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A Statistical Measurement Study on the Influencing Factors and Spatial-Temporal Evolution of Healthcare Service Development in Economic Regions of Guangdong Province

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Abstract: *With the rapid development of the socio-economic landscape, the investment of various levels of government in healthcare services has been continuously increasing. To achieve the optimal allocation of healthcare resources, promote balanced development of healthcare services, and enhance the quality of healthcare services, it is crucial to explore the influencing factors of healthcare service development. In this study, we conducted an in-depth investigation into the impact mechanisms and spatial-temporal evolution of healthcare service development in different economic regions of Guangdong Province. By utilizing actual data and principal component analysis, we conclusively demonstrated that the level of healthcare service development in various economic regions of Guangdong is closely related to core factors such as population density, economic level, and medical facilities. Notably, in the economically developed Pearl River Delta region, we found that the level of healthcare service development is significantly higher than in other regions. This provides an important reference for guiding the allocation of healthcare resources across the province and promoting the balanced development of healthcare services overall.*

Keywords: *Guangdong Province; Economic Regions; Healthcare Services; Influencing Factors; Spatial-Temporal Evolution; Principal Component Analysis*

1. Problem Posing

As one of the most economically developed provinces in China, Guangdong has not only experienced rapid economic growth but has also focused on improving and enhancing healthcare services. In recent years, the Guangdong provincial government has been dedicated to promoting the balanced development of healthcare services, particularly in the mountainous, eastern, and western wing regions. The government has continuously increased funding and strengthened the allocation of medical facilities and human resources in these areas [1].

Within Guangdong, the Pearl River Delta (PRD) region has always been at the forefront in terms of healthcare services. However, as the economic development of Guangdong has progressed, healthcare services in the eastern, western, and mountainous regions have also gradually improved. In the mountainous areas, the government has made significant investments, continuously improving medical facilities and greatly enhancing the healthcare level. Nevertheless, compared to other economic regions, there is still a significant shortage of medical resources in these areas [2].

Research has shown that the level of healthcare service development in Guangdong's various economic regions is influenced by multiple factors. The level of economic development is one of the most important determinants. The higher the economic development, the greater the investment in healthcare services, leading to better medical facilities and more human resources. Additionally, factors such as medical facilities, human resources, medical technology, and healthcare insurance are also important influences on healthcare service levels. To gain a deeper understanding of these factors and the differences between economic regions, we applied principal component analysis [3].

Through data analysis, we found that healthcare services in the eastern, western, and mountainous regions of Guangdong have also seen improvements in recent years. However, they still lag behind the PRD region. Furthermore, we identified that economic development is a key factor determining the level of healthcare services in each economic region, and medical facilities and human resources are also significant factors influencing healthcare development.

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Based on our analysis of these factors, we have proposed several recommendations for promoting the balanced development of healthcare services. These include increasing government investment in healthcare, strengthening the recruitment and training of medical professionals, and improving the equitable distribution of healthcare resources. As healthcare service levels continue to improve, promoting the balanced development of healthcare across economic regions will become a crucial goal for Guangdong's future healthcare development. We believe that with ongoing attention and support from all levels of government and society, the healthcare service level in Guangdong will achieve more comprehensive and sustainable development [4].

2. Research Design

2.1 Data selection and data source

In this study, the "economic regions of Guangdong Province" are divided into four main areas: the Pearl River Delta (PRD) region, the Eastern Wing, the Western Wing, and the Mountainous Area. This division is based on the analysis and research conducted by the Guangdong Provincial Statistics Bureau on indicators such as economic development in the province. The PRD region includes cities such as Guangzhou, Shenzhen, Zhuhai, Foshan, Huizhou, Dongguan, Zhongshan, Jiangmen, and Zhaoqing. The Eastern Wing region includes cities like Shantou, Shanwei, Chaozhou, and Jieyang. The Western Wing region consists of the cities of Yangjiang, Zhanjiang, and Maoming. Finally, the Mountainous Area region includes cities such as Shaoguan, Heyuan, Meizhou, Qingyuan, and Yunfu. This classification is scientifically sound and rigorous, providing a solid foundation for the in-depth analysis of Guangdong Province's economic development.

