capacity and regional economic development in the Beijing-Tianjin-Hebei region were calculated using the comprehensive index method. Subsequently, the coupling coordination model was applied to derive the coupling degree, coordination index, and coupling coordination degree between these two systems. The results are presented in Table 2. Significant regional disparities in coupling coordination status were evidenced in 2020, with Beijing in the Intermediate coordination stage (D=0.754), while Tianjin (D=0.574) and Hebei (D=0.564) in Marginal Coordination. The coupling coordination of three places in 2022 is not much different from that in 2020.

3.3. Relative Development Degree and Types of Medical security Service Capacity and Regional Economic Development

In 2020, the relative development degree of medical security service capacity and regional economic development in Beijing (0.736), Tianjin (0.934), and Hebei (1.568) indicated that the balance between medical security service capacity and regional economic development needed improvement (Table 5). The relative development types of medical security service capacity and regional economic development in the Beijing-Tianjin-Hebei region are as follows: Beijing exhibited lagging type of medical security service capacity (A41), while Tianjin demonstrated Coordinated Development Type between Regional Economic Development and Medical security Service Capacity (A32). And Hebei was a lagging type of regional economic development (A33). In 2022, Beijing's relative development degree increased to 0.781, whereas Tianjin's decreased to 0.849. Development types remained unchanged for Beijing, Tianjin and Hebei.

Table 5. Correlation Indexes of Medical security Service Capacity and Regional Economic Development Levels in the Beijing-Tianjin-Hebei Region in 2020 and 2022

Year	Region	2020			2022		
		Beijing	Tianjin	Hebei	Beijing	Tianjin	Hebei
Comprehensive Index	S1	0.488	0.319	0.399	0.500	0.319	0.423
	S2	0.663	0.341	0.254	0.640	0.376	0.247
Difference	S1-S2	-0.175	-0.022	0.144	-0.140	-0.057	0.175
Absolute Value of Difference	S1-S2	0.175	0.022	0.144	0.140	0.057	0.175
Coupling Degree	C	0.988	0.999	0.975	0.565	0.346	0.323
Coordination Index	T	0.576	0.330	0.326	0.570	0.347	0.335
Coupling Coordination Degree	D	0.754	0.574	0.564	0.752	0.588	0.569
Relative Development Degree	S	0.736	0.934	1.568	0.781	0.849	1.708

Note: S1 and S2 represent the comprehensive index of medical security service capacity and the comprehensive index of regional economic development, respectively.

4. Discussion

From the perspective of the coordinated development between medical security service capacity and regional economic development levels in the Beijing-Tianjin-Hebei region, this study represents the first attempt to systematically analyze relevant data on medical security service capacity and economic development levels in the region for the years of 2020 and 2022. The objective was to provide an in-depth understanding of the recent development status and coordinated evolution trends of these two interdependent systems in the Beijing-Tianjin-Hebei region, and to formulate evidence-based policy recommendations tailored to their specific synergistic needs.

4.1. Scale Expansion and Efficiency Enhancement of Medical security Resource Allocation

Compared with 2020, the number of healthcare institutions in the Beijing-Tianjin-Hebei region showed an upward trend in 2022, indicating a continuous expansion of the infrastructure scale for regional medical service provision. Particularly in Hebei, a populous province, the steady increase in the number of institutions alleviated primary-level medical service accessibility issues to some extent. Although the Number of Healthcare Institution Beds per 1,000 Population increased across all three regions, the hospital bed occupancy rate exhibited divergent trends. Beijing and Tianjin showed a slight rise, while Hebei experienced a significant decline. Existing research suggests that Beijing and Tianjin improved bed turnover efficiency by optimizing diagnosis and treatment processes and promoting hierarchical medical systems^[21, 22]. Conversely, the decrease in bed utilization rate in Hebei might have been associated with patient outflow due to the siphoning effect of high-quality medical resources within the region and insufficient service capacity at primary-level institutions^[23]. Meanwhile, the Average Length of Hospital Stay shortened in all three regions, potentially attributable to structural adjustments in resource allocation accompanying the increase in bed numbers. The sustained growth in the number of health professionals reflects proactive investments in human medical resource reserves within the region, laying a human resource foundation for enhancing medical security service capacity. However, the disparity in staffing levels between Hebei and Beijing still highlights the imbalance in human capital accumulation across regions.

