Postprint: Evaluation of Healthcare Levels in Chinese Provinces Based on Principal Component Analysis and TOPSIS Model

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Abstract

Background During the nationwide prevalence of the Coronavirus Disease 2019 (COVID-19) pandemic, the spatial agglomeration effect of medical resources in China became prominent, with significant differences in medical levels among provinces. Currently, domestic scholars mostly employ quantitative methods to evaluate provincial medical levels across the country, while few apply comprehensive methods for such evaluation. Objective To understand the differences in medical and health service development levels among provinces in China, so as to provide references for policymakers in the medical and health sector. Methods In November 2022, a computer-based search was conducted on CNKI, Wanfang Data Knowledge Service Platform, and Web of Science databases for literature related to medical level evaluation. Based on existing research findings, relative and average indicators were selected to construct an evaluation index system. Using the "2022 China Health Statistics Yearbook" as the data source, data for each evaluation indicator were extracted/calculated. Principal component analysis and the TOPSIS model were employed to conduct a comprehensive evaluation of the medical levels of 31 provinces in China (excluding Hong Kong Special Administrative Region, Macao Special Administrative Region, and Taiwan Province from the statistical scope). Results A total of 6 eligible literature sources were retrieved. Thirteen relative and average indicators were selected from three aspects—medical resources, medical services, and medical security—to construct the evaluation system. The KMO value was 0.733, and Bartlett's sphericity test showed 2=346.908, P<0.001, indicating that the data were suitable for principal component analysis. According to the criterion of eigenvalues >1.000, four principal components could be extracted: medical resource scale and medical service quality (F1), medical institution work efficiency (F2), infectious disease control capability (F3), and other factors (F4). The cumulative variance contribution rate of the four principal components was 84.012%. After establishing linear models for each principal component based on the principal component score coefficient matrix, a comprehensive evaluation model for assessing medical levels was obtained based on the variance contribution rates of the four principal components: Y=0.439 85×Y1+0.158 54×Y2+0.154 40×Y3+0.087 34×Y4. The top three provinces in terms of comprehensive medical level scores were Beijing (151.908 points), Shanghai (124.379 points), and Tianjin (78.673 points). The TOPSIS proximity ranking results showed that Beijing and Shanghai were at the forefront (proximity values of 0.767 and 0.646, respectively). Using proximity values of 0.400 and 0.200 as cut-off points, the 31 provinces could be divided into three echelons: the first echelon included three provinces—Beijing, Shanghai, and Tianjin; the second echelon included 25 provinces such as Zhejiang and Sichuan; and the third echelon included three provinces—Hebei, Ningxia Hui Autonomous Region, and Tibet Autonomous Region. Conclusion There exists a significant problem of inter-provincial development imbalance in China's medical level, with the distribution of medical levels across the 31 provinces overall exhibiting an olive-shaped structure characterized by "large in the middle and small at both ends." The government should increase policy support for provinces with lower medical level rankings such as Hebei, give full play to the coordinating role of regional health planning, and implement targeted assistance through telemedicine and medical big data.

Full Text

Evaluation of Medical Level in China by Provinces Based on Principal Component Analysis and TOPSIS Model

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Abstract

Background: During the nationwide epidemic of COVID-19 infection, the spatial agglomeration of medical resources in China has been highlighted, and there are obvious differences in medical level among provinces. Currently, the evaluation of medical level in China by provinces was mainly conducted by quantitative methods by domestic scholars, while comprehensive method was less applied to evaluate the medical level by provinces.

Objective: To understand the differences in the level of healthcare development in China by provinces, so as to provide a reference for healthcare decision makers.

Methods: In November 2022, CNKI, Wanfang Data Knowledge Service Platform, and Web of Science were searched by computer for the researches in the field of medical level. Based on the existing research results, relative and average indicators were selected to construct the evaluation index system. Using *China Health and Health Statistical Yearbook 2022* as the data source, the data of each evaluation index was extracted or calculated. Using the principal component analysis and TOPSIS model, the medical levels of 31 provinces in China (Hong Kong Special Administrative Region, Macao Special Administrative Region and Taiwan Province were not included in the statistics) were comprehensively evaluated.

