Spatial dependence pattern of Chinese tertiary hospitals and its influencing factors

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Introduction

Due to uneven economic development across regions, disparity in financial support among local health facilities, income gap as well as urban-rural dual division of medical security, the accessibility of tertiary hospitals resources vary regionally.

- More than 50% are located in central-eastern advanced developed regions in China
- Most of the Chinese tertiary hospitals concentrate on the first-tier cities as well as provincial capitals
- Tertiary hospitals distribute unbalanced even in a city

Introduction

The analyses employing GIS on the spatial distribution of medical service facilities and resources as well as its accessibility, effectiveness and fairness, have become hot topics for the scholars worldwide(Kitchen et al., 2011; Fransen et al., 2015; Bruni et al., 2017; Shaikh et al., 2019). Researches focus on the following three aspects:

- measuring and evaluating the spatial accessibility of medical resources
- measuring and evaluating the fairness of medical resources
- developing and evaluating approaches for hospital site selection.

Introduction

This article matches the spatial distributions of all the tertiary hospitals in Chinese province-level municipalities, sub-provincial cities and prefectural-level cities (excluding Hongkong, Macao and Taiwan) with their administrative regions and portrays their spatial dependence pattern using exploratory spatial data analysis, then examines the influencing factors by Method of Ordinary Least Squares (OLS), Spatial Lag Model (SLM) and Spatial Error Model (SEM). (Anselin,1998,2002; Chi and Zhu, 2008; Lesage and Pace, 2009; Griffith and Chun, 2014).

Methods and materials

- Research methods

  Exploratory spatial data analysis (ESDA) aims to explore the spatial distribution of tertiary hospitals with spatial autocorrelation. Moran's I and Local Moran Index are two commonly used tools to measure the global and local spatial correlation characteristics respectively.

$$I = \frac{n\sum_i\sum_j W_{ij}(X_i-\bar{X})(X_j-\bar{X})}{(\sum_i\sum_j W_{ij})\sum_i(X_i-\bar{X})^2} \quad (1)$$

$$Z(\mathrm{I}) = \frac{\mathrm{I}-\mathrm{E}(\mathrm{I})}{\sqrt{\mathrm{var}\,(\mathrm{I})}} \quad (2)$$

$$G_i^* = \frac{\sum_j W_{ij}x_j - \bar{x}\sum_j W_{ij}}{\sqrt{\frac{n\sum_j W_{ij}^2 - (\sum_j W_{ij}^2)}{n-1}} \times S} \quad (3)$$

Methods and materials

- Research methods

Spatial econometrics model can make up for the deviation of OLS caused by the spatial effect through establishing statistical and econometric relations of geographical location and spatial correlation, it provides a new research perspective and analysis tool for exploring regional difference and its influencing factors (Lesage and Pace, 2009). This study utilizes some spatial regression models such as Spatial Lag Model (SLM) and Spatial Error Model (SEM).

$$Y=\alpha+\rho WY+\beta X+\varepsilon \quad (4)$$

$$Y=\alpha+\beta X+\mu ; \quad \mu=\lambda W\mu+\varepsilon \quad (5)$$

Methods and materials

- Date processing

This study obtained the data of Chinese tertiary hospitals from Chinese Hospital Classification Query System. Up to 31 December 2017, the system collected 1151 tertiary hospitals, including 705 upper tertiary hospitals (Grade I AAA), 198 middle tertiary hospitals (Grade I AA), 186 unclassified tertiary hospitals, 60 other tertiary hospitals and 2 tertiary hospitals with unknown classification.

We download the longitudes and latitudes of all the tertiary hospitals and match their geographical coordinates with the prefectural-level units of Chinese 31 provinces, autonomous regions and municipalities using software of ArcGIS10.2.

Methods and materials

- Date processing

  The influential factors on the tertiary hospital distribution include geographical, historical, political, economic as well as societal factors.

- Geographical factor involve the altitude and the territorial area of observed administrative unit.
- Historical factor is medical education, namely the number of medical college or medical school according to China Directory of Medical School and Affiliated Hospitals.
- Political factor is the city level, namely the administrative level of cities, data from The List of Municipalities, Provincial Capitals and Cities Specially Designated in State Plan.
- Economic development level include GDP, GDP per capita and urbanization level, data from various “Statistical Communiqué on the 2017 Economic and Social Development” at prefectural level.