To gain a more comprehensive understanding of the development of each economic region, we collected data from the Guangdong Provincial Statistical Yearbook for the years 2012 to 2021 in order to conduct detailed analysis and research on various indicator factors. The data includes regional GDP totals, as well as social indicators such as population density, medical resources, and health indicators. The credibility and authority of this data source come from the statistical yearbooks published by the Guangdong Statistics Bureau each year, ensuring that we can confidently conduct scientific analysis of the development status of each economic region [5].

Through detailed analysis and research of these data, we have drawn a series of conclusions about the development of each economic region and have conducted in- depth analysis and discussion of these findings. We hope that our analysis will provide valuable economic policy recommendations and references to the government and related organizations, contributing to the further advancement of Guangdong Province's economic development [6].

2.2 The Selection of Index Factors

After reviewing relevant papers and conducting discussions within the research team, this study selected 8 indicator data reflecting the development of medical services in the four economic regions of Guangdong Province from 2012 to 2021. These indicators are as follows: regional GDP (X1), population density (X2), number of healthcare institutions in each economic region (X3), number of healthcare beds in each economic region (X4), number of healthcare staff in each economic region (X5), number of practicing physicians in each economic region (X6), number of outpatient visits at healthcare institutions in each economic region (X7), and average length of hospital stay at healthcare institutions in each economic region (X8).

GDP (X1): Economic growth is an important indicator that reflects the productivity and economic strength of a region. If a region has a higher GDP growth rate, it indicates that the region has more resources and human capital, which can positively promote the development of healthcare services. Therefore, a higher GDP coefficient may imply a higher level of healthcare in that region.

Population Density (X2): The higher the population density, the greater the demand for healthcare services, and consequently, the demand for the number of healthcare institutions, beds, and medical staff also increase.

Number of Healthcare Institutions (X3): The number of healthcare institutions reflects the capacity for healthcare services in a region and also affects the coverage and quality of healthcare services. Therefore, a higher number of healthcare institutions may indicate a higher level of healthcare in that region.

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Number of Healthcare Beds (X4): The number of beds is another important indicator of healthcare service capacity. When combined with the number of healthcare institutions, it better serves the medical needs of the population. Therefore, a higher number of healthcare beds may also indicate a higher level of healthcare in that region.

Number of Healthcare Staff (X5): Healthcare staff are key to providing medical services. Both the quantity and quality of healthcare workers significantly impact the quality of healthcare services. Therefore, a higher number of healthcare staff may suggest stronger healthcare service capabilities in the region.

Number of Practicing Physicians (X6): Practicing physicians are one of the most critical components of healthcare services and a significant indicator of healthcare capacity. The number and quality of practicing physicians have a substantial impact on healthcare service quality. Therefore, a higher number of practicing physicians may reflect ahigher level of healthcare in the region.

Number of Outpatient Visits at Healthcare Institutions (X7): The number of outpatient visits at healthcare institutions is an important indicator of the quality and capacity of healthcare services. A higher number of visits indicates that healthcare institutions can meet more health demands and provide a higher level of service. Therefore, a higher number of outpatient visits may also suggest a higher healthcare level in the region.

Average Length of Stay at Healthcare Institutions (X8): This typically refers to the average length of hospital stay for patients and is an important indicator for assessing hospital treatment efficiency and resource utilization. Longer stays may indicate poor treatment outcomes or inefficient use of medical resources, which can also increase the economic burden and risk for patients.

These indicators reflect various aspects of healthcare services, such as the number of healthcare institutions, beds, staff, practicing physicians, outpatient visits, and average length of stay at healthcare institutions. These data provide insights into the overall situation and development trends of healthcare services in each economic region, offering valuable reference for formulating relevant healthcare policies.

It is important to note that in this study, we did not include other factors that might have significant effects, such as healthcare investment, medical costs, and insurance policies. This is because the focus of our research is on comparing the healthcare service development levels of various economic regions, and these factors are not variables we are particularly concerned with. Of course, this does not mean that these factors are unimportant; on the contrary, they are crucial to the development of healthcare services. However, based on the theme and purpose of the study, we focused on quantitative analysis and comparison of healthcare service development, avoiding the interference of other factors.

