

# Study on Spatial Distribution Pattern of Medical Facilities Based on POI Data

## —A Case Study of Panyu District, Guangzhou City

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**Abstract**—Medical facilities as an important part of urban public service facilities, its spatial distribution has a direct impact on the residents of the convenience of medical treatment and quality of life. Getting the POI data of Panyu District's medical facilities from Gaode map, combining with GIS spatial analysis function, and analyzing the spatial distribution of medical facilities, the spatial disposition of medical and health resources and the spatial distribution of medical facilities quality in Panyu District. The results show that: (1) Panyu District medical facilities are mainly distributed in the central, and western and eastern medical facilities distribution is relatively small, uneven distribution of medical facilities area. (2) Medical facilities are multi-center agglomeration pattern, in which the Municipal Shiqiao Street as the center, has been extended to the Shiqiao Street and Donghuan Street, Shatou Street, Qiaonan Street and Dalong Street at the junction of the concentration range is the largest, surrounding the scattered distribution of a plurality of secondary core; the rest dispersed gathering center in Panyu District Bureau and other street (town). (3) According to the population distribution, the medical facilities of Panyu District are more reasonable, but in the geographical distribution, the medical facilities are relatively scarce and concentrated in the marginal areas of the region; from the perspective of health care resource density index, the population and area of each street (town) are matched with the distribution of medical resources. (4) Medical facilities overall rating density is located in the northeast of Dashi Street, and the secondary center is located in the west of the Shiqiao Street and the eastern part of Shatou Street transfer zone.

**Keywords**—POI; GIS; medical facilities; spatial distribution; Panyu district

### I. INTRODUCTION

With the development of economy, the level of residents' income and the improvement of health consciousness, more and more residents have begun to pay more attention to their physical health. As an important part of public service facilities, medical facilities spatial distribution has a direct impact on the residents' convenience and quality of life<sup>[1]</sup>. In recent years, with the maturity of GIS analysis technology, it has provided an important technical means for studying the spatial distribution of medical facilities rationality of spatial layout. In view of the research on the spatial distribution of medical facilities, many scholars have done lots of research using GIS spatial analysis method. Zhu J has used the GIS analysis method to analyze the spatial distribution of

community health service institutions in Guiyang city, and finds that the community health service institutions of Guiyang city were multi-center cluster pattern<sup>[2]</sup>; Xie X and Wang R use the GIS "LA model" to optimize the spatial distribution of medical facilities in Xiangnan District<sup>[3]</sup>; Zhou X, Xu F, and Yu S has used GIS spatial analysis to study the spatial layout of urban hospital, and optimized the location of medical facilities basing on location allocation model<sup>[4-6]</sup>; Based on the GIS analysis technology, XH Jiang has studied on the spatial distribution of medical institutions in Fuzhou city<sup>[7]</sup>.

Most of the above research is based on traditional methods, the researchers mainly obtain medical information data from government agencies or websites, and the data acquisition means are more traditional. With the development of Internet technology and the arrival of big data era, new means and methods are provided to study the spatial distribution of medical facilities. Compared to the mobile phone positioning data, taxi track data, bus card data, check-in data and other big data, as a low threshold and easy to obtain open source data, POI has been widely used in urban spatial identification, temporal and spatial behavior characteristics of residents, living facilities spatial distribution, urban living convenience index and other aspects of research. Chi J has used POI data to make quantitative identification and visualization of Wuhan urban functional areas<sup>[8]</sup>; Based on POI data of public service facilities, Cui Z has studied and compared the convenience index of living convenience in Beijing, Tianjin, Shanghai and Guangzhou<sup>[9]</sup>; Based on POI data, Sun Z has studied the spatial distribution and matching of living facilities in five districts of Jinan city<sup>[10]</sup>; The application of POI in urban planning has discussed by Suo C<sup>[11]</sup>.

Based on the POI data which is obtained from Gaode map, and combined with the powerful spatial analysis function of GIS, this paper studies the spatial distribution of medical facilities in Guangzhou, Panyu District.

