Study on Regional Differences and Spatial Correlation of Medical and Health Care Consumption of Urban Residents in China Based on GeoDa

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Abstract—This paper uses Stata software to calculate the Theil indexes of per capita health care consumption of urban residents in Eastern, Centra and Western China, and measure the contribution of each obtained Theil index. Then Moran'I indexes are obtained by GeoDa software, analyzing the spatial correlation of the consumption level. GI indexes are used to explore the changes of high consumption agglomeration areas and low consumption agglomeration areas.

Keywords-medical and health care consumption; regional differences; spatial autocorrelation analysis

1 INTRODUCTION

In recent years, with the continuous progress of China's technology and economy, residents' living standards have been significantly improved, which has also driven residents' medical and health care consumption. Before the 1990s, the overall health care of Chinese residents accounted for 3% - 3.5% of the total GDP. In the late 1990s, the ratio was on the brink of 5%. In the 21st century, the ratio exceeded 5% before 2010, but it has declined in recent years. Although the per capita health care expenditure increases rapidly, there are some differences among different regions and provinces. Taking 2019 as an example, Beijing, which is subordinated to the eastern region of China, had the highest per capita medical and health care consumption of 3974 yuan. Shanxi Province and Tibet Autonomous Region belong to the west of China's administrative region, but the level of medical and health care consumption in the two provinces was quite unlike. Urban residents' per capita medical and health care consumption of Shanxi Province is 2528 yuan, while that of Tibet Autonomous Region is only 965.8 yuan, which is also the lowest in 2019.

In September 2021, the General Office of the State Council of China issued *the National Medical Security Plan for the 14th Five- Year Plan*, which clearly defines the sustainable development goal of creating fair and coordinated medical insurance, continuing to improve the basic medical security system, and establishing an overall coordinated medical security governance system[1]. However, China covers different regions in which medical and health care consumption is quite different, so it is necessary to explore the characteristics and the differences of residents' medical and health care consumption in different regions, to help the functional departments of the government in different regions achieve the established goals more effectively. This paper combines the methods of mathematical statistics and spatial

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statistics, using Theil index, spatial autocorrelation index, and local correlation index to explore the regional differences, and analyze the spatial relationship of urban residents' per capita medical and health care consumption of 31 provinces and cities in China.

The research sample of this paper is 31 provinces and cities of China. According to the division method of the National Bureau of Statistics, it consists of three regions: the East, the Central and the West. The East includes Beijing, Hebei, Tianjin, Shandong, Jiangsu, Shanghai, Zhejiang, Liaoning, Fujian, Guangdong, and Hainan. The Central covers Henan, Shanxi, Anhui, Hubei, Jiangxi, Hunan, Heilongjiang, and Jilin. The West refers to Shanxi, Sichuan, Yunnan, Guizhou, Guangxi, Gansu, Qinghai, Ningxia, Tibet, Xinjiang, Chongqing, and Inner Mongolia.

2 STATISTICS AND METHODS

2.1 Sources of the Statistics

This paper consults and collects statistics about the urban residents' medical and health care consumption from 2000 to 2019. The collected data are from the websites of China's National Bureau of Statistics, the websites of the Provincial Bureau of Statistics, and the Statistical Yearbook of each year.

2.2 Study Method

2.2.1 Theil Index

This paper intends to use the Theil indexes to measure the regional differences of medical care consumption of Chinese urban residents and analyze the contribution of the inter-regional difference and the intra-regional difference. The Theil index has two types of indicators named T indicator and L indicator. The former takes GDP as the weighted variable and the latter takes population as the weighted variable.

Some scholars considered the population factor when measuring regional differences, and found that the calculation result of the Theil index with the population as the weight has better robustness[2][3]. Therefore, in the selection of the weight indicator, this paper takes the urban population as the weight to investigate the regional differences. Taking each province as the basic unit and according to the Theil index method, the calculation formula with the number of urban residents as the weight are as follows[4]:

$$T_E = \sum_{i=1}^{e} \frac{Y_i}{Y_E} \ln\left(\frac{Y_i/Y_E}{P_i/P_E}\right), e = 11 \tag{1}$$

$$T_M = \sum_{i=1}^{m} \frac{Y_i}{Y_M} \ln\left(\frac{Y_i/Y_M}{P_i/P_M}\right), m = 8 \tag{2}$$