Results: A total of 6 qualified papers were retrieved and 13 relative and average indicators were selected from three aspects of medical resources, medical services, and medical security to construct the evaluation system. The KMO value was 0.733, and Bartlett's spherical test showed that ^{2}=346.908, P<0.001, suggesting that the data were suitable for principal component analysis; four principal components were extracted according to the criterion of characteristic root above 1.000, including the scale of medical resources and quality of medical services (F1), the efficiency of medical institutions (F2), infectious disease control ability (F3), and other factors (F4), and the cumulative percent variance of the four principal components was 84.012%. After establishing the linear model of each principal component based on the matrix of the principal component scores, the comprehensive evaluation model for the medical level was obtained based on the cumulative percent variance of the four principal components: Y=0.439 85×Y1+0.158 54×Y2+0.154 40×Y3+0.087 34×Y4. The top three provinces in terms of comprehensive score of medical level were Beijing (151.908 points), Shanghai (124.379 points), and Tianjin (78.673 points). The TOPSIS proximity ranking showed that Beijing and Shanghai were at the top level (proximity was 0.767 and 0.646, respectively), and the 31 provinces could be divided into three echelons with proximity 0.400 and 0.200 as the nodes. The first echelon included three provinces of Beijing, Shanghai and Tianjin, the second echelon included 25 provinces such as Zhejiang Province and Sichuan Province, the third echelon included three provinces of Hebei Province, Ningxia Hui Autonomous Region and Tibet Autonomous Region.

Conclusion: There is an obvious imbalance in the level of medical development in China by provinces, showing an olive-shaped structure of "big in the middle and small at the two ends" in the overall distribution of medical level in 31 provinces. The government should increase the incline degree of policy for provinces with low ranking in medical level, such as Hebei Province, play a coordinating role in regional health planning, and implement targeted assistance by using telemedicine and medical big data.

Keywords: Medical level evaluation; Principal component analysis; TOPSIS model; China; Evaluation

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1. Introduction

The *Key Tasks of Deepening the Reform of the Medical and Health System in 2022* proposed to deepen the reform of the medical and health system and promote the expansion and balanced layout of high-quality medical resources. The spatial distribution of medical resources in China is unbalanced, and regional medical and health development is uneven (the medical level in the eastern region is significantly higher than that in the western region). Therefore, making an objective evaluation of the medical level of each province is of great significance for improving the overall operational efficiency of the medical and health service system and the coordinated development level of regional medical and health services.

Comprehensive studies on medical level evaluation conducted by Chinese scholars can be divided into two categories. One category uses methods such as principal component analysis, TOPSIS, and cluster analysis to evaluate the medical level of 31 provinces, such as Guo Yuling et al. [4], Li Ji [5], and Liu Pingqing et al. [6], who constructed index systems and evaluated the medical level of Chinese provinces based on *China Health Statistical Yearbook* data in 2016, 2019, and 2020, respectively. The other category combines principal component analysis, TOPSIS, and cluster analysis to evaluate the medical level of a specific region, medical institution, or department, such as Chinese scholars who have attempted to evaluate the medical level of Anhui Province [7], Jiangsu Province [8], and Hebei Province [9], evaluate the medical quality of a tertiary Grade A hospital [10], and evaluate the surgical benefits of medical institutions [11]. These studies all evaluated medical level based on a constructed comprehensive evaluation index system, which provides reference significance for government departments to further introduce policies and regulations aimed at promoting the smooth implementation of medical and health system reform, promoting the equalization of medical resource allocation, and improving people's health level. However, the data used in the above studies can no longer be used to fully explain the current status of medical level in Chinese provinces, and the evaluation results for specific regions/institutions are not generalizable. Based on *China Health and Health Statistical Yearbook 2022*, this study uses principal component analysis and TOPSIS model to conduct statistical analysis and evaluation of the medical level of provinces across the country, in order to provide reference for government departments to coordinate the allocation of national medical resources and make scientific and reasonable decisions.