4.2. Disparities in Coupling Coordination within the Beijing-Tianjin-Hebei Region

The coupling coordination degree between medical security service capacity and the regional economy varied across the Beijing-Tianjin-Hebei region. Overall, it remained at an exploratory and adaptive stage, indicating substantial room for improvement in the development level of coupling coordination between the two systems. In the Yangtze River Delta region, areas with higher coupling coordination degree are typically those with better economic development, while economically less developed areas exhibit a lower coupling coordination degree^[24]. The Beijing-Tianjin-Hebei region exhibits a similar pattern. This study finds that Beijing's regional economy is more developed than that of Hebei, and its degree of coupling coordination is higher than that of Hebei. This discrepancy might be arisen because the development level of medical security and the pace of economic growth differed, leading to variations in their interrelation and coordination. Compared to Hebei, Tianjin enjoys a higher level of economic development. However, the concentration of large hospitals within its six central urban districts in Hebei resulted in lower accessibility to high-quality medical and health services for residents in other areas. This constraint impeded the development of healthcare institutions, thereby diminishing medical security service capacity. Tianjin's basic medical insurance system should cover all citizens, operated within fiscal capacity, adhered to the fundamental principle of ensuring basic coverage and equitable allocation, while also prioritizing subsidies for low-income groups to enhance the efficiency of medical insurance fund utilization^[16].

Additionally, in 2022, Beijing achieved phased progress in governing unbalanced development between their medical security service capacity and regional economic development when compared to 2020. During the process of relocating non-capital functions, Beijing optimized its service system structure, alleviating the issue of high medical security service costs caused by excessive resource

concentration ^[25]. This facilitated a rebalancing between medical security service capacity and economic development. Hebei, by undertaking the relocation of high-quality medical resources from Beijing, propelled catch-up growth in its service capacity dimension, gradually narrowing the adaptation gap with its level of regional economic development ^[26]. The increase in the coupling coordination degree value for these two regions, contrasted with the slight decrease observed in Tianjin, reflects the differential impact of regional coordination policies on the strength of system interlinkages. Collectively, these findings demonstrate that the development of coupling coordination between medical security service capacity and the regional economy exhibits certain spatial heterogeneity. Each region needs to identify key leverage points tailored to its specific circumstances to shorten the alignment period between the two systems and achieve coordinated development.

4.3. Relative Development Degree in Beijing-Tianjin-Hebei

In 2022, the relative development degree of Beijing and Hebei exhibited a slight increase, while that of Tianjin decreased. This reflects a marginal alleviation in the lag of medical security service capacity relative to economic development in Beijing and Hebei. Critically, however, the classification of development types remained unchanged: Beijing (A41), Hebei (A33), and Tianjin (A32). This persistence signifies that despite positive shifts in localized indicators, the underlying structural contradictions between medical security and economic development had not been fundamentally resolved across the three regions in 2020 and 2022. Specifically, Beijing, as a megacity, continued demonstration of a regional economic development level significantly exceeding its medical security service capacity. This disparity might have been attributed to spatial misallocation of resources induced by the "siphoning effect," resulting in medical overload in central urban areas and insufficient service provision in suburbs ^[27], persistently constraining the synchronized development of both systems. Tianjin exhibited the most severe population aging among the three regions. Consequently, the decline in its relative development degree between medical security service capacity and economic development likely stemmed from accelerated aging driving up security demand, thereby exacerbating the imbalance between service supply and economic support capacity. Hebei, though promoting service capacity growth through coordinated development policies, suffered from insufficient economic development levels, potentially influenced by regional industrial restructuring. This limitation constrained improvements in its relative development degree, preventing an escape from the "lag-type development trap." The synergistic evolution of medical security and economic development within the Beijing-Tianjin-Hebei region necessitates more targeted policy interventions. Beijing should address bottleneck problems of resource concentration. Tianjin requires prioritizing medical security services for the elderly population. Hebei necessitates strengthening the positive feedback mechanism between service capacity and economic growth. These measures are essential to propel the system's transition from "low-level coupling" to "high-quality coordination."