2.3 Data Analysis Thinking

This study aims to explore the potential impact of various indicators on healthcare service development in different economic regions of Guangdong Province from 2012 to 2021. Through a comparative analysis of the influences of different factors on healthcare service development in each economic region, the study provides more targeted recommendations for achieving a balanced development of healthcare services across these regions.

Healthcare services are crucial to the physical health of the public, and the attention and investment from various levels of government in the development of healthcare services are gradually increasing. However, the development levels across different regions vary. In the process of advancing healthcare service development, it is essential to conduct an in-depth study of the development situation in different regions and explore the various factors influencing healthcare service development.

Principal component analysis (PCA) is a common multivariate statistical method. The basic idea of PCA is to combine the original variables through linear combinations, aggregating highly correlated variables into new indicators. These newly created indicators, which result from the aggregation of multiple indicators, typically explain more of the variance and thus better reflect the essence of the issue under study.

In this study, we will use principal component analysis to aggregate the selected indicators into new ones and analyze the extent to which each factor influences the development of healthcare services in different economic regions of Guangdong Province. By comparing the comprehensive evaluation results of each region, we will assess the strengths and weaknesses of healthcare service development

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across different economic regions and provide more targeted recommendations for achieving a balanced development of healthcare services.

It is important to note that the results of principal component analysis only reflect the relationships between the indicators and do not directly explain the underlying causes. Further qualitative analysis and interpretation are needed. Therefore, when interpreting the results of principal component analysis, reasonable judgment and inference must be made to derive more accurate and scientific conclusions.

3. Empirical Analysis

3.1 Data verification method to check the rationality of data

Before conducting principal component analysis (PCA), we need to standardize the collected raw data to eliminate the influence of different units across the various factors. Standardization involves converting each indicator's data using a specific formula, transforming it into data with a mean of 0 and a standard deviation of 1. This allows for easier PCA and enables an intuitive comparison and analysis between the indicators.

For testing the suitability of PCA, Table 1 presents the results of the Kaiser-Meyer- Olkin (KMO) test and Bartlett's sphericity test. The KMO testis an important indicator to assess whether the data is suitable for principal component analysis, as it reflects the degree of correlation between factors when performing PCA. The KMO test results indicate that the sampling adequacy measure suggests there is a certain degree of correlation between the selected indicators, making the data appropriate for PCA.

Bartlett's sphericity test is used to check whether the correlations in the original data matrix are sufficiently large. If the correlations are strong enough, PCA is considered applicable. The results of Bartlett's test provide the approximate chi-square and significance values for the indicators of each economic region. The data indicates the rejection of the null hypothesis that the correlation coefficients are an identity matrix, confirming that the indicators are correlated and that the data is suitable for PCA.

In conclusion, both the KMO test and Bartlett's sphericity test show that the standardized data is appropriate for principal component analysis. This enables further exploration of the correlations between the factors, identification of the key factors influencing healthcare service development, and determination of their respective weights, thereby providing scientific decision-making support for the development of healthcare services in Guangdong Province.

Table 1. Factor test analysis of medical service index in various economic regions of Guangdong Province in the past ten years

		Pearl River Delta	East Wing	West Wing	Mountainous Region
KMO sample appropriateness measure		0.6	0.7	0.6	0.5
Bartlett sphericity	Approximate Chi-square	146.8	138.6	121.4	134.978
	Degree of Freedom	28	28	28	28
	Significance	0.000	0.000	0.000	0.000

3.2 Principal component analysis process

In this study, we will consider that healthcare service indicators in different economic regions may exhibit differences. Therefore, we will perform principal component analysis (PCA) on healthcare service indicators for the four economic regions—Pearl River Delta, Eastern Wing, Western Wing, and Mountain Areas—over a period often years. We will analyze and discuss each principal component in detail.

For each economic region, we will examine the correlations between the indicators and compute the correlation matrix to identify the most critical principal components and their respective weights. Then, we will evaluate the healthcare service development status of each region in detail by calculating and analyzing the principal component scores.

It is important to note that due to the differences in healthcare service development levels across

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regions, the principal components and weight coefficients may vary. Therefore, the data should not be simply pooled together. Only by analyzing and evaluating the data for each region separately can we gain a more accurate understanding of their respective healthcare service development conditions.