Results and analysis

- Exploratory spatial data analysis on Chinese tertiary hospitals

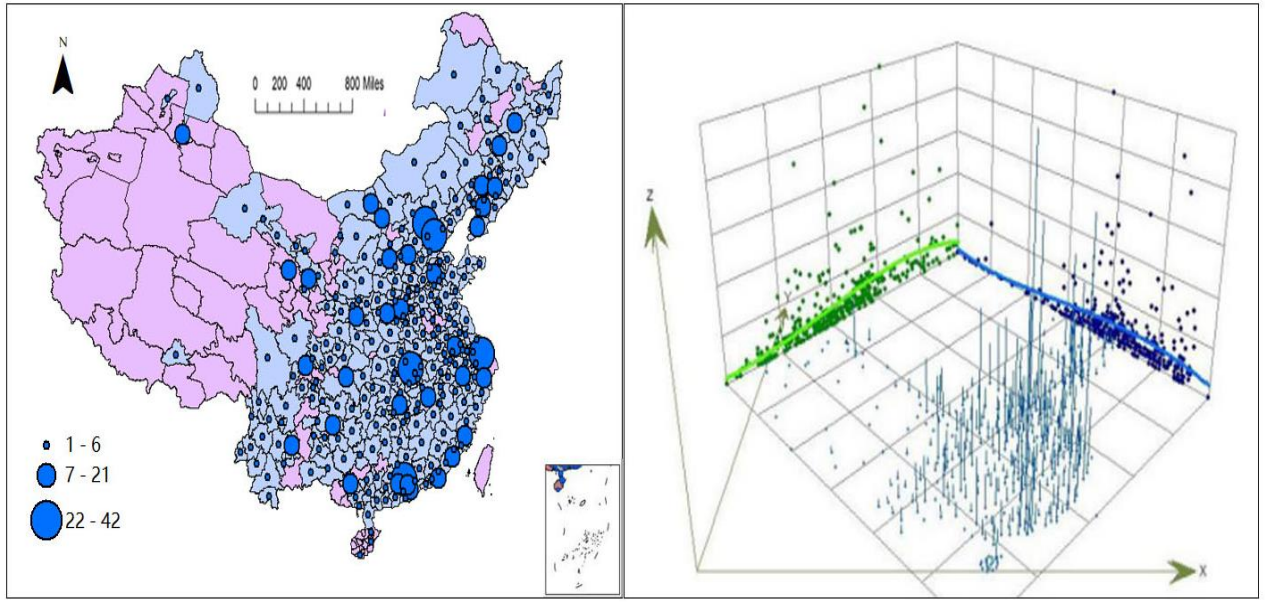

Figure 1. Spatial distribution and its trend analysis of Chinese tertiary hospitals.

Results and analysis

- Exploratory spatial data analysis on Chinese tertiary hospitals

Table 1. Statistical result of Global Moran' s I of Chinese Tertiary Hospitals Distribution

Weights (permutations=99999)	Contiguity Weight (order=1)		Distance Weight	
	Queen	Rook	Threshold (550000)	k-Nearest (4)
Moran's I	0.1007	0.1010	0.0511	0.0966
mean	-0.0026	-0.0027	-0.0027	-0.0025
sd	0.0321	0.0320	0.0138	0.0338
z-value	3.2152	3.2376	3.9078	2.9285
pseudo p-value	0.0050	0.0049	0.0039	0.0080

Results and analysis

- Exploratory spatial data analysis on Chinese tertiary hospitals

Due to the results of contiguity weight matrix are more robust, this study uses binary queen contiguity weight matrix to define the spatial relationship.