5. Conclusions

This study constructed a coupling coordination degree model to evaluate the synergistic level between medical security service capacity and regional economic development in the Beijing-Tianjin-Hebei region in 2020 and 2022. The evaluation revealed significant disparities in the coupling coordination degree across the three regions. Although Beijing was initially in the Primary Coordination stage, its coupling coordination degree decreased from 2020 to 2022. In the same period, Tianjin remained persistently in a state of Mild Dyscoordination, with its medical security service capacity lagging behind economic development. Hebei progressed from Marginal Dyscoordination toward more coordinated development from 2020 to 2022. Overall, medical security service capacity lagged behind regional economic development in all three regions, revealing a differentiated pattern characterized by "optimizing and adjusting in Beijing, lagging development in Tianjin, and catch-up enhancement in Hebei." Future efforts should prioritize innovation in regional coordination

mechanisms. This involves optimizing medical resource allocation in Beijing, enhancing attention to medical insurance services for the elderly population in Tianjin, and strengthening the positive feedback between economic growth and medical security in Hebei. These measures are crucial to advance the coupling coordination development between medical security services and the regional economy in the Beijing-Tianjin-Hebei region.

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Author Contributions

LC conceived and designed the study. WYH and ZX conducted the literature research, analyzed, and wrote the draft manuscript. All authors read and approved the final manuscript.

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Data Availability

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- [1] S. Rajak, A. Summaq, M. P. Kumar, A. Ghosh, K. Elumalai and S. Chinnadurai, Revolutionizing Healthcare With 6G: A Deep Dive Into Smart, Connected Systems, in *IEEE Access*, 2024, 12:194150-194170.
- [2] He, W. J. Optimization of the medical security system based on common prosperity. [J]. *China Higher Education Social Sciences*, 2024, (05): 56-66+158.
- [3] Yao, H. Y., Tao, S. Q., Tao, Q. S., et al. Coupling coordination and spatiotemporal characteristics between basic medical insurance and regional economic development [J]. *Journal of Nanjing Medical University (Social Science)*, 2024, 24 (03): 215-223.
- [4] Cai, Y. D. Impact of regional economic development on the level of basic medical insurance [D]. *Shanghai University of Finance and Economics*, 2023.
- [5] Liu, L. J., Xiao, L. H., Liu, X. L., et al. Coordinated development between health system and socio-economy from the perspective of total health expenditure. [J]. *Health Economics Research*, 2014(05):7-11.
- [6] Mao, H. Y Institutional innovation and regional policy for coordinated development of the Beijing-Tianjin-Hebei Region. [J]. *Progress in Geography*, 2017, 36(01):2-14.
- [7] Zha, Y. N., & Gao, X. Analysis of coupling coordination degree between basic medical insurance and regional economy in China. [J]. *Medicine and Society* 2024, 37 (01): 130-136.
- [8] Cooper MM. The Dartmouth Atlas of Health Care: what is it telling us?[J]*Health Systems Review*, 1996, 29(29):44-5.47.

