Impact of the presence of private hospitals on the spatial equality of healthcare accessibility in Beijing, China

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Abstract

Providing equal geographical access to hospitals, either in the public or private healthcare sector, is vital and will benefit public health in general. Against the background of the partial privatization of the healthcare sector, the impact of private hospitals on equal healthcare access has been a highly neglected issue. We have applied an assessment methodology to study this situation by comparing the *status quo* scenario with one without private hospitals, based on accessibility analysis and spatial equality measurements. The case study of Beijing, China revealed a double-sided impact. With the presence of private hospitals, the Gini coefficient of spatial accessibility in urban districts was reduced from 0.03391 to 0.03211, while it increased from 0.1734 to 0.1914 in suburban districts. Thus, private hospitals improved spatial equality in urban districts in Beijing but jeopardized it in suburban districts. These research findings should enlighten policymakers to promote healthcare equality but would also need to be repeated in some other big cities.

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Introduction

Privatization of the health care sector has taken place in a wide range of countries in an expectation to improve its performance. In the late 1990s, China started ownership reforms in the healthcare sector against the background of transitioning to a market economy (Blomqvist, 2009). Since 2013, China has been vigorously introducing social financing to run and develop private healthcare institutions, as well as providing them with policy support. The number of private hospitals in China, as a major outcome of the reforms, has increased significantly (Deng *et al.,* 2018). The establishment of a large number of private hospitals has helped to create sufficient competition between public and private hospitals, thereby improving the quality of hospital services and reducing the cost of medical treatment for residents.

Oliver and Mossialos (2004) argued that equal access to health care for those in equal need was the most appropriate principle of healthcare equity. Access to healthcare is often defined as "the opportunity to reach and obtain health services" (Levesque *et al.,* 2013, p.1) and include both spatial and non-spatial aspects (Evans *et al.,* 2019; Glorioso and Subramanian, 2014; Khan, 1992). While China's privatization reform of the healthcare system has achieved positive effects on healthcare delivery efficiency owing to increased competition (Li and He, 2019; Pan *et al.,* 2015), the inequality of access (mostly non-spatial) to healthcare has increased (Akin *et al.* 2005, Gao *et al.* 2002, Tang *et al.* 2008). Regarding that equal access to healthcare (spatially or non-spatially) is one of the most important principles for public healthcare policy (Oliver and Mossialos, 2004), the Chinese Government has recently begun shifting the focus from efficiency to equality in a broader policy context of "continuously improving the equity of health care services in China's urban and rural areas".[1] Therefore, evaluating the impacts of private hospitals on healthcare equality is critical for better informed policy making.

The influence of privatization reform on spatial inequality of accessibility in developing countries has seldom been investigated (Alkhamis, 2017) despite some studies on the non-spatial equality of access to healthcare services (Benitez *et al.,* 2018) and on accessibility differences between private and public hospitals in Mumbai (Sharma and Patil, 2021), in Kenya (Ilinca *et al.,* 2019) and in Iran (Reshadat *et al.*, 2019). In contrast to the consensus of

[1]http://www.centv.cn/esjct/p/440286.html, a video was released by China Education Network Television (CETV) on 28 September 2022. CETV is part of the Chinese Ministry of Education and is the only national professional television station in China.

efficiency improvement (Shen *et al.,* 2007, Tiemann and Schreyögg, 2012), the effects of hospital privatization on the spatial equality of healthcare services may have diverse outcomes even from a theoretical perspective (Hossler, 2013). According to economic theories, such as the Hotelling model (1929), private hospitals with good reputation will tend to locate as close as possible to hospitals with bad reputation in order to obtain the largest market share, while the latter will tend to locate as far away as possible from the former to gain spill-over skilled labour from them, this leads to the instability and unpredictability of the spatial distribution of private hospitals. Moreover, the actual location strategies proffered by the Government may vary across regions due to the specific economic, political and social contexts. For example, a hospital may be established in a suburban district with a sparse population for both economic and policy reasons. Although this can provide some minimum standard of spatial accessibility, this policy can also result in large-scale transferral of so called "non-capital functions" (entities not essential for the development of the city) to the suburbs of Beijing according to the policy of "non-capital functional dispersal".[2] New private hospitals might be encouraged to locate in districts with high population concentrations to alleviate the difficulties of accessing health care for residents, which can either have a positive or a negative impact on spatial equality. The effect of opening private hospitals in the suburban districts in Beijing could be complementary when the catchment districts of private hospitals are separate from those of public ones; alternatively, the private hospitals could employ a co-location pattern with public hospitals to compete for market share (Brown and Barnett, 2004), *e.g.*, some private maternity hospitals with good reputation, or gain the proximity benefits of skilled labour sharing with public ones. As the theoretical outcome of the contribution of private hospitals to space equality is vague, plus the additional influence of specific policies, empirical research is required.