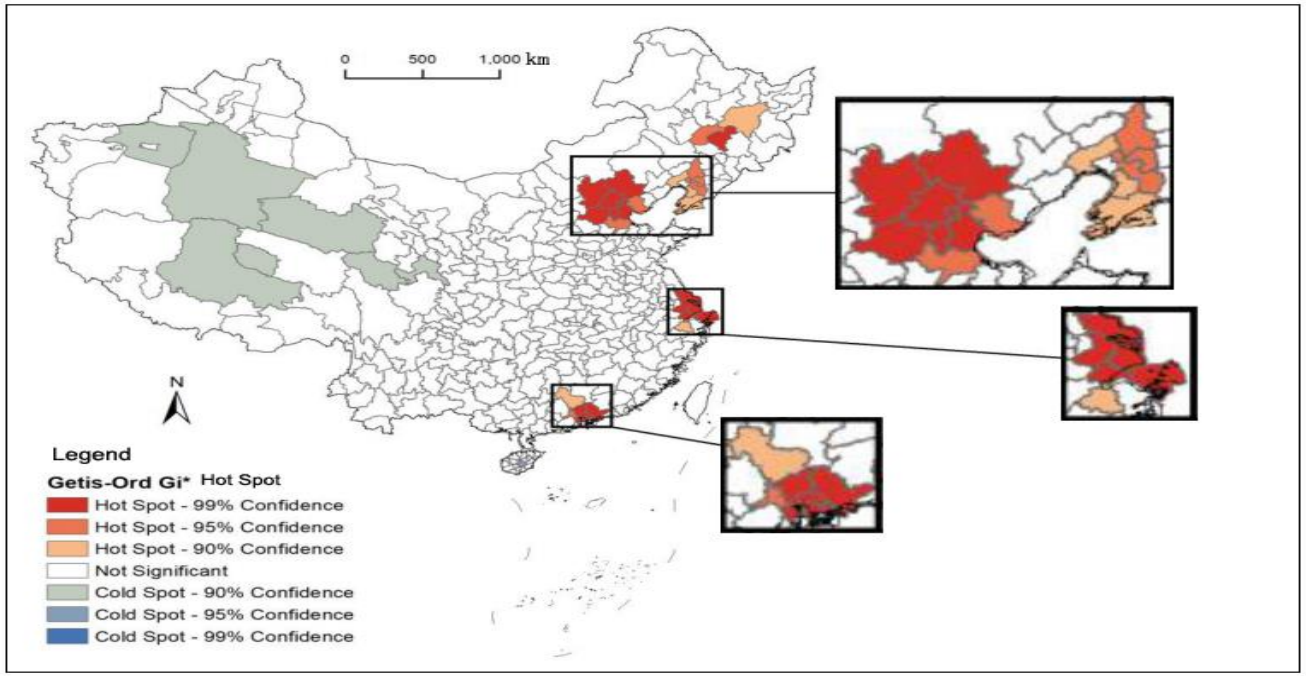

Figure 2. Local Hotspot Analysis of the Distribution of Chinese Tertiary Hospitals (Getis-Ord Gi*)

Results and analysis

- The influencing factors on and spatial effect of Chinese tertiary hospitals distribution

Table 2. The influencing factors of tertiary hospitals distribution in China (OLS).

	OLS (1)		OLS (2)		OLS (3)	
	Estimator	Standard error	Estimator	Standard error	Estimator	Standard error
Intercept	-0.1065	0.4978	-0.2645	0.4447	-0.4118	0.3919
GDP	0.0005**	7.41E-05	0.0004**	1.00E-04	0.0004**	8.37E-05
Urbanization rate	0.0204**	0.0081	0.0208**	0.0096	0.0217**	0.0074
City level	3.8945**	0.5457	3.81**	0.553	3.8127**	0.5329
Number of medical schools	2.5796**	0.2414	2.503**	0.2457	2.4937**	0.2389
Urban population			0.0025*	0.0014	0.0027**	0.0012
Resident population	0.0001	0.0006				
Population density	3.96E-05	0.0003	-2.11E-06	0.0003		
Altitude	-0.0001	0.0001	-7.35E-06	0.0002		
GDP per capita			-2.18E-07	5.65E-06		
Territorial area			-2.56E-06	2.33E-06		
R^2	0.8466		0.8489		0.8482	
AIC	1523.29		1521.61		1515.43	
Moran's I (error)	0.1281**		0.1094**		0.1140**	
LM (lag)	8.6951**		8.1000**		8.9992**	
Robust LM (lag)	1.225		1.7904		2.2061	
LM (error)	14.8274**		10.8077**		4.9472**	
Robust LM (error)	7.3572**		4.4981**		13.9464**	

Remark: ** for significance level of 5%; * for significance level of 10%; with binary queen adjacent weight matrix.

Results and analysis

- The influencing factors on and spatial effect of Chinese tertiary hospitals distribution

Table 3. The influencing factors of tertiary hospitals distribution in China (SEM).

	OLS (1)		OLS (2)		OLS (3)	
	Estimator	Standard error	Estimator	Standard error	Estimator	Standard error
Intercept	-0.1065	0.4978	-0.2645	0.4447	-0.4118	0.3919
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Conclusion and discussion

- the tertiary hospitals gather themselves not only on a prefectural-level, but also present spatial differentiations at a regional and national levels shown by the spatial distribution and trend analysis of tertiary hospitals in China
- using four various spatial weights matrices to measure global Moran’ s I, cluster of regions with more tertiary hospitals is evidenced by obvious spatial positive autocorrelations. Meanwhile, through Getis-Ord Gi* we explore that Bohai rim metropolis, Yangtze River Delta and Pearl River Delta city clusters are hot spots where high value of tertiary hospitals is agglomerated
- The distribution of the tertiary hospitals is significantly correlated with regional economic volume, urbanization rate, meanwhile the administrative level as well as the medical education resources also play major roles

THANK YOU