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An Empirical Study on the Coupling and Coordination of Health Investment, Resident Health and Economic Growth in Sichuan Province

—Based on a Modified Coupling Model

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Abstract

We should calculate the coupling degree of medical investment, resident health and economic growth in Sichuan Province, and make clear the coordinated development of the aforementioned three factors. In that, the government was able to formulate policies that feature the positive interaction and coordinated development of regional medical investment, health and economy. Methods on index system for the evaluation of health investment, resident health and economic growth were constructed, and the coupling and coordination degree of the three systems were empirically studied based on the entropy weight method, the coupling coordination model and the gray correlation method. From the perspective of time series, the overall coupling and coordination level of Sichuan Province is relatively low, and the comprehensive development level of health investment and economic growth system has lagged behind the resident health system; from the perspective of spatial distribution characteristics, in 2019, the coordinated development level of health investment resident health and economic growth coupling in western Sichuan, southern Sichuan, northern Sichuan, eastern Sichuan and northern Sichuan is in the primary coordination stage, but there is a lag in the development of the health investment system between western Sichuan and southern Sichuan, and there is a lag in the development of the economic growth system between northern Sichuan and eastern Sichuan. From the analysis of gray correlation degree, the main correlation factors are diverse. All in all, the overall coordination level of health investment, resident health and economic growth in Sichuan Province is relatively low, and in order to achieve its coor-

dinated development, it is necessary to narrow regional differences, formulate coordinated development strategies according to local conditions, and improve the overall coordination level.

Keywords

Health Investment, Resident Health, Economic Growth, Coupling Model

1. Introduction

Health is the human eternal theme; it is not only the inevitable requirement to promote the development of society, the basic condition of social and economic development, but also an important symbol of progress at the medical level. The most important thing in development is putting people's health as the priority development of strategic position, realizing the benign coordinate health and economic and social development, the coordinated development of economy and health is the inevitable evolution trend of social development. A good medical condition is the security of the resident health, healthy people is the key to promoting social and economic development, and then, economic development will bring more medical resources and health investment, so as to form a kind of resident health and economic growth development of closed loop [1]. From the needs of social development to the national instruction, it is of great importance to coordinatively develop medical investment, resident health and economic growth. Medical investment, resident health, and economic growth are all intertwined. A disparity in medical investment will harm residents' health and have a negative impact on economic growth. Coordinating the relationship between medical investment, resident health, and economic growth promotes more effective development [2] [3] [4]. Most scholars believe that a lack of medical investment will increase the mortality rate, according to research on the relationship between medical investment and residents' health [5] [6]. On the contrary, increased medical investment can help residents improve their health. Some scholars believe that in the research on the relationship between residents' health and economic development, people are the most active factor of production, and that perfect health is a necessary condition to promote economic growth [7]; other scholars believe that a country's or region's economic growth will increase people's income and quality of life, which will help improve people's health [8] [9]. Improving the resident's health status, which has a positive meaning for the transformation of economic development in our country, while the unreasonable health investment will significantly affect this process, especially in the lack of medical resources in our country; under the background of diversified needs for people's health, we need more clear health investment, resident coordination development condition between health and economic growth, promoting the benign interaction among the three, improving the level of medical service, promoting resident health sustainable development, in order to promote health and

achieve the goal of China's grand strategy, providing a more lasting power for economic growth. This study is based on the revised coupling coordination degree model, building health investment, resident health and coupling coordination between the economic growth models, analysing administrative division between the coupling relationship and the coordinated development of the three systems across the Sichuan province level, in order to promote regional health coordinated development, resident health, and economic growth to provide the reference.

2. Methods

2.1. Index System Construction

Based on the previous literature (e.g., Fu *et al*. [10]; Tang *et al*. [11]; Li *et al*. [12]) and the availability, scientificity and objectivity of data, we developed a system of indicators for health investment, resident health and economic development. The specific indicators are shown in **Table 1**.

2.2. The Coupling Coordination Degree Model

Traditional coupling coordination degree model is low, can't narrow the system reliability and validity of the gap between the problem, as a result, this study uses the adjusted coupling coordination degree model, a more reasonable measuring coupling coordination and development level of each system [13]. Medical three system, the resident health and economic growth influence each other, Assuming R_3 to R_{max}, The calculation method is as follows:

Formulas (1) and (2) are specific formulas for calculating the comprehensive level index and coupling degree respectively.

$$R_i = \sum_{i=1}^{n} W_i X_i' \tag{1}$$

$$C = \sqrt{\left[1 - \frac{\sqrt{(R_3 - R_1)^2} + \sqrt{(R_2 - R_1)^2} + \sqrt{(R_3 - R_2)^2}}{3}\right] \times \sqrt{\frac{U_1}{U_3} \times \frac{U_2}{U_3}}} \tag{2}$$