According to Penchansky and Thomas (1981), healthcare access is a general concept, which summarizes a set of more specific areas between the patients and the health care system. The specific area of access includes accessibility, availability, affordability, accommodation and acceptability, where accessibility reflects the relationship between the supply location and the customer location. Among the limited studies on access equality of health care, most have focused on the non-spatial aspects (Levesque *et al.,* 2013). However, against the background of Chinese practice of privatization reform, an increasing number of studies focus on China's healthcare inequality from the spatial perspective (Cheng *et al.,* 2016; Ding *et al.,* 2018; Hu *et al.,* 2019; Jin et a*l.;* 2019, Pan *et al.,* 2018; Wang *et al.* 2018; Xu *et al.;* 2019, Yang *et al.* 2016; Yin *et al.,* 2018; Zhang *et al.,* 2017; Zhang *et al.,* 2019; Zhu *et al.,* 2019). Based on the index of spatial accessibility (Kunzmann, 1998; Talen and Anselin, 1998), most found that huge spatial disparities exist across study areas and that urban districts were reported to have a higher level of equality (Hu *et al.,* 2019; Zhu *et al.,* 2019). However, the effects of private hospitals on the spatial inequality of accessibility in China has seldom been discussed, except for two studies (Pan *et al.* 2016.; Zhu *et al.,* 2019) that mention the competition between public and private hospitals and that the role of private hospitals in the equality of medical care across urban and suburban districts has not been evaluated.

The aim of the study was to quantify the impact of private hospitals on spatial equality in terms of accessibility. Multiple approaches have been used to measure accessibility to health care services, including models of distance and travel time to the nearest service, population-to-provider ratios (PPR), gravity models, two-step floating catchment area (2SFCA) and kernel density estimation (KDE) (Neutens, 2015). Among these approaches, the most widely used method, 2SFCA, allows the incorporation of distance decay and integrates the demand and supply size (McGrail, 2012; Wang 2012). Similarly, there are many indices that measure the equality of health services, such as the Gini coefficient, the coefficient of variation and Theil's index (Davis *et al*., 2013; Liu *et al*., 2016; Neutens, 2015). Here, we chose the Gini coefficient derived from Lorenz curve to measure the equality of hospital accessibility, since it is considered to be the most widely recognised in the economic and social welfare literature (Marsh and Schilling, 1994; Whitehead 2019). Therefore, this paper proposes comparing the scenarios with and without private hospitals by applying the hierarchical 2SFCA method and the Gini coefficient as equality measures, with Beijing used as case study. Unlike foreign cities with a functional territorial concept, Beijing is a province-level municipality (an administrative territorial concept) comprising 16 districts (6 urban and 10 suburban) since 2016. The urban and suburban districts cover an area of approximately 1381 km^2 and 15,029 km^2, respectively. Under each district there are several sub-districts, with the total number in 2016 amounting to 321, 131 of which located in urban districts. Regarding the huge disparity of population density and development pattern among urban and suburban districts in Beijing, they were analysed separately. It should be noted that some private hospitals in Beijing are more expensive than public hospitals, and have better environments and services, the former mainly targeting those who can afford the cost and the latter serving all people. As this paper focuses mainly on the spatial accessibility, non-spatial accessibility items, such as cost, hospital environment, service and difference in target population between these two types of hospitals are not considered in this study. However, the hierarchy of hospitals is accounted for as the service areas of city-level hospitals are significantly larger than that of county-level hospitals.