Through principal component analysis of healthcare service indicators in each economic region, we will be able to uncover the underlying relationships between the principal components and the various factors, allowing for a detailed and in-depth analysis and discussion. Additionally, by examining the correlations between the data, we can provide more targeted recommendations and suggestions for the development of healthcare services in different economic regions, promoting a more balanced and enhanced healthcare service level across these regions.

3.3 The Pearl River Delta region solves the principal component

Table 2. Explanation of the total variance of medical service indicators in the Pearl River Delta region in the past ten years

ingredient	total	Initial characteristic value contrast percentage	Cumulative %	total	Extract the load Square sum contrast Percentage	Cumulative %
1	6.220	77.748	77.748	6.220	77.748	77.748
2	1.176	14.696	92.444	1.176	14.696	92.444
3	0.485	6.059	98.502			
4	0.089	1.119	99.621			
5	0.024	0.305	99.926			
6	0.004	0.053	99.979			
7	0.002	0.20	99.999			
8	4.774E -5	0.001	100.000			

According to the results of the correlation matrix in Table 2, we found that the first two principal components, 1 and 2, can explain 92.444% of all the indicators. This means that these two principal components can accurately reflect the relationships between various economic indicators in the Pearl River Delta region of Guangdong Province, representing 92.444% of the information contained in the original 8 indicator factors. Therefore, we can consider that the extracted principal components 1 and 2 are reasonable and applicable for evaluating the healthcare service level in this economic region. As a result, these two principal components are extracted and named Y1 andY2.

①Calculate the principal component coefficients for the Pearl River Delta region.

According to the obtained principal component coefficients, a linear combination of Y1 andY2 is obtained:

$$Y1=0.397X1+0.383X2+0.394X3+0.398X4+0.395X5+0.393X6+0.191X7-0.185X8$$

$$Y2=0.081X1+0.083X2+0.107X3+0.098X4+0.128X5+0.137X6-0.661X7+0.671X8$$

By comparing the absolute values of the principal component coefficients, it can be observed that principal components Y1 and Y2 represent different aspects of the healthcare situation.

In principal component Y1, the absolute values of the coefficients for the indicators of economic growth (GDP, X1), number of healthcare institutions (X3), number of hospital beds (X4), number of healthcare workers (X5), and number of practicing physicians (X6) are larger than those of other variables. Therefore, principal component Y1 can be seen as a comprehensive reflection of these five indicators, representing the development of healthcare resource levels in the region over the ten years. It reflects the government's investment in healthcare resources, the demand for healthcare resources, and the allocation of those resources in the Pearl River Delta region during this period. Additionally, the coefficient for the average length of hospital stay (X8) is negative, indicating a negative correlation with the principal component. This suggests that the healthcare service level in this region is relatively good, with a shorter average hospital stay. Therefore, principal component Y1 can be used to compare the healthcare resource levels in different economic regions over the past ten years and assist decision-makers in the Pearl River Delta in improving the distribution and utilization of healthcare resources.

In principal component Y2, the absolute values of the coefficients for the indicators of the number of healthcare institutions (X3), number of healthcare workers (X5), and number of practicing physicians (X6) are larger than those of other variables. Thus, principal component Y2 can be seen as a comprehensive reflection of these four indicators, representing the healthcare service quality in the region over the ten years. Consequently, principal component Y2 can be used to compare the healthcare

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service quality in different economic regions over the past decade and help decision-makers in the Pearl River Delta improve the quality and efficiency of healthcare services.

3.4 The east wing region is solved for the principal component

Table 3. Interpretation of the total variance of medical service indicator factors in the Eastern Wing region during the decade

ingredient	total	Initial characteristic value contrast percentage	Cumulative %	total	Extract the load square Sum contrast Percentage	Cumulative %
1	6.921	86.515	86.515	6.921	86.515	86.515
2	0.599	7.492	94.007			
3	0.248	3.104	97.111			
4	0.124	1.555	98.666			
5	0.102	1.271	99.937			
6	0.004	0.049	99.986			
7	0.001	0.011	99.997			
8	0.000	0.003	100.000			

From Table 3, it can be seen that Principal Component 1 alone explains 86.515% of the healthcare service indicator factors in the East Wing region over the past ten years. This means that the extracted Principal Component 1 can also represent 86.515% of the information contained in the original eight indicator factors. Therefore, it is reasonable and applicable to use this principal component to evaluate the healthcare service level in this economic region.