R_1 is a comprehensive evaluation index system of health investment, R_2 is a comprehensive evaluation index system of resident health, and R_3 is a comprehensive evaluation index system of economic growth. For three system coupling, C is [0, 1], the more value it approaches to 1, the bigger degree of three system coupling will be shown. Due to the coupling can only describe the degree of internal coordination between systems, rather than measuring system in different levels of coordination degree, introducing the coupling coordination degree [14].

$$T = \alpha_1 R_1 + \alpha_2 R_2 + \alpha_3 R_3 \tag{3}$$

$$D = \sqrt{C \times T} \tag{4}$$

T is the comprehensive evaluation index of health investment, resident's health and economic growth; $\alpha_1 \alpha_2 \alpha_3$ is the contribution of the three indices,

Table 1. Indicator system for health investment, resident Health and economic development.

The target system	Level 1 indicators	Level 2 indicators
Health investment	Human input	Per thousand population health technical personnel number
		Hospital health technical personnel number
	Financial investment	Outpatient all medical expenses
		Discharged patients per capita medical expenses
	Material resources	Number of health facilities
		Medical institutions of beds per thousand population
Resident health	Health level	Children under the age of 7 rate of health care
		Health management rate of maternal
		Medical and health institutions health check the number of people
		Mortality rate
Economic development	Economic scale	Local fiscal revenue
		Gross Domestic Product
	Economic benefit	Urban per capita consumer spending
		Rural per capita consumer spending
		Per capital gross regional product

and $\alpha_1 = \alpha_2 = \alpha_3 = \frac{1}{3}$; D is the coupling coordination degree, and the value's range is from 0 to 1.

2.3. The Entropy Weight Method (EWM)

The entropy weight method was developed from the Shannon entropy, which is a quantitative measure of the uncertainty of information systems [15]. Compared to subjective human evaluation, the entropy weight method is an objective weighting method that has higher reliability, as its weighting coefficient depends entirely on the value of the indicator [16]. The calculation method is as follows:

Formula (5) Standardized calculation to eliminate data differentiation; Formula (6) is the specific calculation formula of entropy method.

$$X'_i = \frac{X_i - X_{\min(i)}}{X_{\max(i)} - X_{\min(i)}} \tag{5}$$

$$W_i = \frac{V_i}{\sum_{i=1}^{n} V_i} \tag{6}$$

where X' represents the standardized data for indicator in year i, X_i represents the original data, while $X_{\max(i)}$ and $X_{\min(i)}$ indicate the maximum and minimum value of the indicator, respectively.

2.4. Gray Relational Analysis

Grey relational analysis employs multivariate analysis to determine the degree of mutual influence or comprehensively evaluate the contribution of each index to variations in the data based on the geometric similarity of index factors [17]. Using grey correlation analysis method can be better for health investment, the resident health and economic growth three coupling in the coordinated development of various factors that affect its coordination.

3. Result

3.1. Sichuan Province Coupling Coordination Analysis of Health Investment, Resident Health and Economic Growth
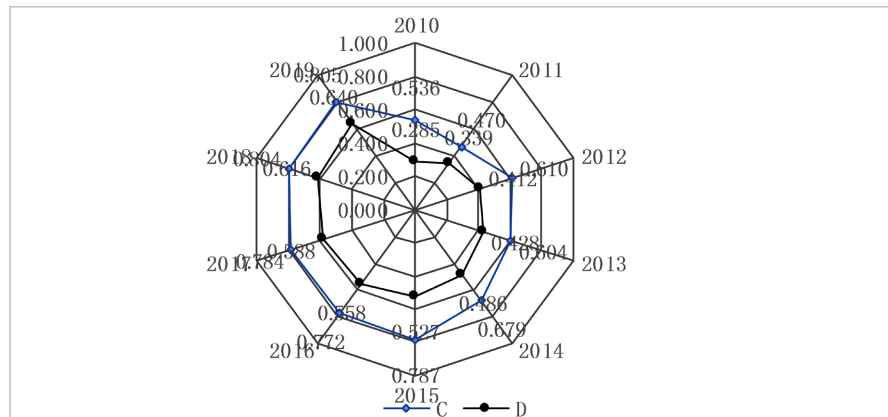
3.1.1. Time Series Analysis