Materials and Methods

To explore the impact of private hospitals on the geographical equality of healthcare access, we first calculated the spatial accessibility of the study area under three scenarios: all hospitals, only public hospitals, only private hospitals, and then use 2SFCA method to analyse the contribution of private hospitals to accessibility by calculating the share of the accessibility value offered by private hospitals within the accessibility value offered by total number of hospitals. Afterwards, based on the accessibility analysis, the index of spatial inequality under the scenario of all hospitals were compared to the scenario without private hospitals to estimate the contribution of the latter to spatial equality.

Study area and data sources

Beijing is a province-level municipality that includes16 district-level administrative units, which are further divided into 321 sub-districts. Open population data under the sub-district scale are not available in China, so the calculations are implemented at the

[2]"non-capital functional dispersal" policy is intended to relieve Beijing of functions nonessential to its role as the capital,which was formally proposed in 2015 but had already been implemented before that. Sources:http://www.gov.cn/zhengce/2015-07/16/content_2898401.htm

sub-district scale. Among the 16 districts, 6 are urban, including Chaoyang, Haidian, Dongcheng, Xicheng, Fengtai and Shijingshan, and the rest suburban (Figure 1). Table 1 lists the data used and sources. The population data were accessed from the statistical yearbooks published by the district governments in Beijing (BMBS, 2020). In 2016, there were 13.63 million registered residents in Beijing. The geometric centroid of a sub-district represents the location of the population.

Hospital data for 2015 were obtained from the statistics communique published by Beijing Municipal Health Commission Information Center (BMHCIC). This study focuses on general hospitals in Beijing supposed to supply services in an area wider than the local community and divide these hospitals into the city-level and county-level according to "*Hospital Classification Management Measures (Trial Draft)*" issued by the Ministry of Health of China. In document, hospitals are divided into primary, secondary and tertiary levels according to function, namely primary, county-level and city-level hospital. Whereas county-level hospitals are managed by the municipal health bureau, city-level hospitals are managed by the provincial health department. The level of medical conditions, facilities and the doctors' speciality levels at the county-level hospitals is not as highly developed as that at the city-level hospitals, and they mainly provide medical and health services to many neighbouring communities. City-level hospitals, on the other hand, provide high-level medical and health services to several districts. In 2019, 17 (13.6%) of all hospitals (125) were private, while the rest 108 (86.4%) were public. In prior health accessibility research on hospitalized people in China, the number of practicing doctors (Cheng *et al.* 2016) and the number of beds (Pan *et al.* 2018) indicates the capacity of hospitals. We used the former indicator, since it is the fundamental factor attracting patients.

The shortest travel time from each sub-district to each hospital was calculated with the network analysis tool in ArcGIS 10.6