②The principal component coefficients of the east wing were calculated

According to the obtained principal component coefficients, a linear combination of Y1 is obtained:

$$Y1=0.372X1-0.346X2+0.360X3+0.374X4+0.379X5+0.376X6+0.298X7+0.310X8$$

In Principal Component Y1, the coefficients of the five factors—economic growth GDP (X1), number of medical institutions (X3), number of medical beds (X4), number of healthcare workers (X5), and number of licensed physicians (X6)—have larger absolute values than those of other factors. Therefore, these five factors can collectively reflect the level of healthcare resource development in the East Wing region from 2012 to 2021. As for the linear combination in Principal Component 1, the coefficient of population density (X2) is negative, which reflects that the healthcare resources in this region cannot meet the population's demand. This may indicate that the government needs to increase the investment in healthcare resources in this area or optimize the allocation of healthcare resources to meet the population's needs and improve the quality of healthcare services.

3.5 The west wing region is solved for principal components

Table 4. Interpretation of the total variance of health service indicator factors in the Western Wing region during the decade

ingredient	total	Initial characteristic value contrast percentage	Cumulative %	total	Extract the load square Sum contrast Percentage	Cumulative %
1	5.550	69.373	69.373	5.550	69.373	69.373
2	1.195	14.942	84.315	1.195	14.942	84.315
3	1.004	12.547	96.862	1.004	12.547	96.862
4	0.139	1.739	98.601			
5	0.099	1.234	99.835			
6	0.009	0.112	99.947			
7	0.004	0.052	99.999			
8	7.628E -5	0.001	100.000			

From Table 4, it can be seen that Principal Components 1, 2, and 3 together explain 96.862% of the variance in the healthcare service indicators for the West Wing region over the ten years. This indicates that the extracted Principal Components 1, 2, and 3 can represent 96.862% of the information contained in the original 8 indicator factors. Therefore, the proposed principal components are considered to be a reasonable and applicable way to evaluate the healthcare service level in this economic region.

③The principal component coefficients of the west wing were calculated

According to the obtained principal component coefficients, a linear combination of Y1, Y2, andY3

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is obtained:

$$Y1=0.407X1+0.164X2+0.397X3+0.419X4+0.421X5+0.422X6+0.337X7-0.061X8$$

$$Y2=0.192X1+0.823X2-0.184X3+0.067X4-0.053X5-0.01X6-0.449X7-0.205X8$$

$$Y3=0.107X1+0.109X2+0.042X3+0.021X4+0.061X5+0.04X6-0.216X7+0.962X8$$

In Principal Component Y1, the coefficients of the five factors—economic growth GDP (X1), number of medical institutions (X3), number of medical beds (X4), number of healthcare staff (X5), and number of licensed physicians (X6)—have higher absolute values compared to the other factors. Therefore, these five factors can comprehensively reflect the level of healthcare resource development in the West Wing region over the past ten years.

In Principal Component Y2, the absolute value of the coefficient for population density (X2) is significantly higher than that of the other coefficients, while the coefficients for the number of medical institutions (X3), number of healthcare staff (X5), number of licensed physicians (X6), number of average medical visits (X7), and average patient length of stay (X8) are negative. This reflects that the region's healthcare resources cannot meet the population's demands, and the quality of healthcare services in the area still has considerable room for improvement. It suggests that the government may need to increase investment in healthcare resources in this region or optimize the allocation of healthcare resources to meet population needs while also improving the quality of healthcare services.

In Principal Component Y3, the coefficient for average patient length of stay (X8) has the highest absolute value, indicating that the average length of stay is a significant influencing factor for this principal component. The average length of stay refers to the average time a patient stays in a hospital for treatment and is an important indicator of healthcare service utilization and quality. If the coefficient for average length of stay is high, it may suggest that the quality of healthcare services in the region or time period is insufficient, leading to poorer treatment outcomes and longer hospital stays for patients. It could also reflect the need for improvements in the management and operation of healthcare institutions in the region.