1.1 Conceptual Definition of Medical Level

Domestic and foreign scholars have different definitions of medical level, with different focuses. The Chinese government proposes that medical level is a regional and holistic concept [12], but it does not provide a detailed explanation of the concept. The subjects of medical level are diverse, such as the medical level of doctors, medical institutions, and even the medical level of a region (the West) [13]. Domestic scholars rarely define medical level, and mostly only define "the medical level at that time" in the process of medical liability determination. Zhang Zhong et al. [14] believe that medical level can be reflected by medical institutions and their medical staff providing medical services adapted to their own capabilities under the premise of complying with diagnostic and treatment norms and following scientific, safe, reasonable, effective, economical, and ethical principles in diagnosis and treatment activities. In foreign studies, scholars mainly focus on health equity when defining medical level. Kai Huter believes that in the context of scarce public resources, whether to use resources in the public health field for projects aimed at actually reducing health inequalities (such as unfairness in outpatient and inpatient health service utilization, unfairness in outpatient and inpatient expenses, unfairness in inpatient expense compensation, etc. [15-16]) is an important content of medical level evaluation [17]. Although previous studies have not systematically proposed the concept of medical level, based on their research content and results, it can be summarized that the evaluation content of medical level not only covers medical services, but also should cover patient satisfaction, medical work efficiency, medical technology economic effects (input-output relationship), and the continuity and systematicity of medical care.

1.2 Construction of Medical Level Index System and Data Sources

An index system that can effectively reflect medical level must be both comprehensive and representative [18]. In November 2022, CNKI and Wanfang Data Knowledge Service Platform were searched with the keywords "medical level" and "medical level evaluation," and Web of Science database was searched with the topics "Medical level evaluation" and "Medical level" to obtain literature on medical level evaluation. The search period was from database establishment to November 2022. Reviews and comments, as well as literature whose keywords did not include medical level or medical level evaluation and whose content did not involve evaluation indicators, were excluded. A total of 6 qualified papers were retrieved [4-9]. Six papers mentioned evaluation indicators of medical service capacity, mainly including bed utilization rate and case fatality rate; five papers mentioned evaluation indicators of medical resources, mainly including number of medical institutions, number of hospital beds, and number of health personnel; three papers mentioned evaluation indicators of medical security capacity, mainly including total health expenditure and number of urban and rural residents participating in medical insurance. To eliminate the interference of factors such as population size [4], based on existing research results, 13 relative and average indicators were selected from three aspects: medical resources, medical service capacity, and medical security capacity to construct the evaluation system (Table 1). Relevant indicator data were extracted from *China Health and Health Statistical Yearbook 2022* [19] or calculated using data extracted from it. Among them, the basic medical insurance participation rate (x9) was calculated by dividing the number of basic medical insurance participants in each province extracted from *China Health and Health Statistical Yearbook 2022* by the population number of each province in the attached table, while the remaining indicator data were directly extracted from *China Health and Health Statistical Yearbook 2022*. The data of each province on the 13 evaluation indicators are shown in Table 2 .