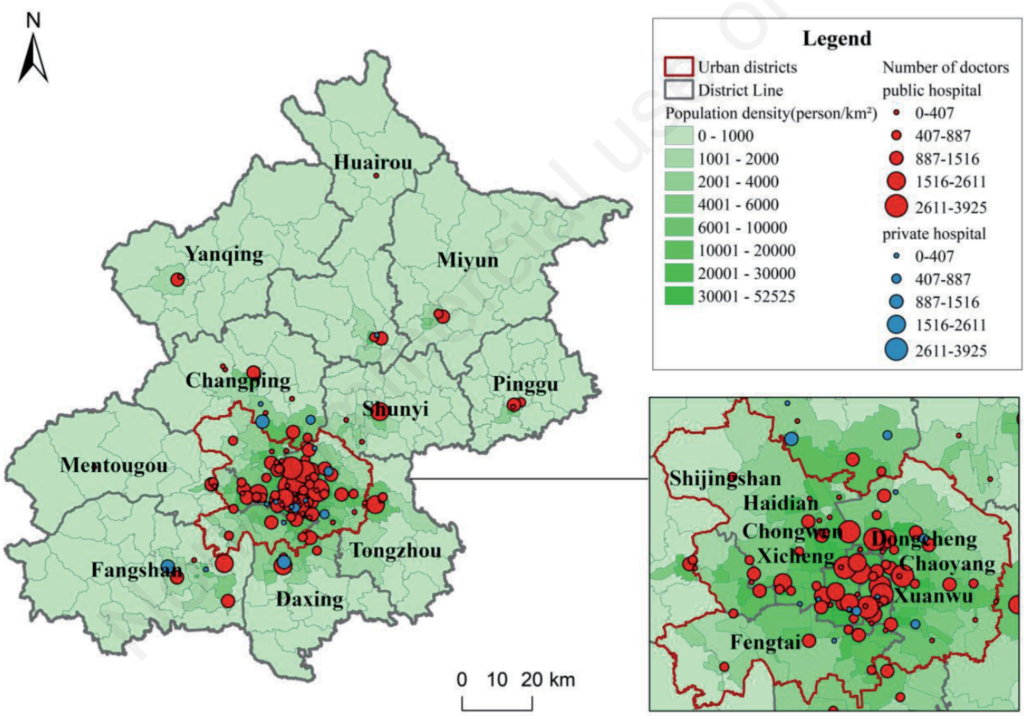

Figure 1. Overview of public and private hospitals in the study area.

Table 1. Data and sources used.

Data	Source
Population data of 2019 for Beijing's 321 sub-districts in	Statistical yearbooks published by the Beijing district governments in 2020 (BMBS 2020)
Hospitals in 2015	Statistical yearbooks published by Beijing Health and Family Planning Yearbook 2016
Number of medical practitioners in hospitals Number of patients in hospitals (Includes number of outpatients and number of emergency attendances)	Health and Family Planning Yearbook 2016
Road data of Beijing	Datatang (http://www.datatang.com/)
Administrative division document of Beijing	Datatang (http://www.datatang.com/

(ESRI, Redelands, CA, USA). According to Zhao *et al.* (2018), the vehicle speed parameters were set with reference to the classifications of the road: 45 km/h for highways, 40 km/h for national roads, 30 km/h for urban expressways, 25 km/h for provincial and county roads, 20 km/h for rural roads, and 5 km/h for other roads. Each sub-district is represented by the centroid of its polygon.

Methods of analysis

Accessibility measurement

This study applies the 2SFCAmethod, which is calculated in two steps: the first to search for which demand population are within the catchment area (30min service threshold for county-level hospital and unlimited for city-level hospital), which number was used to calculate the supply/demand ratio of each facility point; the second step to calculate the sum of the supply/demand ratios for each demand point (Luo, 2003). The generalized formula is as follows:

$$A_i = \sum_{j=1}^{n} \frac{S_j f(d_{ij})}{\sum_{k=1}^{m} D_k f(d_{kj})}, \quad (1)$$

where A_i is the accessibility score at demand point i; S_j the supply at location j; D_k the population at location k; d_{ij} (or d_{kj}) the travel time between i and j (or k and j); and f a distance decay function shown in the next equation:

$$f(d_{ij}) = \begin{cases} d_{ij}^{\beta}, d_{ij} \le d_0 \\ 0, d_{ij} > d_0 \end{cases}, \quad (2)$$

where β is the distance decay parameter reflecting the sensitivity of the demand to the spatial distance; and d_0 the threshold distance within which the supply locations are regarded as accessible. The distance decay parameter and the threshold distance are two key parameters for the 2SFCA method. Generally, the distance decay parameter β in the previous studies ranges from 0.5 and 2.29 (Berens and Körling, 1985; Brimberg and Love 1993; Jin *et al.,* 2019; Love and Morris, 1979). In this study, different parameters were set for two levels of hospitals. Here we follow a recent study on multi-level health accessibility in which the value of 0.5 was set for city-level hospitals, with1 for county-level hospitals (Jin *et al.,* 2019), which thus become a hierarchical 2SFCA method. For the threshold distance parameter, 30 minutes was set for the county-level hospitals according to China's National Health Care Commission's requirement to "build a 30-minute medical circle for rural residents" by 2021 that is considered as an appropriate threshold for analysing health care spatial access (Lee, 1991; Luo and Wang, 2003). Unlimited threshold distance was set for city-level hospitals considering that their service area covers the Beijing, in both urban and suburban districts (Jin *et al.* 2019).