- [9] Wennberg John E, Fisher Elliott S, Skinner Jonathan S. Geography and the debate over Medicare reform.[J]. Health affairs (Project Hope),2002,Suppl Web Exclusives.
- [10] Kujawska, J. Efficiency of Healthcare Systems in European Countries-The DEA Network Approach. *Metody Ilościowe w Badaniach Ekonomicznych = Quantitative Methods in Economics*,2019(1)60-70.
- [11] Liu H, Dai W. An Empirical Study on the Benefits Equity of the Medical Security Policy: the China Health and Nutrition Survey (CHNS). *International Journal of Environmental Research and Public Health*. 2020; 17(4):1203. <https://doi.org/10.3390/ijerph17041203>
- [12] Xiao, H. W. Macro-level analysis of the development of basic medical insurance in China [J]. *Journal of Insurance Professional College*,2015,29(04):17-20.
- [13] Ma, D., Han, X. W., Du, J., et al. Evaluation of coupling level between primary healthcare service capacity and regional economy in Shandong Province. [J]. *Chinese Health Resources*,2022,25(03):363-366.
- [14] Shao Y.M, Liu Z.Q. Research on the Collaborative Development Path of Medical Security in the Beijing-Tianjin-Hebei Region [J]. *Review of Economic Research*,2017,2838(62):28-33.
- [15] Zhou M.J, Zhou KS, Z J.M. Spatiotemporal Differentiation and Coupling Coordination of Medical Services and Economic Development in the Yangtze River Delta [J]. *Journal of Inner Mongolia Normal University (Natural Science Chinese Edition)*,2023,52(01):42-48.
- [16] Zhou J.M, Xu Q, Li Y.S. Research on the Collaboration between Commercial Medical insurance and Basic Medical Insurance in China—Based on Spatiotemporal Evolution Analysis of Coupling Coordination [J]. *China Medical insurance*,2022(12):104-110.
- [17] Liang J.F, Yang Q.Q. Research on the Coupling Coordination Degree between Traditional Chinese Medicine Service Capability and Regional Economy in China [J]. *Health Economics Research*,2021,38(05):22--26.
- [18] Zhang FL, Li Y, Zhang J.Q, et al. Research on the Coupling Coordination Degree of Supply and Demand of Traditional Chinese Medicine Human Resources in Eastern, Central and Western Regions of China [J]. *Soft Science of Health*,2022,36(05):22-26.
- [19] Yu T.H. Analysis of the Spatiotemporal Evolution of Coupling and Coordinated Development between China's Circulation Industry and Urbanization [J]. *Southeast Academic Research*,2018(05) : 175-182.
- [20] Bi G.H, Yang Q.Y, Liu.S. Coupling and Coordinated Development of Ecological Civilization Construction and Urbanization in Chinese Provinces [J]. *Economic Geography*,2017,37(01):50-58.
- [21] Zhang Y, Shi Y.J, Li T.Y, et al. Realizing Intelligent Unified Management of Hospital-wide Beds Based on ECRS Optimization Principles [J]. *Chinese Hospitals*, 2025, 29(01): 89-92.
- [22] Wu F, Chu Y.J, Cai Han. Demand Analysis of Tianjin's Health Material Resources Allocation from the Perspective of Hierarchical Medical Treatment [J]. *China Health Industry*, 2023, 21(04): 223-226.
- [23] Dong X.X. Analysis of the Service Status and Countermeasures of Primary Medical and Health Institutions in Y County, Hebei Province [D]. Hebei: Hebei University, 2023.
- [24] Huang S.H. Accelerating the Construction of a New Development Pattern to Promote High-Quality Development During the 14th Five-Year Plan Period [J]. *Administrative Reform*, 2021(05): 4-15.
- [25] Wang J.I. Beijing's Medical Function Renewal Policies and Market Responses from the Perspective of Relocation [J]. *Urban and Regional Planning Studies*, 2022, 14(01): 183-194.
- [26] Wang H.J. Undertaking the Capital's Medical Service Functions: Current Status and Development Proposals for Hebei Xiongan New Area [C] School of Public Administration, Yanshan University; Hebei Public Policy Evaluation and Research Center, 2023: 221-225.
- [27] Zhao P, Li S, Liu D. Unequable spatial accessibility to hospitals in developing megacities: New evidence from Beijing. *Health Place*. 2020;65:102406.