3.6 The mountainous region is solved for principal components

Table 5. Interpretation of the total variance of regional medical service indicator factors in mountainous areas during the decade

ingredient	total	Initial characteristic value contrast percentage	Cumulative %	total	Extract the load square sum contrast Percentage	Cumulative %
1	6.000	74.998	74.998	6.000	74.998	74.998
2	0.908	11.348	86.346			
3	0.732	9.150	95.496			
4	0.201	2.513	98.009			
5	0.155	1.939	99.947			
6	0.003	0.039	99.987			
7	0.001	0.013	99.999			
8	5.557E -5	0.001	100.000			

From Table 5, it can be seen that Principal Component 1 explains 74.998% of the healthcare service indicator factors in the mountainous region over the past ten years. This indicates that the extracted Principal Component 1 can represent 74.998% of the information contained in the original eight indicator factors, and thus, the proposed principal component is reasonable and applicable for evaluating the healthcare service level in this economic region.

④The principal component coefficients of mountainous areas were calculated

According to the principal component coefficients obtained, a linear combination of Y1 is obtained:

$$Y1=0.391X1-0.358X2+0.375X3+0.399X4+0.405X5+0.403X6+0.241X7+0.184X8$$

In Principal Component Y1, the coefficients of the five indicators—economic growth GDP (X1), number of medical institutions (X3), number of hospital beds (X4), number of healthcare workers (X5), and number of practicing physicians (X6)—have larger absolute values compared to other factors. Therefore, these five indicators can comprehensively reflect the development of medical resource infrastructure in the mountainous region over the past ten years.

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The coefficient of the population density (X2) indicator is negative, and when combined with the patient average length of stay (X8) indicator, this could likely be attributed to the uneven distribution of urban and rural medical services in the mountainous region. This suggests that, from a policy perspective, the government may need to focus more on the economic efficiency and effectiveness of healthcare services in cities with higher population density. Improving the management efficiency of medical services and increasing the utilization of medical resources would help meet the growing healthcare demand in densely populated areas. At the same time, the government must pay special attention to mountainous and remote areas with lower population density, increasing investment in healthcare services to address the shortage of medical resources in these areas. This will help improve healthcare service levels and promote the balanced development of medical services.

4. Conclusion and Suggestion

Through principal component analysis, we extracted principal components from the healthcare development indicators of the four economic regions of Guangdong Province over the past decade and calculated the principal component scores for each region. By combining the results with real-world data, we analyzed the differences in healthcare influencing factors across these regions.

For the Pearl River Delta region, the economic level is relatively high, with sufficient investment in healthcare resources, greater demand for healthcare, and better distribution of resources. Furthermore, the quality of healthcare services in this region is superior compared to the other three economic regions. In contrast, for the East Wing, West Wing, and Mountainous regions, the population density (X2) coefficient in principal component Y1 is negative, indicating that the healthcare services in these regions are not keeping up with local population growth. This suggests that the healthcare development in these regions is still lagging behind.

Through analysis of other indicator factors in the principal components, it is clear that the number of healthcare workers (X5) and practicing physicians (X6) in the East Wing, West Wing, and Mountainous regions are relatively higher than the coefficients of other factors in the same principal component. This is largely due to Guangdong Province's recent efforts to promote the balanced distribution of healthcare resources across economic regions. The provincial government has also encouraged healthcare personnel to work in grassroots areas to enhance the healthcare capacity at the grassroots level.

Compared to other indicator factors in principal component Y1, the coefficient differences in the East Wing, West Wing, and Mountainous regions are not significant.

Over the past decade, the healthcare service levels in these regions have gradually moved toward a more balanced development, and the cooperation and development between these regions have become closer, making them more aligned with the Pearl River Delta region. However, further investigation into each indicator still reveals some degree of disparity.

Geographic distribution is one of the key factors influencing the differences in healthcare service levels across regions. For example, some remote areas maybe restricted by geographic location, preventing their healthcare services from keeping up with the development levels of other regions. Additionally, urban-rural differences are another important factor affecting disparities in healthcare service levels. In general, urban areas have higher economic indicators, while rural areas tend to be lower, which can lead to differences in healthcare services and resources.