Since the distance decay parameter β of the two levels of hospitals were different in the work by Jin *et al.* (2019), their results of accessibility were not numerically comparable and needed to be normalized. We therefore standardised the calculated accessibility for different hospitals in a special way so that the accessibility results could be compared with each other in the following three steps: i) the maximum-minimum values were standardised together for all hospitals, both public and private; ii) as city-level and county-level hospitals receive different numbers of patients, we used the proportion of the total number of patients of each grade to the total number of patients of all hospitals as weight, and multiplied the result of the previous standardisation step by the weight corresponding to each hospital level; and iii) for each sub-districts, we added up the results of the previous calculation, so that the calculation of the comparable accessibility from each sub-districts to the hospital was:

$$A^T = Z^{city} \times \frac{P^{city}}{P^T} + Z^{county} \times \frac{P^{county}}{P^T} \quad (3)$$

where A^T is the total accessibility for each sub-districts; P^T the total number of patients of all hospitals; Z^{city} and Z^{county} the standardised accessibility of city-level and county-level hospitals, respectively; and P^{city} and P^{county} the total number of patients of city-level and county-level hospitals, respectively. The accessibility scores for all hospitals, public hospitals and private hospitals in each sub-districts were graded into five classes with the breakpoints identified by the natural breaks in Figure 2 which minimize the sum of variance within the groups, which shows the spatial distribution of the accessibility between urban and suburban districts more clarity.

To reveal the contribution of private hospitals to the total accessibility score, we calculated the ratio of each sub-district's original accessibility score provided only by the private hospitals to the total accessibility score provided by all hospitals.

Spatial equality measurement

We choose the Gini coefficient derived from Lorenz curve, one of the most commonly used indices (Whitehead 2019), to measure the equality of hospital accessibility. The calculation, approximated according to Delbosc (2011) is:

$$G = 1 - \sum_{k=1}^{N} (X_k - X_{k-1})(Y_k + Y_{k-1}), \quad (4)$$

where N is the total number of sub-district; X_k the cumulative proportion of the population for sub-district k; and Y_k the cumulative proportion of the non-standardized accessibility for sub-district k after all sub-districts have been arranged according to the accessibility score from low to high. The Gini coefficient ranges from 0 to 1, where he former value means perfect equality and the latter perfect inequality. The Gini values were divided into 3 classes, 0 to 0.20, 0.20 to 0.50 and 0.50 to 1, which denote low, medium and high inequality, respectively. These are typical Gini coefficient thresholds, which can be relatively insensitive to the presence of outlier values at the top and the bottom of the distribution (Haidich, 2004; Jenkins, 1999; Weich *et al*., 2001). To illustrate the overall distributions, Lorenz curve (Delbosc 2011) displays the cumulative distribution of original accessibility scores across the population at the sub-district scale. It visualizes the proportion of the population of each sub-district's medical and health resource allocations along the abscissa, with the original accessibility scores by the sub-district along the ordinate.

Results

Spatial distribution of hospital accessibility and the contribution of private hospitals

The accessibility of each sub-district scores are presented in Table 2. Several main observations can be made. First, a significant disparity between urban and suburban districts can be observed, as the average accessibility score for all hospitals in urban districts is approximately twice that in the suburban districts, twice that for public hospitals and 1.5 times that for private hospitals. The variation in accessibility was found to be greater for public hospitals and less for private hospitals. This is because for all urban and suburban districts, the standard deviation (SD) of accessibility for public hospitals was calculated at 0.142, which is much greater than the SD for private hospitals. The difference in accessibility between public and private hospitals in urban districts was relatively small, with an overall SD of 0.085. However, the difference in accessibility between private and public hospitals was more obvious in suburban districts, with an SD of 0.126 for public hospitals compared to 0.033 for private hospitals. Secondly, the average score of accessibility for private hospitals was much smaller than that for public hospitals. While the ratio of private hospitals to public hospitals was approximately 0.0311 for all districts. This ratio in suburban districts (0.0328) was larger than that in the urban districts (0.0294). Thirdly, both minimal and the maximum accessibility scores appeared in suburban districts. The former value was 0 for private hospitals and 0.125 for public hospitals, and the latter was 0.359 for private hospitals and 0.696 for public hospitals. Figure 2 compares the spatial distributions of the accessibility scores for all hospitals, public hospitals and private hospitals. For the distributions of accessibility to all hospitals or to public hospitals, there was an obvious pattern of high scores in the centre decreasing outwards. For the distributions of accessibility to private hospitals, the scores were rather low in most areas but high for some suburban sub-districts.