1) Holistic health investment, resident health and economic growth of Sichuan province coupling coordination level analysis
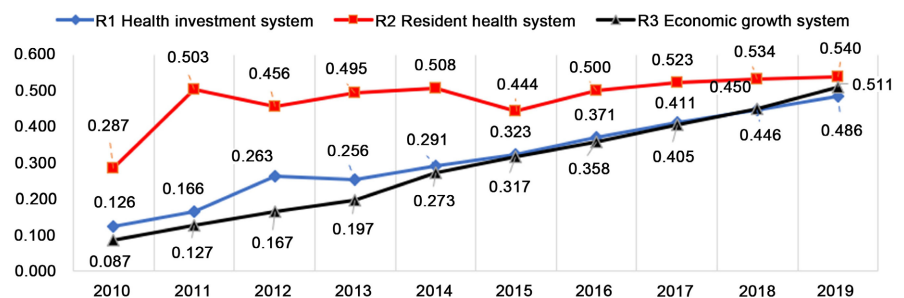
Health investment, resident health and economic growth of Sichuan province coupling coordination development level are relatively low, but overall, it has risen in a spiral. As shown in Figure 1, coupling coordinated development index of the lowest is in 2010, at only 0.285, with the policy support and government spending, the overall coordination has been continuously improved, moderate disorder gradually optimized from 0.285 in 2010 to 0.626 in 2018 primary coordination, coordination level in 2019 is still the primary coordination. The developing trend of coupling coordination degree can be found above, health investment, resident health and economic growth of Sichuan province have gotten into the coordinated development today, from the primary coordinate to intermediate coordinate transition stage, current level of development of harmonization, apart from the real coordinated development, still has a long way.

2) Health investment, resident health and economic growth of Sichuan province three systems analysis of the comprehensive development level

As shown in Figure 2, the comprehensive development of the three factors is going on well. Medical investment and economic growth tend to catch up with each other and show balanced comprehensive development in 2018. In 2019, the development rate of economy was higher than that of medical investment. This may be attributable to the establishment of the China (Sichuan) Pilot Free Trade Zone in 2017 in Sichuan Province, which increased investment opportunities, reduced operating costs and invigorated the economic development. At the same time, study shows in the period of entire 2010-2019, between the health investment and economic growth system of comprehensive development level, although the gap is getting smaller, resident health system has lagged.

Figure 1. Sichuan province health investment, resident health and economic growth time coupling coordination degree.

Figure 2. Health investment, resident health and economic growth of Sichuan province comprehensive development level.

3.1.2. Analysis of Characteristics of Space

Spatial characteristics of coupling coordination degree in Sichuan Province in 2019

From the perspectives of geographical regions of Sichuan province health investment, resident health and economic growth of distribution of coupling coordination degree to calculate the three systems of integrated development index and coupling coordination degree in Sichuan all regions in 2019. The coupling coordination development level among the health investment, resident health and economic growth of the four regions which include western Sichuan, northern Sichuan, eastern Sichuan and southern Sichuan is in the stage of primary coordination in 2019. The coupling coordination degree of western Sichuan region is the highest (0.670), secondly (0.656), thirdly (0.652) and finally (0.606). Looking from four regions of Sichuan province to each region, the overall recession class has no disorders, whole is given priority concerning transitional development and the coordinated development of two types. In 2019, the western Sichuan is in the transition of development and the coordinated development of regions 2 and 4 comes true, respectively, in which the coupling coordination level of Chengdu is highest (0.970), and achieves good coordination, the lowest coupling coordination level is Ganzi (0.500), which is at a transition in the class of development coordination level. The south of Sichuan region is in the transi-

tion of development and the coordinated development of regions are 3 and 5, respectively, Zigong's coupling coordination level is the highest (0.734), intermediate coordinate, Panzhihua's coupling coordination level is the lowest (0.468), close to disorder. The north of Sichuan region is also in a transition and coordinated development of regional development have 1 and 2, respectively, Mianyang coupling coordination level is the highest (0.747), intermediate coordinate, paper coupling coordination level is the lowest (0.552), only for coordination. The east Sichuan region, as a whole, is in the coordinated development of types, and primary coordination, including Dazhou's highest (0.688) coupling coordination level. The specific condition is shown in Table 2.

3.2. Sichuan Province Health Investment, Resident Health and Economic Growth of the Coupling Coordination Level Correlation Factor Analysis

Using the grey correlation method to explore the factors of the influence degree of the three system coordination development level in Sichuan province, correlation analysis and calculating the correlation. From Table 3 we can see the influence of various factors.

Table 2. Regions of Sichuan province in 2019 the health investment, resident health and economic growth of coupling coordination degree analysis.

region	health investment system	resident health system	Economic growth system	The coupling coordination degree (D)
The western of Sichuan				
Aba	0.220	0.376	0.461	0.505
Ganzi	0.231	0.494	0.359	0.500
Chengdu	0.948	0.936	0.954	0.970
Deyang	0.551	0.397	0.591	0.652
Yaan	0.447	0.602	0.395	0.677
Ziyang	0.567	0.513	0.536	0.713
mean	0.494	0.553	0.549	0.670
The south of Sichuan				
Zigong	0.595	0.548	0.560	0.734
Panzhihua	0.132	0.498	0.633	0.468
Luzhou	0.588	0.386	0.511	0.632
Neijiang	0.499	0.197	0.463	0.518
Leshan	0.544	0.416	0.597	0.659
Meishan	0.468	0.557	0.525	0.632
Yibin	0.500	0.458	0.536	0.611