$$T_W = \sum_{i=1}^{w} \frac{Y_i}{Y_W} \ln\left(\frac{Y_i/Y_W}{P_i/P_W}\right), w = 12 \tag{3}$$

$$T_D = \frac{Y_E}{Y} T_E + \frac{Y_M}{Y} T_M + \frac{Y_W}{Y} T_W \tag{4}$$

$$T_B = \frac{Y_S}{Y} \ln\left(\frac{Y_S/Y}{P_S/P}\right) + \frac{Y_M}{Y} \ln\left(\frac{Y_M/Y}{P_M/P}\right) + \frac{Y_N}{Y} \ln\left(\frac{Y_N/Y}{P_N/P}\right) \tag{5}$$

$$T = T_D + T_B \tag{6}$$

T_E, T_M, T_W respectively represent the Theil index of the Eastern, Central and Western regions. T_D, T_B are intra-regional difference and inter-regional difference Theil index respectively. T indicates the whole Theil index of urban residents' medical care expenditure. Y_i refers to the total medical and health care consumption of urban residents in province i, P_i is the number of urban residents in province i. Y_E, Y_M, Y_W are the total medical and health care consumption of urban residents in the eastern region, the central region and the western region. P_E, P_M, P_W are the total population of urban residents of the three regions respectively. Y represents the total medical and health care consumption of the three regions. P is the total population of urban residents of the three regions.

2.2.2 Global Moran's I

Global Moran's I is often used to determine whether there is a correlation between different regions in the same space[5]. The value of the index is usually between [-1,1]. On the premise of meeting the significance, the index is positive indicating that there is a positive correlation between adjacent elements in space. If the index is negative, it indicates that there is a negative correlation between them. When the index is 0, it infers that there is no correlation between the two regions.

$$I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\left(x_i - \bar{x}\right)\left(x_j - \bar{x}\right)}{\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2 \sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \tag{7}$$

Among them, n is the number of provinces, x_i, x_j are the medical and care consumption of urban residents in a certain province i, $\bar{x}$ represents mean medical and care consumption of urban residents, w_{ij} is the spatial weight matrix, expressed as the spatial weight of the province i and province j. If the two provinces are adjacent, the weight value is 1, otherwise, it is 0.

2.2.3 Local G_i^* Index

Common methods to detect the scope of agglomeration areas include the local Moran's I index and the local G_i^* index. Since the result obtained by the local G_i^* index is more accurate when detecting regionalized variables[6], this paper selects the local G_i^* index to identify the areas with high-value agglomeration and low-value agglomeration.

$$G_i^* = \sum_{j=1}^{n} w_{ij} x_j \Big/ \sum_{j=1}^{n} x_j \tag{8}$$

According to the Z-test, $Z\left(G_i^*\right) = \left(G_i^* - E\left(G_i^*\right)\right) \Big/ \delta\left(G_i^*\right)$, $E\left(G_i^*\right)$ and $\delta\left(G_i^*\right)$ are the mean and standard deviation of the G_i^* index respectively, under the condition of significance, if the score is positive, the greater the value, the closer the agglomeration of high values. If the score is negative, the smaller the value, the closer the agglomeration of low values.

3 RESULTS AND DISCUSSIONS

3.1 The Theil Indexes of Regional Differences in Health and Care Consumption

Taking the urban population as the weight index, according to the relevant data of 31 selected provinces from 2000 to 2019, the Theil index formula is used to calculate the total regional difference of urban residents' medical care consumption, and the total difference is further decomposed into the inter-regional difference and the intra-regional difference expressed as T_D and T_B. The results are shown in Figure 1.