The various ratios of sub-district accessibility score exclusively provided by the private hospitals to the total accessibility score provided by all hospitals are shown in Figure 3. There was a significant difference between the urban districts and the suburban districts. The average contribution in urban districts (2.8%) was larger than that in suburban districts (2.1%). However, the cases with more than 13% of contributions provided by private hospitals were all found in the suburban districts, and the maximum ratio was as high as 56%. The standard deviation of the contributions in suburban districts (5.762) was approximately twice that of suburban districts (2.543). These results above indicate that the private hospitals might prefer to be located in urban districts, but play a more important role among some suburban districts in spatial accessibility.

Spatial equality of hospital accessibility and the role of private hospitals

To understand the impact of private hospitals on the spatial equality of accessibility, the Lorenz curves and the corresponding Gini coefficients were applied (Figure 4). For the whole study area, the distribution of accessibility to public hospitals or to all hospitals was quite similar. The Gini coefficients were 0.1249 and 0.1246, respectively. However, the situations look different when comparing urban districts with suburban districts. The Gini coefficients of the urban districts were lower than those of the whole area and the value for all hospitals (0.03211) was slightly smaller than public hospitals (0.03391). Conversely, the distributions of geographical accessibility to public hospitals and to all hospitals in suburban districts were much less equal, with relatively high values of 0.1734 and 0.1914, respectively. The corresponding Lorenz curves of suburban districts indicated that 50% of the population shared only 35% of the opportunities offered by all hospitals, only 36% of the opportunities offered by public hospitals. Only a few suburban sub-districts (rather than the large majority) made a large gain in spatial accessibility owing to the operation of privation hospitals, thus enlarging the spatial inequality of accessibility within suburban districts.

Discussion and Conclusions

Although spatial equality is a widely accepted principle for health services from a public policy perspective (Glorioso and Subramanian 2014), few papers have quantitatively investigated the impacts of private hospitals on it. This paper proposed a methodology to fill this research gap. Based on the hierarchical 2SFCA method and Gini coefficients, the impacts of private hospitals on the spatial equality of hospital accessibility were measured by the comparison of the status quo scenario and the one without private hospitals.

We found a significant disparity between the accessibility of

Table 2. Average accessibility scores by type of hospitals.

District	Type of hospital	Average	Max	Min	SD
All	All	0.3710	0.705	0.125	0.1500
	Public hospital	0.3600	0.696	0.125	0.1420
	Private hospital	0.0112	0.359	0	0.0270
Urban	All	0.4830	0.675	0.286	0.0858
	Public hospital	0.4690	0.647	0.284	0.0816
	Private hospital	0.0138	0.071	0.001	0.0128
Suburban	All	0.2940	0.705	0.125	0.1360
	Public hospital	0.2850	0.696	0.125	0.1260
	Private hospital	0.0094	0.359	0	0.0333

SD= $\sqrt{\frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n-1}}$, where x_i is the standardised accessibility of each hospital, $\bar{x}$ is the average value of each category and n is the number of hospitals in this category.