1.3 Methods

1.3.1 Principal Component Analysis Principal component analysis is a dimensionality reduction algorithm that transforms multiple indicators with certain correlations into principal components through orthogonal transformation. These principal components are linear combinations of original variables and are independent of each other. First, the mortality rate of Class A and B notifiable infectious diseases, average length of stay, and case fatality rate in the evaluation indicators are low-priority indicators, which need to be processed with the same trend. The mortality rate of Class A and B notifiable infectious diseases and the case fatality rate were inverted and then multiplied by 100; the average length of stay was inverted and then multiplied by 1,000 to transform them from low-priority indicators to high-priority indicators. At the same time, to eliminate the dimensional differences between different indicators, all original data were standardized [20]. Second, the processed data were imported into SPSS 26 software for KMO and Bartlett's spherical test. Principal components were extracted based on eigenvalues and cumulative variance contribution rate. Typically, if the first n principal components can reflect 85% of the information of the original indicators, the extracted n principal components are considered usable [5]. Finally, a factor loading matrix was established to explain the main information reflected by each principal component. Based on the principal component score coefficient matrix, the linear model of each principal component was obtained. The variance contribution rate of each principal component was used as the weight to weighted sum the n principal components to obtain the comprehensive evaluation model for evaluating the medical level of each province, and then the comprehensive score of medical level of each province was calculated and ranked according to the comprehensive score.

1.3.2 TOPSIS Model The TOPSIS method is a method that ranks each evaluation object according to its proximity to the ideal solution. Based on the scores of 31 provinces on each principal component, the original matrix was formed and imported into Excel 2016 software. The original matrix was standardized, and then the distance of each evaluation object from the maximum value (di^+) and the distance from the minimum value (di^-) were calculated by extracting the maximum and minimum values of each evaluation indicator. Finally, the distance between each evaluation object and the optimal object, i.e., the proximity (Si value), was calculated. The Si value ranges from 0 to 1, and the closer it is to 1, the higher the comprehensive level of the evaluation object [6].

2. Results

2.1 Principal Component Analysis Results

2.1.1 KMO Value and Bartlett's Spherical Test Results The KMO value was 0.733, and Bartlett's spherical test result was ^{2}=346.908, P<0.001, indicating strong correlation between variables, meeting the preconditions for principal component analysis, and further analysis could be conducted.

2.1.2 Extraction of Principal Components With eigenvalue >1.000 as the criterion, 1-4 four principal components could be extracted. The cumulative variance contribution rate of the four principal components reached 84.012% (Table 3), indicating that the first four principal components could fully reflect the medical level of 31 provinces across the country.

2.1.3 Establishment of Factor Loading Matrix The maximum variance method was used to perform Kaiser standardized orthogonal rotation on the initial factor loading matrix. The 归属 of original indicators was determined based on the loading magnitude of original indicators on each principal component [7]. Six indicators, x1 (number of health technicians per thousand population), x2 (number of medical institution beds per thousand population), x10 (per capita total health expenditure), x11 (life expectancy), x12 (average medical expenses per inpatient), and x13 (average medical expenses per outpatient), had the largest loading on the first principal component. These six indicators mainly reflect the scale of medical resources and quality of medical services, so principal component F1 is called the scale of medical resources and quality of medical services. x3 (average daily number of outpatients per physician), x4 (average annual number of visits per resident), and x7 (bed utilization rate) had the largest loading on the second principal component. These three indicators mainly reflect the work efficiency of medical institutions, so principal component F2 is named the work efficiency of medical institutions. Only x5 (mortality rate of Class A and B notifiable infectious diseases) had the largest loading on the third principal component, so principal component F3 is named infectious disease control ability. x6 (average length of stay), x8 (case fatality rate), and x9 (basic medical insurance participation rate) had the largest loading on the fourth principal component. These three variables are not significantly collinear, so principal component F4 is called other factors. F1 reflects the scale and benefit of medical resources and medical services, while F2 reflects the work efficiency of medical institutions. Both F3 and F4 include indicators related to case fatality rate, so F1 and F2 are benefit-type indicators, while F3 and F4 are cost-type indicators.