### II. DATA SOURCE AND RESEARCH METHODS

#### A. Research Area Overview

Panyu District is located in the middle and south part of Guangzhou city. It belongs to the typical south subtropical marine monsoon climate in the latitude of 22 degrees 26 'to 23 degrees 05', longitude 113 degrees 14 'to 113' 42 '. The north

connects with Haizhu District, and the South borders on Nansha District; the west is adjacent to Nanhai District of Foshan and Shunde district and Zhongshan City, and the east lion sea is opposite to Dongguan City; the total area is 529.94km<sup>2</sup>, with six towns and ten streets.

### B. Data Source and Processing

Medical POI data is taken from Gaode map. There were 394 medical POI data for the node, and the information is deleted and 324 effective information was selected, so the information efficiency was 82.2%. Because Gaode map are GCJ - 02 coordinate system, it cannot be directly added to the GIS spatial analysis, so this study by rectifying the software will be valid data coordinate transformation is WGS - 84 coordinates.

The population and area data of each street (town) in Panyu District are mainly from the government network of Panyu District.

The medical POI review data is taken from Public comment network. The main contents include: overall score of medical facilities, number of comments, doctor scores, facilities score and registration score, all 283 information. After removing the lack of comment content and irrelevant information, a total of 52 valid information was retained.

### C. Research Methods

#### (1) Nuclear density analysis

Kernel density analysis is used to calculate the density of the elements in the neighborhood, and the method can be used to obtain the density change diagram of the object. The density distribution is highest at the center of each point, and decreases continuously outwards. When the distance center reaches the search radius, the density value is zero. The commonly used kernel density estimation equations are as follow:

$$f(x) = \frac{1}{nh} \sum_i^n K\left(\frac{x - x_i}{h}\right) \quad (1)$$

#### (2) Overlay analysis

Overlay analysis is a very important spatial analysis function in GIS. It refers to the process of generating new data by a series of operations of two sets of data under the unified spatial reference system. Through the overlapping of multi-layer data, not only can the new spatial relationship be generated, but also the characteristics of new attribute characteristics and the differences, connections and changes of multi-layer data are found.

#### (3) Health resource density index

Health resource density index (HRDI) is a resource allocation model based on the equilibrium distribution of health resources in population and geographical area. The index conforms to the principle of balanced distribution of health resources in population and geographical area, which is helpful to solve the problem of unbalanced spatial distribution of health resources. Using the medical resource allocation scheme established by the index, it can better solve the effective allocation of medical resources in space, and improve the

efficiency of medical resources utilization and the health of residents<sup>[12]</sup>.

#### (4) Standard deviation ellipse

The standard deviation elliptical algorithm was firstly proposed by the University of southern California professor of sociology in 1926. The ellipse half axis represents the direction of data distribution, and the short half axis represents the distribution range of the data. The shorter the half axis is, the more obvious the centripetal force of the data presents; On the contrary, the longer the shorter half axis is, the greater the dispersion of the data; The larger the difference between the length and the half axis (the larger the flat rate), the more obvious the direction of the data. The calculation formula is as follow:

$$\tan \Theta = \frac{\left(\sum_{i=1}^n x_i^2 - \frac{(\sum_{i=1}^n x_i)^2}{n}\right) + \sqrt{\left(\sum_{i=1}^n x_i^2 - \frac{(\sum_{i=1}^n x_i)^2}{n}\right)^2 + 4\left(\sum_{i=1}^n x_i y_i\right)^2}}{2\sum_{i=1}^n x_i y_i} \quad (2)$$

$$\sigma_x = \sqrt{\frac{2\sum_{i=1}^n (\bar{x}_i \cos \Theta - \bar{y}_i \sin \Theta)^2}{n}} \quad (3)$$

$$\sigma_y = \sqrt{\frac{2\sum_{i=1}^n (\bar{x}_i \sin \Theta + \bar{y}_i \cos \Theta)^2}{n}} \quad (4)$$

## III. RESULT ANALYSIS

### A. The Spatial Distribution of Medical Facilities in Panyu District

To begin with, according to the POI data of medical facilities crawled by Gaode map, the spatial location attributes are used to visualize them in GIS (Fig.1). We know that medical facilities of Panyu District are mainly distributed in the middle of the Shiqiao Street, Dalong Street, Shiji Town, Nancun Town, Dashi street and Luopu street, the western and Eastern medical facilities distribution of a relatively small quantity, especially the Shibi Street facilities a minimum number of medical facilities, uneven regional distribution.