Based on the above analysis, we believe that the following measures can be taken to promote healthcare reform and balanced development in the various economic regions of Guangdong Province:

1) Considering the impact of geographic distribution and urban-rural differences, we can further study how to meet the healthcare service needs of remote and rural areas through more refined allocation and upgrading of healthcare resources, thereby promoting the overall development of healthcare services in Guangdong Province.

2) Although the healthcare service levels in the East Wing, West Wing, and Mountainous regions are relatively lower, we can focus on factors such as the number of healthcare workers and practicing physicians, and explore ways to increase healthcare personnel resources and improve their technical skills to better meet the healthcare needs at the grassroots level.

3) The healthcare service level in the Pearl River Delta region is significantly superior to that of other economic regions. We can further study the healthcare development models and experiences of

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the Pearl River Delta region, exploring how to apply these models and experiences to improve the healthcare service levels in other economic regions.

4) Since principal component analysis only reflects the correlation between indicators and cannot fully represent causal relationships, it is recommended that further research combine the actual conditions of each economic region and use multiple statistical methods for comprehensive evaluation to thoroughly analyze the healthcare service levels across regions.

When addressing the development of healthcare services in the relatively underdeveloped economic regions, even in the first-tier cities of Guangdong Province such as the Pearl River Delta, continuous efforts are needed to improve the quality and level of healthcare services. Therefore, we can promote the overall development of healthcare services in Guangdong Province from the following aspects:

The government should increase investment in healthcare resources: By increasing the number of medical equipment and healthcare personnel, as well as improving the quality of healthcare services, the demand for healthcare services from the general public can be met. In addition, there is a need to focus on investing in the development of grassroots healthcare institutions to improve the level of primary healthcare services, providing patients with more timely and effective medical care.

Promote the standardization of healthcare service quality: Standardize healthcare services, continuously improve the medical level and service quality of medical institutions at all levels, and enhance patient satisfaction with healthcare services, providing the public with safer, more reliable, and high-quality healthcare.

Introduce advanced international medical technologies and concepts: By introducing advanced international medical technologies and concepts, we can promote technological updates and development in the healthcare industry. This can provide patients with more efficient and reliable healthcare services, and simultaneously promote the overall development of China's healthcare industry.

Promote the construction of healthcare service informatization: Establish modern healthcare service information systems and electronic medical records, achieve resource sharing and communication, and improve the quality and efficiency of healthcare services. This can maximize the use of modern technology to provide more efficient and convenient healthcare services to the public.

Through increased investment, standardization, introduction of advanced technologies, and informatization measures, healthcare service development can be comprehensively promoted in Guangdong Province, providing better healthcare services to the public and promoting social health and development. At the sametime, by radiating from the more advantageous economic regions to the surrounding areas, actively driving healthcare resources to grassroots levels, the gap in healthcare service levels between urban and rural areas can be narrowed. On the road of continuously advancing the development of healthcare service levels, Guangdong Province needs to actively promote the sinking of healthcare resources. This will ensure that people in rural and remote areas can also enjoy high-quality healthcare services, reduce the gap in healthcare service levels between urban and rural areas, and achieve universal healthcare services.

In any case, the road to the development of healthcare services in Guangdong Province remains long, requiring the joint efforts of healthcare workers, the government, and the broader society. With everyone’s joint efforts, the healthcare service level in Guangdong Province will surely become more comprehensive and balanced, providing better healthcare services to the public and promoting social health and development.

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Appendix

Data Collection Method: The data was collected by visiting the official website of the Guangdong Statistical Information Network (gd.gov.cn), where data from the Guangdong Statistical Yearbook for 2012-2021 was retrieved. The data was then downloaded in Excel format, followed by filtering and merging the relevant data.

Statistical Software: The statistical software used in this study includes Microsoft Excel and IBM SPSS Statistics 26.

Detailed Explanation of Principal Component Analysis: Principal Component Analysis (PCA) is a multivariate statistical analysis method used to transform multiple correlated variables into a set of uncorrelated principal components in order to better understand the relationships between variables and the structure of the data. The main idea is to convert the original variables into new principal components through linear combinations, so that these principal components can reflect the commonality and differences of the original variables as much as possible, thus achieving dimensionality reduction, information compression, and simplifying the analysis process.