2.1.4 Establishment of Principal Component Linear Model and Comprehensive Evaluation Model of Medical Level According to the principal component score coefficient matrix (Table 5), the linear models of each principal component were obtained:

Y1=0.398×x1+0.050×x2-0.100×x3+0.064×x4+0.006×x5+0.122×x6-0.091×x7-0.039×x8+0.179×x9+0.281×x10+0.013×x11+0.174×x12+0.277×x13

Y2=-0.179×x1-0.073×x2+0.353×x3+0.230×x4-0.185×x5-0.030×x6+0.405×x7+0.068×x8-0.079×x9-0.046×x10+0.149×x11+0.015×x12-0.066×x13

Y3=-0.206×x1-0.336×x2+0.087×x3+0.016×x4+0.357×x5+0.008×x6-0.186×x7-0.069×x8-0.432×x9-0.046×x10+0.058×x11+0.054×x12-0.076×x13

Y4=0.154×x1-0.222×x2-0.034×x3+0.101×x4+0.036×x5+0.554×x6+0.041×x7+0.359×x8+0.231×x9+0.094×
0.216×x11-0.032×x12+0.035×x13

The variance contribution rates of the above four principal components were used as weights to weighted sum the four principal components to obtain the comprehensive evaluation model for evaluating the medical level of each province:

Y=0.439 85×F1+0.158 54×F2+0.154 40×F3+0.087 34×F4

2.1.5 Comprehensive Score and Ranking of Medical Level by Province

The standardized data were substituted into the comprehensive evaluation model to calculate the comprehensive scores of medical level by province (Table 6). The top three provinces in terms of comprehensive score were Beijing (151.908 points), Shanghai (124.379 points), and Tianjin (78.673 points); the bottom three provinces were Heilongjiang Province (-38.368 points), Gansu Province (-39.934 points), and Guizhou Province (-45.811 points).

2.2 TOPSIS Analysis Results

Using the variance contribution rate of each principal component in the principal component analysis as the weight, a weighted standardized matrix was constructed, and the optimal value, worst value, and Si value were finally obtained (Table 7). The Si value ranking results showed that Beijing and Shanghai were at the top level (Si values were 0.767 and 0.646, respectively). With Si values of 0.400 and 0.200 as nodes, the 31 provinces could be divided into three echelons: the first echelon included three provinces of Beijing, Shanghai, and Tianjin; the second echelon included 25 provinces such as Zhejiang Province and Sichuan Province; the third echelon included three provinces of Hebei Province, Ningxia Hui Autonomous Region, and Tibet Autonomous Region.

3. Discussion

3.1 The Combination of Principal Component Analysis and TOPSIS Model is More Scientific and Reasonable for Evaluating Provincial Medical Levels, but Has Certain Limitations

There are many methods that can be used for medical level evaluation in China, including TOPSIS, analytic hierarchy process, Delphi method, principal component analysis, and comprehensive index method. A comprehensive index system is needed to realize the evaluation of medical level, and evaluating medical level based on only a single indicator is too one-sided. Considering that in a comprehensive index system, evaluation indicators may interact with each other, if principal component analysis is not used (principal component analysis can transform multiple interrelated indicators into several independent principal components through certain mathematical operations [10]), the interaction between evaluation indicators may reduce the objectivity and authenticity of evaluation results. In this study, the extracted four principal components replaced the original 13 evaluation indicators, and the cumulative variance contribution rate of the four principal components reached 84.012%, indicating that the four principal components can reflect most of the information of the original indicators, and the results of principal component analysis are comprehensive. Using the variance contribution rate of each principal component as the weight for TOPSIS analysis, the distances between each evaluation object and the optimal solution and the worst solution were calculated, and the comprehensive ranking of medical level of each province was finally obtained. This method avoids artificially determining weights and has a good mathematical theoretical foundation, ensuring the objectivity of evaluation results. Liu Pingqing et al. [6] once used the combination of principal component analysis and TOPSIS model to evaluate the overall medical level of China, but their evaluation of China's medical level was only based on a small number of health resources and indicators of outpatient and emergency health service utilization, and the indicator data came from *China Health and Health Statistical Yearbook 2018*, so the research results have limited reference significance for current decision-making by relevant departments. Based on existing research results, this study included the indicator "mortality rate of Class A and B notifiable infectious diseases" that conforms to China's current national conditions into the index system, and constructed a scientific, reasonable, and complete evaluation index system, and combined principal component analysis and TOPSIS model to comprehensively evaluate the medical level of each province.