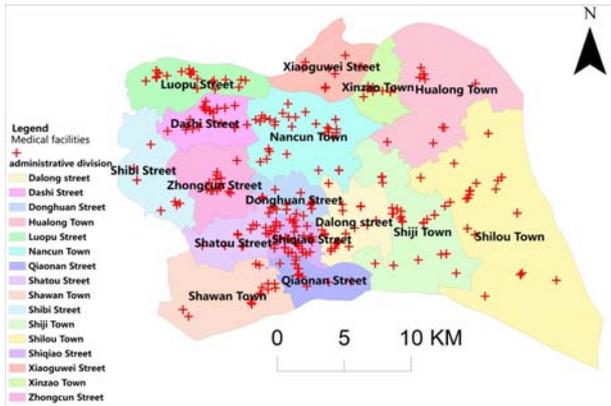


FIGURE I. THE SPATIAL DISTRIBUTION OF MEDICAL FACILITIES

Secondly, using the GIS medium density analysis tool to calculate the nuclear density of the medical facility distribution in Panyu District, the search radius is set to 800m, and the nuclear density map of medical facilities in Panyu District is available. It can be seen from Fig.2 that the distribution of medical facilities shows obvious multi-center agglomeration pattern in Panyu District. (1) northwest of Luopu Street; (2) northeast corner of Dashi Street; (3) northwest of Hualong Town; (4) eastern part of Nancun Town; (5) the middle part of Zhongcun Street; (6) taking the Shiqiao Street as the center, it has been extended to the Shiqiao Street and Donghuan Street, Shatou Street, Qiaonan Street and Dalong Street junction, and peripheral has scattered a number of secondary core.

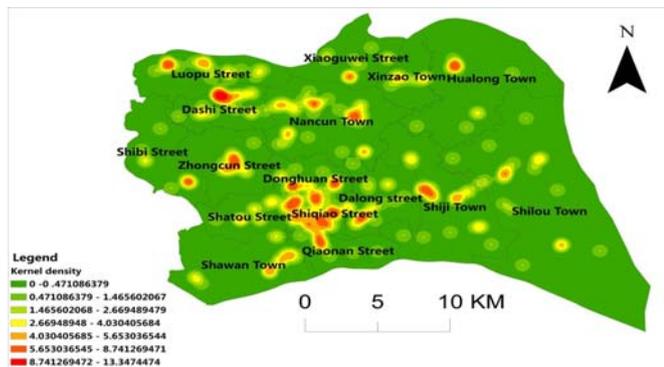


FIGURE II. THE NUCLEAR DENSITY OF MEDICAL FACILITIES IN PANYU DISTRICT

**B. Spatial Distribution of Medical Resources in Panyu District Streets and Towns**

Based on the GIS spatial overlay analysis tool, the population density and medical facilities of Panyu District are analyzed with superposition (Fig. 3). The result shows that the largest population density in Panyu District is the Shiqiao Street, the density of up to 13722 person per square kilometer, followed by Dashi Street, once again Luopu Street; The lowest population density is the town of Shilou, with a density of only 593 person per square kilometer; The regional population is dense in the central part and sparse in the East and the West. On the whole, according to the population distribution, medical facilities of Panyu District is more reasonable; the

population density of street (town) medical facilities is large, and distribution is relatively centralized. In the geographical distribution, located at the edge of the region, the Hualong Town and Shilou Town are sparsely populated, the medical facilities are relatively rare, and the medical facilities are not evenly distributed.