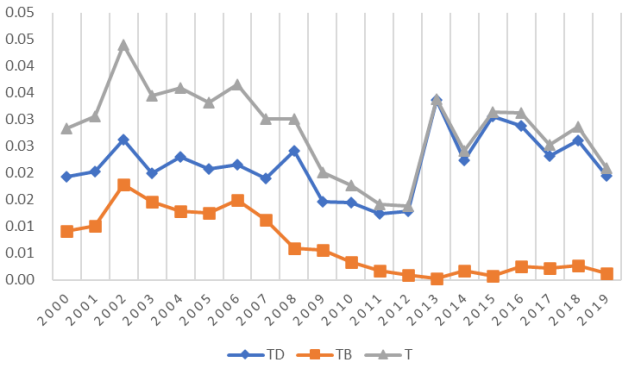

Figure 1 The Theil indexes from 2000 to 2019

Comparing the inter-regional difference, the intra-regional difference, and the total difference, it can be found that the three indexes increased from 2000 to 2002, and there was no change from 2003 to 2006. From 2006 to 2012, the three Theil indexes all showed a downward trend, but the intra-regional difference gradually deviated from the inter-regional difference over time and became closer to the total difference instead. From 2012 to 2019, with the popularity of medical service facilities and the concept of health care and medical treatment reaching a certain level, the changing trend of the inter-regional difference is almost flat, while the intra-regional difference is almost equal to the total difference and fluctuates with time, but the overall trend is still downward. It can be found that the intra-regional difference has always been much higher than the inter in recent years, indicating that the intra-difference of the three regions is more significant than the inter-regional difference.

Table 1 The values of Theil index in the three regions

Year	T_E	T_M	T_W
2000	0.022	0.021	0.009
2001	0.025	0.015	0.013
2002	0.033	0.009	0.025
2003	0.022	0.013	0.021
2004	0.026	0.014	0.023
2005	0.022	0.019	0.018
2006	0.019	0.024	0.028
2007	0.016	0.022	0.028
2008	0.017	0.040	0.028
2009	0.011	0.016	0.028
2010	0.009	0.019	0.029
2011	0.010	0.010	0.026
2012	0.009	0.015	0.024
2013	0.037	0.031	0.027
2014	0.026	0.020	0.016
2015	0.033	0.027	0.027
2016	0.032	0.025	0.023
2017	0.025	0.024	0.018
2018	0.031	0.022	0.015
2019	0.022	0.017	0.014

From 2000 to 2005, the Theil index of the East was higher than that of the Western Region and the Central Region, indicating that the difference in medical and health care consumption of urban residents in the East was more significant than that in the other two regions. From 2005 to 2012, the difference in the East was the smallest among the three regions, and the Theil indexes of the Central Region and the Eastern Region showed a downward trend, additionally, the Theil index in the Western Region was the largest entirely. From 2012 to 2019, the Theil indexes of the three regions increased initially and then decreased gradually, and the changing pace was basically the same, but the difference in medical and health care consumption of urban residents in the East was higher than that of the Centre and the West again. It can be found that the difference in medical and health care consumption levels of urban residents in the Eastern Region is higher, and the differences of the other two regions are relatively smaller.

3.2 Comparative Analysis of Contribution of Each Theil Index

To study the impact of the following five factors on the total difference: T_E, T_M, T_W, T_D, T_B. This paper measures and analyzes the contribution of each factor to the overall difference. The calculation formula is as follows:

$$\frac{T}{T} = \frac{T_B}{T} + \frac{Y_E/Y}{T/T_E} + \frac{Y_M/Y}{T/T_M} + \frac{Y_W/Y}{T/T_W} \tag{9}$$

Among them, the contribution of the inter-regional difference to the total difference is expressed

as $\frac{T_B}{T}$, and the contributions of the differences of the East, the Central, and the West to the total difference are expressed as $\frac{Y_E/Y}{T/T_E}$, $\frac{Y_M/Y}{T/T_M}$, and $\frac{Y_W/Y}{T/T_W}$. The results are shown in Figure 2.