Principal component analysis, as a comprehensive evaluation method that has been widely used in recent years, uses fewer variables to explain most of the variation in the original data. However, due to the different regional health planning goals and health development goals of the 31 provinces, and the different health needs of the people in each province, for example, Beijing and Shanghai have relatively developed medical systems, and local residents not only require basic medical needs to be met but also have higher requirements for diagnosis and treatment quality, while Tibet Autonomous Region is an economically underdeveloped area that currently focuses on primary medical system construction in its work tasks and has also introduced corresponding policies to promote the development of ethnic medicine. Therefore, evaluating the medical level of 31 provinces based on only one set of indicators has certain irrationality. When evaluating the medical level of each province, in addition to using comprehensive evaluation methods such as principal component analysis and TOPSIS model, the actual situation of each province should also be combined to ensure that the evaluation results and corresponding suggestions are more scientific and reasonable.

3.2 The Medical Level of Each Echelon Corresponds to Its Economic Development Level

From the analysis results, there is an obvious imbalance in the development of medical level among provinces in China, which is consistent with the distribution structure characteristics of the current economic development level of 31 provinces in China [21]. The overall distribution of medical level in 31 provinces shows an olive-shaped structure of "big in the middle and small at the two ends." The top three provinces in terms of Si value were Beijing, Shanghai, and Tianjin, with Si values all greater than 0.400, belonging to the first echelon. These three provinces are all provinces with relatively high economic development levels in China, and their medical levels are correspondingly high [6]. As the political and economic centers of China, Beijing and Shanghai have a large amount of high-quality medical resources, and a large number of high-level medical personnel are concentrated here, with some medical institutions under their jurisdiction representing the highest level of medical care in China. From the perspective of individual indicators, Beijing had the highest Y1 score, which may be related to its largest number of health technicians per thousand population. Tianjin's medical level is also at the forefront, which is closely related to its unique geographical location and high level of economic development. Tianjin ranked high in Y3, which may be related to its excellent performance in the prevention and control of COVID-19. Tianjin responded quickly to the sudden epidemic, being the first to adopt traditional Chinese medicine therapy to deal with COVID-19, effectively reducing the case fatality rate of COVID-19 patients [22]. In addition, a large number of patients from other provinces choose to seek medical treatment in medical institutions in Beijing, Shanghai, Tianjin and other provinces, but the data on changes in the average annual number of visits per resident in each province caused by medical treatment in other places are not separately listed in the statistical yearbook, which may have a certain impact on the conclusions of this study. The impact of changes in the average annual number of visits per resident in each province caused by medical treatment in other places on the ranking of medical level of each province needs to be further discussed.

The bottom three provinces in terms of Si value were Hebei Province, Ningxia Hui Autonomous Region, and Tibet Autonomous Region, with Si values all lower than 0.200, belonging to the third echelon. Each of the three has its own advantages and disadvantages: policies aimed at promoting the inheritance, innovation, application, development, and talent cultivation of ethnic minority medicine are inclined toward Ningxia Hui Autonomous Region and Tibet Autonomous Region [23], while Hebei Province is strengthening medical scientific research cooperation and talent exchange with Beijing and Tianjin relying on the Beijing-Tianjin-Hebei integration strategy. According to the regional GDP of 31 provinces in 2022 released by the provincial government in February 2023, among these three provinces, Hebei Province's regional GDP reached the 4 trillion yuan level, ranking 12th, which is at a medium level nationwide, but its medical level ranks at the bottom. This shows that the conclusion that areas with high economic level also have high medical level is not completely correct and should be further discussed based on actual conditions. Hebei Province's medical level ranks third from the bottom, especially with low scores in Y1 and Y2, indicating that the scale and benefit of medical resources and medical services and the work efficiency of medical institutions in Hebei Province are lower than the general level, which may be related to insufficient investment in its own medical and health services. Hebei Province has fewer tertiary Grade A hospitals, concentrates more medical resources in cities with higher economic development levels, has an unbalanced layout of medical infrastructure across the province, and under the influence of the Beijing-Tianjin-Hebei integration strategy, local residents prefer to seek medical services in Beijing and Tianjin. Therefore, Hebei Province should improve the medical environment and improve the quality of medical services by increasing financial investment in the health field, attracting talents, and innovating management models. Due to the particularity of their geographical environment and historical culture, Tibet Autonomous Region and Ningxia Hui Autonomous Region have lower medical levels than other provinces, but the fundamental reasons are backward economy, insufficient medical resources, imperfect medical infrastructure, and limited development of ethnic medicine that cannot maximize its function.