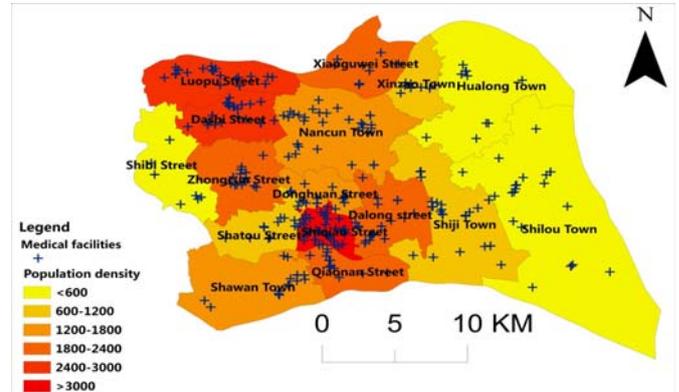


FIGURE III. THE OVERLAY ANALYSIS OF POPULATION DENSITY AND MEDICAL FACILITIES IN PANYU DISTRICT

According to the population size and area of each street, we calculate the density index of medical resources in each street (town) of Panyu District (Fig.4). The results show that: (1) the highest density index of medical resources is Donghuan Street (1.83), followed by Shatou Street and Xinzao Town, the second is Shiqiao Street and Dashi Street, and the density index of medical resources is greater than 1; Shawan Town (0.6), Hualong Town (0.55) and Shilou Town (0.32) medical resource density index is low; (2) the medical resource density index indicates that under the comprehensive consideration of population and regional area, the greater the value of the regional medical resource allocation, the better the allocation of medical resources in the region.

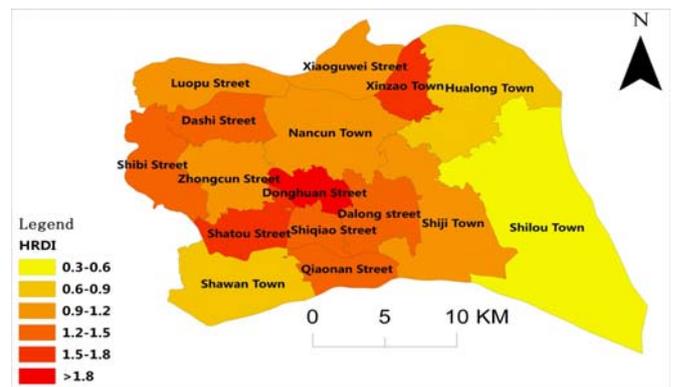


FIGURE IV. THE SPATIAL DISTRIBUTION OF MEDICAL RESOURCES DENSITY INDEX OF STREETS (TOWNS)

**C. Spatial Distribution Characteristics of Medical Facilities Based on Review Data of Public Comment Network**

Through the Public comment network access to comment on the Panyu District health data, deleting no comments and has nothing to do with the research of information, and then according to its spatial properties, using GIS analysis standard deviation ellipse tool to Panyu District public comments on

medical facilities spatial distribution point data mapping, and computing facilities space center of mass. As shown in Fig.5: (1) The long axis of ellipse shows a trend of northwest to Southeast, which shows that based on Public comment network, the spatial distribution of medical facilities in Panyu District is more significant in this direction than other directions; the elliptical short axis is larger, which indicates that the data of medical facilities based on Public comment network is more dispersed and the centripetal degree is lower; (2) The center of quality and the quality of medical facilities of Public comment network are located in the north of Donghuan Street, but the center of gravity of the study area is East, and the mass center of medical facilities is centered on the west.

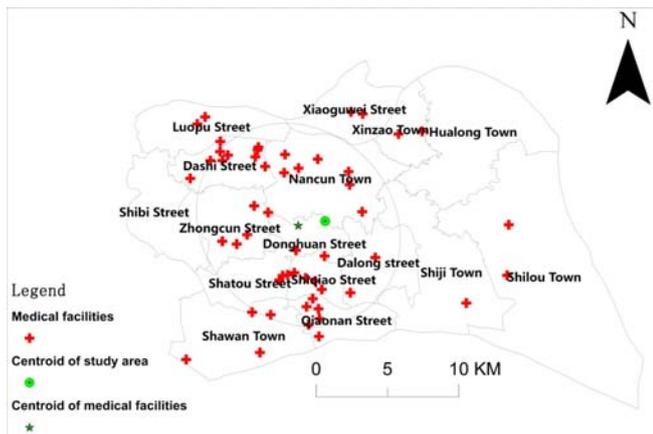


FIGURE V. STANDARD DEVIATION AND CENTER OF MASS DISTRIBUTION

*D. The Spatial Distribution of Quality Value of Medical Facilities Based on the Comment Data of Public Comment Network*

