Habitat International 53 (2016) 485–494

Contents lists available at ScienceDirect

Habitat International

journal homepage: www.elsevier.com/locate/habitatint

Spatial difference analysis for accessibility to high level hospitals based on travel time in Shenzhen, China

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ARTICLE INFO

Article history:
Received 23 May 2015
Received in revised form
31 December 2015
Accepted 31 December 2015
Available online 15 January 2016

Keywords:
High level hospitals
Spatial accessibility
KD2SFCA
Spatial autocorrelation analysis
Shenzhen

ABSTRACT

In the modern metropolis, the coverage of community hospitals is getting larger and larger. But high-level hospitals treating serious and sudden illness are still kind of scarce social resources. Shenzhen is the forefront of China's reform and opening up, its solution to the problem of medical allocation can be used as a reference for other cities. In this paper, we assume that primary, secondary and tertiary hospitals are main places for treating major diseases in Shenzhen, and analyze each sub-districts' spatial accessibility to them based on travel time and spatial difference within the city. A kernel density two-step floating catchment area method (KD2SFCA) is used to calculate how many medical resources each sub-district could share, in which the travel time from residential district to hospitals is used as an important parameter in evaluating the accessibility between suppliers and demanders. According to statistics of travel time by both driving and public transportation, the impedance function in KD2SFCA is modified and actual data of Shenzhen is used to fit its parameters, which could better simulate the attenuation trend of hospital service capabilities over the travel time. The spatial accessibilities are calculated under different travel modes and multiple time thresholds, and then spatial autocorrelation analysis method is used to analyze the spatial correlation of residents' accessibility to these medical resources. From both analysis of spatial accessibility and spatial autocorrelation, distinct variations in spatial distribution of high-level hospitals could be observed: of which the south and central parts of Shenzhen have significantly higher accessibilities, while the eastern and western regions are relatively lower. In particular, 12 sub-districts gain quite lower scores than others, showing that constructions on high-level hospitals should be strengthened further. In conclusion, the spatial configuration of high level hospitals in Shenzhen is not well balanced, Further optimization is urgently needed.

1. Introduction

Public service facilities provide essential resources and services for people's survivals and developments, such as those for education, health, culture, sports, transport, social welfare and security. The rationality on spatial distribution affects their allocation fairness and efficiency, and also the quantity and quality of public services that each individual could share and the achievement of the goal of "equalization of basic public services". As the foundation of peoples' health and life safety, hospitals are the most important public service facilities, their spatial allocation rationality guarantees an equal opportunity for people to enjoy necessary medical treatments.

Accessibility to basic public services represents the relative location value and convenient degree of public facilities to meet social and economic activities within a city or region, This concerns the equity and justice of urban public resources' allocation and is

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http://dx.doi.org/10.1016/j.habitatint.2015.12.023
0197-3975/

regarded as an important symbol for the quality of urban life (Michalos, 1999). In 1959, Hansen suggested that accessibility providing potential opportunities for interaction and it was a desire and ability to overcome space separation, and employment, shopping opportunities and activities of citizens were taken as basic objectives to evaluate this accessibility (Hansen, 1959); Pooler proposed such accessibility to urban public services referred to the relatively close spatial relationship between the facilities' distribution and their users (Pooler, 1995). The most commonly used measurement includes distance method, opportunity cumulative method, contour method, probability method, frequency method, balance coefficient method, temporal method, and methods based on matrix or topological space syntax and so on (Cheng & Lu, 2007). These methods are constantly being improved and new methods are proposed, such as potential model, the two-step floating catchment area method, the kernel density method and methods based on time geography. In 1982, Joseph proposed the concept of potential model in the research of the accessibility to medical service in the Wellington County (Joseph & Bantock, 1982). Potential model reflects the spatial competing effects between facilities and demanders, which includes facilities' competitions for the demanders and the demanders' competitions for limited resources, the result of which is the quantitative description for the number of the public service resources that residents access. Radke and Mu proposed the two-step floating catchment area (2SFCA) method (Radke & Mu, 2000), it repeats the process of floating catchment twice (once on supply locations and once on demand locations). 2SFCA is based on potential model, incorporating the interaction among supply, potential demand, and travel cost in their characterization of spatial accessibility, which is now a key measurement of spatial accessibility, particularly in applications of primary health care access. Luo and Wang used a modified 2SFCA to carry out an empirical study of accessibility to public health care facilities, which distinguished areas with shortage facilities by setting distance or time thresholds, and effectively reflected the status of residents' choice on facilities across administrative boundaries (Luo & Wang, 2003). These methods take the interaction between supply-side and demand-side into account, but how to determine the critical distance is their common difficulty. The often used models improved based on 2SFCA are E2SFCA and KD2SFCA and etc., in E2SFCA the catchment is broken into several discrete zones with different constant weight applied to the accessibility within each one; instead of creating discrete zones, the KD2SFCA uses a continuous decay function (Paul, 2013; Matthew, 2012).