The provinces ranked in the middle performed prominently in the comprehensive evaluation and belong to the second echelon. Among them, Guangdong Province and Jiangsu Province have relatively good overall medical levels, which is supported by long-term accumulation of high-quality medical resources and high economic levels, but there is still room for improvement in their medical levels. Shandong Province's Y2 score was -0.04, indicating that the work efficiency of medical institutions in Shandong Province is low, and the average daily number of outpatients per physician in Shandong Province is comparable to that in Gansu Province. The reasons may be that, on the one hand, Shandong Province has a large population and there is a large gap in economic development levels among cities in the province, with high-quality medical resources excessively concentrated in economically developed cities; on the other hand, having more health technicians per thousand population may help reduce the work pressure of physicians.

3.3 Recommendations for Provinces in Different Echelons to Choose Development Paths Suitable for Themselves

Based on the above analysis results, this study proposes the following three recommendations: First, there is an obvious imbalance in medical level among provinces in China, and the gap in medical level between provinces should be further narrowed. Therefore, the country needs to increase financial investment in economically underdeveloped areas, tilt funds and policies toward underdeveloped areas, and promote their economic development. At the same time, the government should continue to play a leading role in the allocation of medical resources, and through targeted assistance, enable medical resources to flow more to underdeveloped areas, better improve the medical level of underdeveloped areas, and improve the health level of local residents. Second, provinces in the first echelon have high medical levels and should continue to promote high-quality development of medical level. Therefore, areas with high medical levels should leverage their own advantages, improve the work efficiency of medical institutions, and rely on telemedicine and medical big data to exert their own radiation effect and drive the overall progress of regional medical levels. Each province in the second echelon should, on the basis of maintaining the existing medical level, analyze the advantages and disadvantages of current regional medical and health development according to regional health planning goals, pay attention to the coordination of regional medical and health development, and improve the medical level of the whole province by allowing developed areas within the province to drive underdeveloped areas. Third, provinces in the third echelon have backward medical levels and should improve their medical levels from multiple aspects. The country needs to strengthen policy inclination toward provinces in the third echelon, accelerate the construction of rural medical systems, promote the balanced layout of high-quality medical resources, and improve the hierarchical diagnosis and treatment system. For Hebei Province, it should leverage the radiation effect of Beijing and Tianjin on Hebei Province, deeply promote the integrated development of Beijing-Tianjin-Hebei; while promoting economic development in Hebei Province, it should also promote the process of medical and health system reform and medical and health development in Hebei Province. For Ningxia Hui Autonomous Region and Tibet Autonomous Region, the country should not only increase financial investment, encourage health technicians to practice locally, and help them improve medical infrastructure, but also accelerate the implementation of health counterpart support and health poverty alleviation projects to prevent local residents from falling into poverty or returning to poverty due to illness, and fundamentally improve the medical level of underdeveloped areas.

This study evaluated and analyzed the medical level of Chinese provinces based on the constructed evaluation index system, but there are still shortcomings. The objectivity of indicators and the comprehensiveness of evaluation results are affected to a certain extent by medical treatment in other places. At the same time, the researchers only evaluated the medical level of each province based on principal component analysis and TOPSIS model, and both methods have their own limitations, which may adversely affect the persuasiveness of empirical analysis results to a certain extent.

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