In addition to the distinct spatial location attribute information of POI data, some POI also contains rich comment data. Taking Public comment network as an example, the review data in POI mainly includes: the overall score, the score, the number of images, the views and comments, the collection number, check number, etc., and these comments data mainly concentrated in food, travel, shopping and other categories. In this paper, the overall score of medical facilities in Panyu District obtained from Public comment network will be visualized and the overall score will be analyzed by nuclear density analysis. According to Fig.6, the overall score of the medical facilities in Panyu District is mainly distributed in [6-6.9], [7-7.9], and the total score of the medical facilities in the Panyu District is only one medical facility over 8.5. This shows that residents are generally satisfied with the medical facilities in the region, and the medical comfort is not high; (2) The majority of hospitals in general are below 6, mainly due to the low number of registered hospital registration and doctors' scores, and the number of favorable comments.

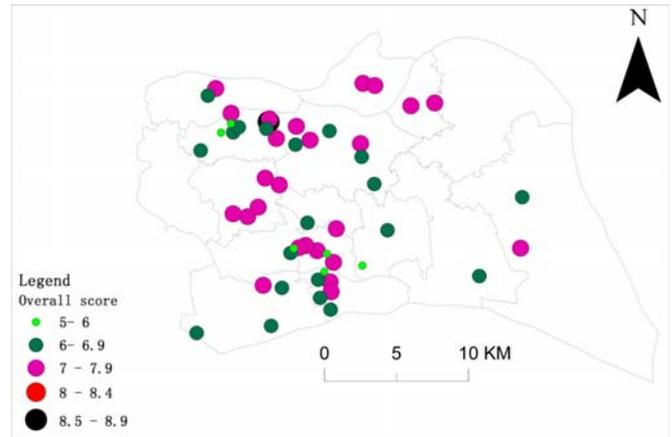


FIGURE VI. PANYU DISTRICT MEDICAL FACILITIES OVERALL SCORE DISTRIBUTION MAP

Then, using the GIS density analysis tool, the overall score of medical facilities in panyu district is estimated. It can be seen that the overall score density of medical facilities is located in the northeast of Dashi Street, which is mainly distributed in the highly rated Baibo mouth hospital and Ruide dental hospital. Secondary center is located in the eastern Shiqiao Street and Shatou west Street transition zone, the distribution of the main medical facilities is Shatou olive mountain health posts, Shiqiao hospital, Jinhui Shatou Street community health service stations, Xinye oral outpatient department.

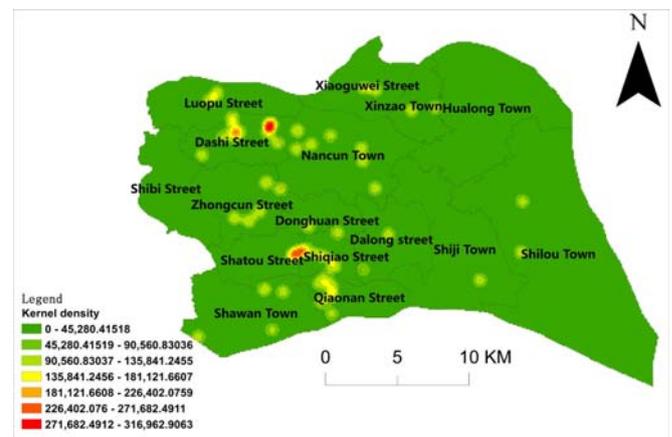


FIGURE VII. THE NUCLEAR DENSITY DISTRIBUTION OF MEDICAL FACILITIES IN PANYU DISTRICT

IV. CONCLUSIONS AND DISCUSSIONS

As the most important component of public service facilities, medical facilities have important influence on residents' convenience and quality of life. In this study, POI data of Panyu District medical facilities are obtained from Gaode map. Basing on Public comment network to obtain its medical health comment data, using the GIS platform, according to the analysis of nuclear density, overlay analysis and density index of health resources, to explore the spatial distribution of medical facilities and the allocation of health resources in the study area and using standard deviation ellipse analysis and nuclear density analysis to explore the spatial

distribution of medical facilities quality value. The main conclusions are as follows:

(1) From the point of view of administrative division, Panyu District medical facilities are mainly distributed in the middle of the Shiqiao Street, Dalong Street, Shiji Street, Nancun Town, Dashi Street and Luopu Street, and the western and eastern medical facilities distribution quantity is relatively small, uneven regional distribution of medical facilities.