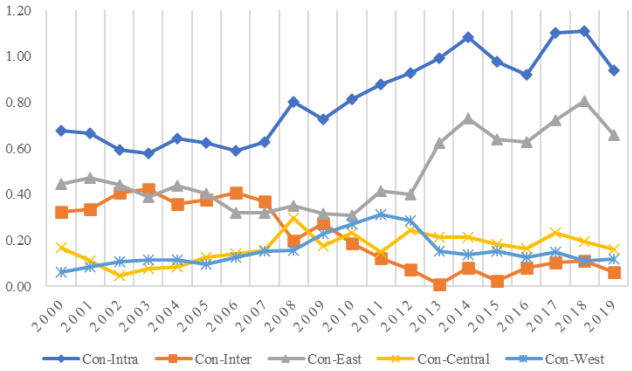

Figure 2 Contribution of each Theil index from 2000 to 2019

Overall, the intra-regional difference always contributes more to the total difference than the inter-regional difference. From 2000 to 2006, the contribution of the inter-regional difference to the total difference fluctuated from 60% to 70%, and the contribution of the intra-regional difference fluctuated from 30% to 40%. After 2006, the intra-regional difference's contribution to the total difference gradually increased, while the inter-regional difference's contribution gradually decreased. The changing trends in the opposite directions show that the impact of the intra-regional difference on the total difference is gradually strengthening, while the impact of the inter-regional difference is decreasing. Since 2012, the contribution of the intra-regional difference has exceeded 90% generally. Especially, the contribution of the intra-regional difference reached 99% in 2013, that is, the intra-regional difference is almost equal to the total difference, indicating that the impact of the intra-regional difference on the total difference is much greater than that of the inter-regional difference, and the intra-regional difference is an important factor affecting the total difference.

The difference of health care consumption among regions still exists, but it is far less serious than the difference within regions. Because residents' health care expenditure is mainly affected by income level, aging, medical price index, and education level, the differences between different provinces will inevitably lead to the differences of urban residents' health care consumption. In recent years, the medical insurance and other measures implemented by the government have made provinces with low per capita disposable income or education level have more autonomy and support in health care expenditure, but the problem of large regional differences still exists, and the intra-difference remains high. On the one hand, considering that different provinces in the same region have different investment levels in medical and health care funds, their medical facilities and services are also different. On the other hand, even if they are located in the same region, the development scale, speed, and stage among provinces are different, and there are certain differences in economic level and education level of residents, resulting in unequal medical care consumption.

3.3Spatial Autocorrelation Analysis of Health and Care Consumption

The GeoDa software is used to calculate the spatial weight matrix of various provinces in China, and the Stata software is used to standardize the matrix, calculate and test the global Moran's I index of per capita health care consumption. The results are shown in Table 2.

Table 2 Moran's I and relevant values

YEAR	Moran's I	E(I)	sd(I)	Z	p-value*
2000	0.273	-0.033	0.112	2.731	0.003
2005	0.315	-0.033	0.109	3.198	0.001
2010	0.419	-0.033	0.117	3.861	0.000
2015	0.340	-0.033	0.116	3.211	0.001
2016	0.239	-0.033	0.115	2.361	0.009
2017	0.203	-0.033	0.115	2.050	0.020
2018	0.235	-0.033	0.114	2.349	0.009
2019	0.174	-0.033	0.114	1.824	0.034

From 2000 to 2019, the global Moran's I index was greater than 0 and passed the significance test, that is, the health care consumption level of each province had a positive autocorrelation in space, indicating that provinces with similar health care consumption levels were concentrated in space, there was a significant spatial convergence effect, and the health care consumption of adjacent provinces affected each other, it is spatially exemplary. In terms of time, before 2009, the global Moran's I index showed an upward trend in fluctuation, indicating that the spatial positive correlation was strengthened. Due to the implementation of the new medical reform policy, the index showed a downward trend after 2009, and the positive spatial correlation weakened, indicating that the policy had played a certain role in controlling the agglomeration of urban residents' medical and health care consumption.

Because the level of health care consumption of urban residents in the study area has an obvious spatial agglomeration effect, the local spatial distribution characteristics of the local G_i^* index are further used to analyze the change of the agglomeration areas.