For accessibility to medical facilities, Higgs selected the number of beds, the number of doctors, transportation supply, population density and others as evaluation factors (Higgs & Gould, 2001); Hare used the ratio of the number of beds, the number of inhabitants and different critical distances to discuss the accessibility to medical facilities for cardiovascular diseases (Hare & Barcus, 2007).

Chinese government regards rational spatial accessibility as an important principle for layout of the public service facilities (Song & Chen, 2010). But the study on spatial accessibility to health care facilities is still in initial stage in China. Y. Wang put forward a geographic accessibility calculation method by using GIS technology and the Voronoi polygon for the study of accessibility to public medical service of Pudong district of Shanghai (Wang, 2006). L. Zhang applied the accessibility with visual programming language Delphi and MapX to Yizheng's hospital planning in Jiangsu (Zhang, Lu, & Zhao, 2008). H. Tao improved the potential model and used it to analyze the shortage area of medical facilities in Zhuhai district of Guangzhou (Tao, Chen, & Li, 2007); Z. Liu studied the spatial accessibility to medical facilities for the 8 districts of Beijing based on the 2SFCA method (Liu, Guo, & Jin, 2007).

As the forefront of China's reform and opening up, Shenzhen is one of the fastest growing cities in China. Besides economic and social development, public health and fair treatment begins to increasingly draw more attention both in governmental and public. Some scholars studied the spatial distribution of some critical diseases in Shenzhen. Hu demonstrated substantial geographic variation in the incidence of hepatitis B infection and hepatoma in Shenzhen (Hu & Du, 2014). Y. Wang analyzed the spatial-temporal variation of IHD hospital admissions from 2003 to 2012 by spatial statistics, spatial analysis and space-time scan statistics (Wang & Du, 2014). Z. Wang applied hierarchical Bayesian models to explore the spatial heterogeneity of the relative risk for hypertension admissions throughout Shenzhen in 2011 (Wang & Du, 2014).

Meanwhile, Shenzhen has made efforts to improve medical conditions, constructing a two-level medical service system which includes community and high level hospitals to solve basic medical problems for a population more than 10 million. A reform on public hospitals is also implemented, aiming to vigorously transform general outpatient clinics in high level hospitals to special clinics, which goal is that by 2015, more than 70% of such transforming achieved and the number of outpatient firstly diagnosed in community hospitals takes more than 40% of the city's total. By using economic instruments, Shenzhen government promoted large hospitals to shunt general outpatient clinics to community hospitals. The medical service system has gradually realized first diagnosis in community hospitals and two-way referral pattern between the two levels (Shenzhen Health Statistic, 2011). In this way, the public with minor illnesses can get basic medical treatments in community hospitals, only those with serious illnesses need to go to high level hospitals. In this case, the configuration issues of high level hospitals have become more important in the health fair of the majority public.

In view of this, the paper aims to research the spatial distribution relationship between high level hospitals and population by using KD2SFCA method, calculates the accessibility and analyzes the spatial variation of these medical institutions with spatial autocorrelation analysis method, and finally to figure out areas which is short of health services, which could provide a reference for the future plan of hospitals.

This paper is organized as follows: Section 2 briefly introduces the study area and methods and the relevant data for Shenzhen; Section 3 describes the results of the spatial distribution characteristics and trends; and Section 4 draws conclusions and discusses potential future studies.

2. Data and methods

2.1. The study area

Shenzhen is a coastal city located in south Guangdong, China, near to Hong Kong, and on the east coast of the Pearl River, with its extent of longitude 113°46′ to 114°37′, latitude 22°27′ to 22°52′. There are 10 administrative districts under the jurisdiction of Shenzhen, they are Futian, Luohu, Nanshan, Yantian, Bao'an, Longgang, Guangming, Pingshan, Longhua and Dapeng. The area of the city is 1991.64 km^2, in 2013 the city's resident population is 10.5474 million, of which household population is 2.8761 million. Shenzhen is China's major international gateway to communicate with other countries, it is a wonderful microcosm of China's reform and opening-up and modernization. In 1980, under the leading of Mr. Deng Xiaoping, Shenzhen was designated to be China's first special economic zone. A small town with 30000 population has been developed into a metropolis with tens of millions of people after 34 years, creating a miracle in world's history of industrialization, urbanization, modernization.