(2) Medical facilities cluster in a multi-center pattern. Taking the Shiqiao Street as the center, it has been extended to the Shiqiao Street and Donghuan Street, Shatou Street, Qiaonan Street and Dalong Street junction, which is the biggest ones, and peripheral has scattered a number of secondary core.

(3) According to the population distribution, the distribution of medical facilities in Panyu District is reasonable. But in the geographical distribution, the medical facilities are relatively scarce and concentrated in the marginal areas of the region.

(4) From the Public comment network review data, we know that the overall score of medical facilities is not high, and especially the overall score of the hospital is low, and residents satisfaction with medical facilities service quality is low; the highest scoring density of medical facilities is located in the northeast of Dashi Street, and the secondary center is located in the transition zone between the west of Shiqiao Street and the east of Shatou Street.

Although this study uses open source POI data and its review data to study the spatial distribution, health resource allocation and quality value spatial distribution of medical facilities in Panyu District, there are still some shortcomings:

(1) The medical facilities POI data obtained from the high moral map does not cover all the medical facilities in Panyu District well.

(2) Only from the number of medical facilities in the streets (town) distribution of the population and area to calculate the health resource density index, spatial allocation measure of medical resources are still not accurate enough, and the lack of specific number of doctors and beds indicators.

(3) Based on the public comment network access to a small number of comments, it cannot well characterize the overall quality of medical facilities and residents comfort medical treatment in Panyu District. At the same time, from the perspective of the comments of crowd, mainly young people who use mobile devices frequently, there is no reference to the medical experience of the social mass group.

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#### REFERENCES

- [1] Ding S, and Chen B, "Rationality Assessment of the Spatial Distributions of Urban Medical Facility," *Journal of Geo-Information Science*, vol.19, no.2, pp.185-196, Feb 2017.
- [2] Zhu J, "Spatial distribution of community health service institutions in Guiyang city: an analysis with GIS," *Chinese public health*, vol.31, no.12, pp.1650-1654, Dec 2015.
- [3] Xie X, Wang R, Wen D, and Zhang Z, "Evaluating the Medical Facilities Layout Based on GIS: An Application of Xiang'an District," *Journal of Geo-Information Science*, vol.17, no.3, pp. 317-328, Mar 2015.
- [4] Zhou X, "Allocation Study of the City Hospital based on GIS---Case study of Tianmen," *Southwest Jiao Tong University*, 2007.
- [5] Xu F, "Research on hospital layout based on GIS spatial analysis," *Medical University of Chongqing*, 2014.
- [6] Yu S, Peng P, Tian X, and Ding J, "Study on the spatial layout and optimization of Changsha hospital based on GIS," *Journal of Changsha University*, vol.26, no.2, pp. 90-94, Mar 2012.
- [7] Jiang X, Yu M, and Ding F, "Spatial Distribution of Medical Institutions in Fuzhou: A Geographical Analysis Based on GIS," *Journal of Subtropical Resources & Environment*, vol.6, no.4, pp. 70-74, Dec 2011.
- [8] Chi J, Jiao L, Dong T, Gu Y, and Ma Y, "Quantitative Identification and Visualization of Urban Functional Area Based on POI Data," *Journal of Geomatics*, vol.41, no.2, pp. 68-73, Apr 2106.
- [9] Cui Z, Huang X, He L, and Zhou Z, "Study on Urban Life Convenience Index Based on POI Data," *Geomatics world*, vol.23, no.3, pp.27-33, Jun 2016.
- [10] Sun Z, Zhai X, Sun X, and Qiao Z, "Study on Spatial Distribution and Matching Situation of Living Facilities Based on POI- Taking Five Districts of Ji'nan as a Case," *Geomatics world*, vol.24, no.1, pp.65-70, Feb 2017.
- [11] Suo C, and Ding Z, "Application of POI in Urban Planning Research," *Annual meeting of China urban planning* 2015, pp. 634-643, 2015.
- [12] Zheng X, "Study on the application of HRDI in township hospital layout and resource allocation," *China health administration*, vol.19, no.10, pp.589-591, 2003.