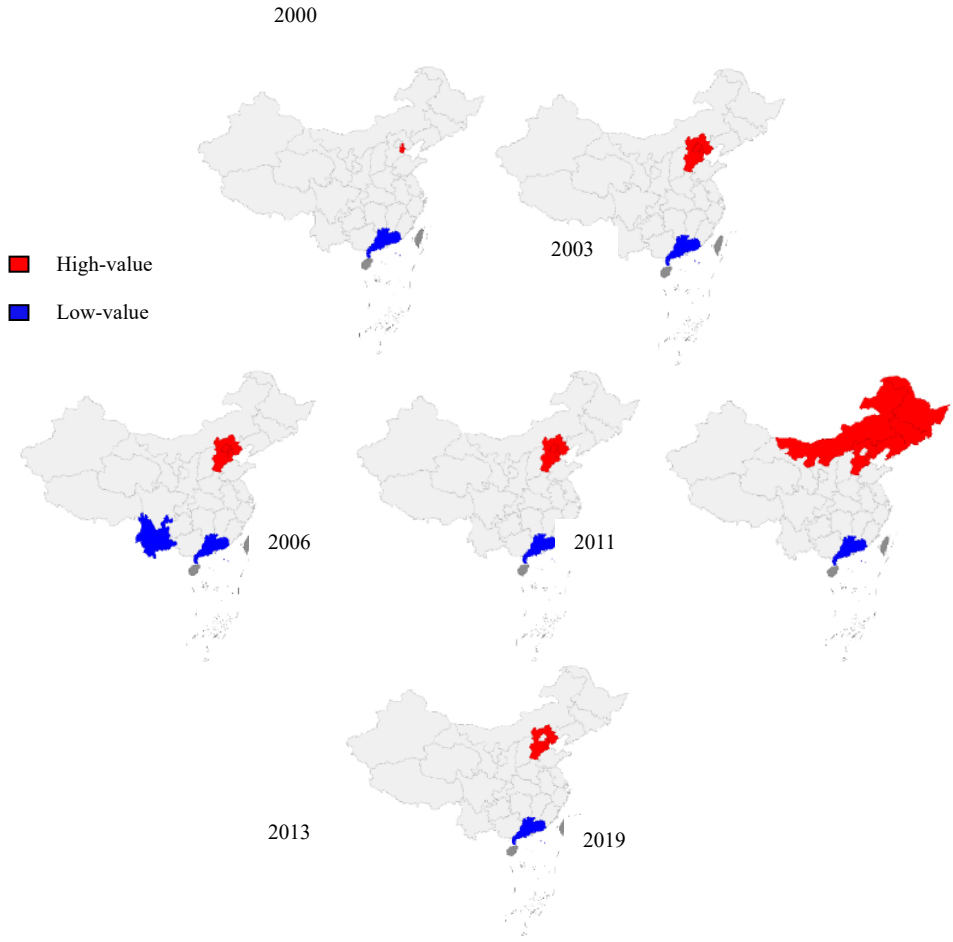

Figure 3 Changes of agglomeration areas

According to the information in Figure 3, it can be found that the high-value concentration range of health care consumption in the three regions is small, mainly around Beijing and Tianjin, and the low-value concentration region is in Guangdong Province all year round. Specifically, Beijing, the capital of China, is an international city. As China's economic, cultural and political center, the urban residents generally have a high level of education, have a strong sense of health care, and will have a certain impact on the concept of health care consumption in its surrounding provinces and cities. Therefore, the per capita health care consumption of urban residents in Beijing and its surroundings is high. Due to the high price of drugs and medical treatment, the low degree of medical insurance for residents, and the insufficient government investment in public health care, Guangdong Province is in a low-value concentration area all year round. From 2006 to 2017, the high-value concentration area gradually extended to Inner Mongolia and northeast China, mainly because Inner Mongolia has vigorously developed animal husbandry and the new energy industry in recent years, stimulating residents' consumption through economic development[7], and increasing medical and health care consumption accordingly. At the same time, the health resources in the three provinces of the northeast continued to grow, and since 2012, the coverage rate of basic medical insurance for urban

residents in the three provinces has reached more than 95%. After 2017, the high-value concentration area returned to the surrounding provinces and cities of Beijing, Tianjin, and Hebei again.

4 CONCLUSIONS

From the perspective of the regional differences of medical consumption, the inter-regional difference decreased entirely, the intra-regional difference decreased before 2013 and increased sharply in 2013, but it still shows a downward trend after that. As the contribution of the intra-regional difference to the total difference is larger and has basically remained above 95% in recent years, the changing trend of the total difference is basically consistent with that of the intra-regional difference. In terms of the regional contributions, the contribution of the East is always higher than that of the middle and western regions, so the regional difference is mainly caused by the difference of the East.

From the perspective of the overall space, urban residents' medical and health care consumption has a significant positive correlation, that is, there is an interaction about the level of health care consumption in two adjacent provinces or cities. Taking 2010 as the dividing point, the spatial positive correlation before this point strengthens with time and then weakens after the point.

From the perspective of the local spatial correlation, in some years, agglomeration areas of high values are mainly distributed in Beijing, Tianjin, Hebei, and their surrounding provinces and cities, while agglomeration areas of low values are mainly distributed in Guangdong Province. In certain years, Yunnan Province was the low-value agglomeration area, Inner Mongolia and the three northeastern provinces were high-value agglomeration areas, but in recent years, Guangdong is still the low-value agglomeration area.

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