Continued

Liangshan	0.387	0.703	0.450	0.592
mean	0.464	0.470	0.534	0.606
The north of Sichuan				
Mianyang	0.622	0.650	0.552	0.747
Guangyuan	0.567	0.666	0.421	0.657
Guangan	0.437	0.369	0.486	0.552
mean	0.542	0.562	0.486	0.652
The east of Sichuan				
Suining	0.523	0.749	0.474	0.655
Nanchong	0.484	0.465	0.452	0.670
Dazhou	0.449	0.689	0.465	0.688
Bazhong	0.437	0.678	0.312	0.613
mean	0.473	0.646	0.426	0.656

Table 3. Sichuan province regional health investment, the factors influencing resident health and economic growth coupled coordination of grey correlation degree.

The serial number	Associated factors	The gray relational degree	ranking
X1	Urban per capita consumer spending	0.974	4
X2	Rural per capita consumer spending	0.978	3
X3	Per capital gross regional product	0.938	10
X4	Local fiscal revenue	0.882	15
X5	Gross Domestic Product	0.899	13
X6	Per thousand population health technical personnel number	0.956	9
X7	Hospital health technical personnel number	0.903	12
X8	Outpatient all medical expenses	0.957	8
X9	Discharged patients per capita medical expenses	0.962	7
X10	Number of health facilities	0.904	11
X11	Medical institutions of beds per thousand population	0.966	6
X12	Children under the age of 7 rate of health care	0.982	2
X13	Health management rate of maternal	0.983	1
X14	Medical and health institutions health check the number of	0.896	14
X15	Mortality rate	0.967	5

4. Discussion

4.1. Sichuan Province Health Investment, the Resident Health and Economic Growth of the Whole Coordination Level Is Not High, System Development Lags behind Health Investment and Economic Growth

According to the results of 2010-2019 health investment system, the resident health and economic growth of Sichuan province's comprehensive development level is of a steady upward trend, but the three-system overall coordination is not high, mainly because the health care investment and economic growth system lag behind the resident health. Based on this, in order to improve the medical system comprehensive development level of the health investment and economic growth system, in the health investment, increases the supply of resources at the same time, according to the need, from past vulgar to hierarchical input, setting the priority area and time preference input area, general area and input tightening area, precision type [18]; take the way of collaboration between cities to promote the circulation of resources, to achieve the optimized allocation of resources, so as to promote the rational use of the resources of the whole. Regarding economic development, expanding domestic demand and promoting consumption upgrading is the inevitable choice to promote the development of economy; we should pay attention to improving the resident per capita income, increasing resident income channels, and giving fair and reasonable allocation policy, from the source to stimulate consumption power, to promote urban economic development.

4.2. Restricting Different Factors of the Four Regions of Sichuan Province's Health Investment, Resident Health and Economic Growth of the Coordinated Development, Including the System Development Level Regional Differences

From the overall, the advantages of regional economy in western and south of Sichuan area did not lead to the development of health investment system, coordination development level for health investment system lags behind the economic growth and resident health system, which leads to a limitation of the overall coordination development level; the east and north of Sichuan, because the economic growth lags behind the health investment and resident health system, failed to achieve a higher level of coordinated development. From the perspective of regional growth, there are differences in the coordinated development of cities (states) in the four regions. Such as the western Sichuan, Chengdu is in the western Sichuan region and completely different from Ganzi coupling coordination degree; their difference is 0.47, its health investment; resident health and economic growth system of the comprehensive development index differences were 0.717, 0.442, 0.595; significant differences led to the development of each system between regions; the coordinated development is in difference. To take different development method, therefore, for the lack of overall medical resources of the western and south of Sichuan, we should make use of the advan-

tage of local finance, strengthen health technical personnel team construction, improve the basic public health service costs, expand health service facilities dropping from the aspects such as human, financial and increase the intensity of support, thus improve the ability of grassroots medical institutions and health services; for the east and north of Sichuan, on one hand, we should strengthen the government fiscal responsibility in grassroots medical payment and increase financial input and transfer payments [19]; on the other hand, economic development should be taken as the key driver and multiple measures should be taken in parallel to improve the scale and economic benefits of local economy. It is imperative to formulate economic development plans that match the advance of health undertakings in Sichuan Province. By doing so, medical investment, resident health and economic growth in Sichuan Province can go hand in hand with each other.

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Authors' Contributions

L. Q. contributed to methodology, and writing original draft preparation; F. C. contributed to conceptualization, funding acquisition, and formal analysis. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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