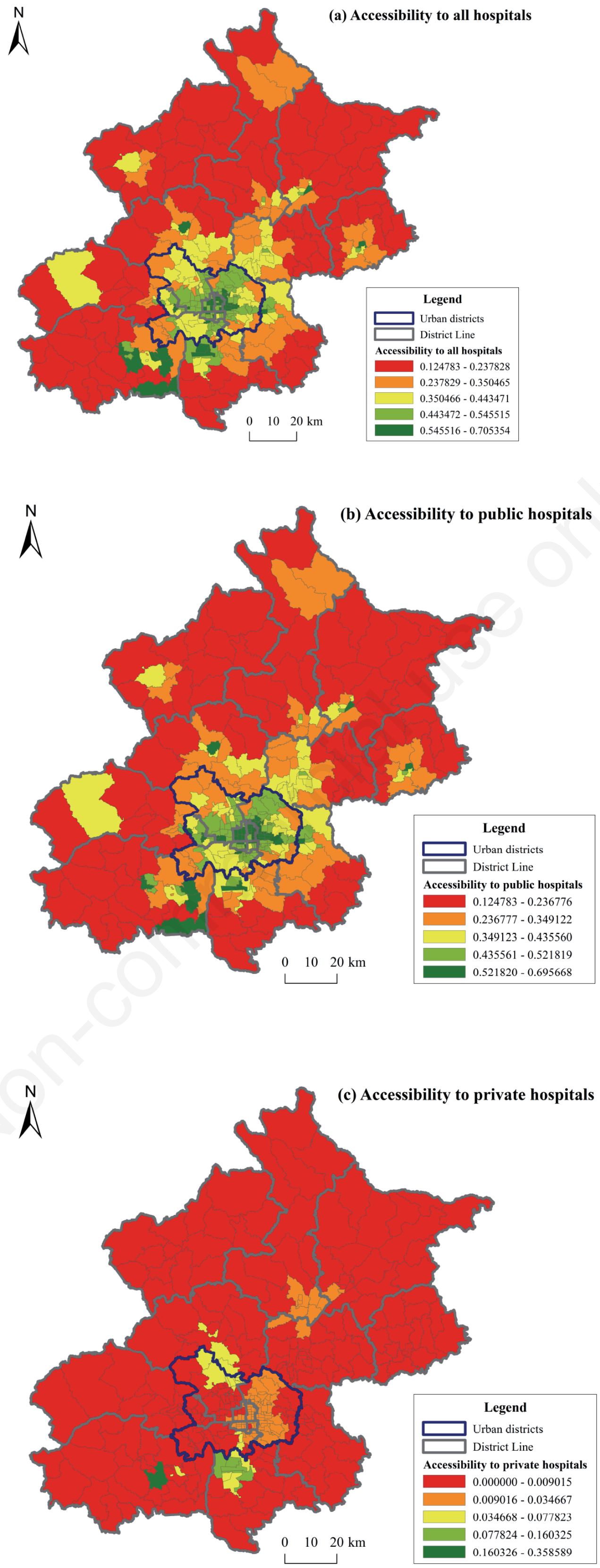

Figure 2. Normalised accessibility to all hospitals: a) accessibility to all hospitals; b) accessibility to public hospitals(c) accessibility to private hospitals.

healthcare in urban and suburban districts. Both minimal and the maximum accessibility scores, caused by the min-max normalization, appeared in suburban districts. This might be due to the relatively lower population density. In terms of accessibility to private and public hospitals, the average score for accessibility in private hospitals is much smaller. It is not surprising since the number of public hospitals is larger than private hospitals. In a similar vein, the similar spatial patterns of accessibility to all hospitals and to public hospitals again indicates that public hospitals had a dominant position in spatial accessibility On the other hand, all the large ratios of sub-district accessibility score exclusively provided by the private hospitals to the total accessibility score are found in some suburban districts, which indicates that the contributions of private hospitals there were quite different. In addition, accessibility to private hospitals were rather low in most areas but high for some suburban sub-districts. This result may be due to the presence of a large private hospital with the highest number of practicing doctors in sparsely populated suburban districts. As for the spatial equality, half of the population in suburban districts share approximately 1/3 of the opportunities offered by public hospitals, while this proportion falls by 1% when considering all hospitals instead. In contrast, there is a decrease of the Gini coefficient from 0.03391 to 0.03211 in urban districts when private hospitals are taken into account. This indicated that private hospitals have a small positive impact on spatial equality in urban districts, whereas they worsen it in suburban districts.

Our study revealed the role of the private hospitals in accessibility equality to health services, and we found that private hospitals provided geographically uneven accessibility and had double-sided effects on the spatial equality. Specifically, private hospitals improved spatial equality in urban districts but enlarged the spatial inequality in suburban districts. This suggests that the interrelationships (in terms of complementary or competition) between public and private hospitals diverge in urban and suburban spaces.

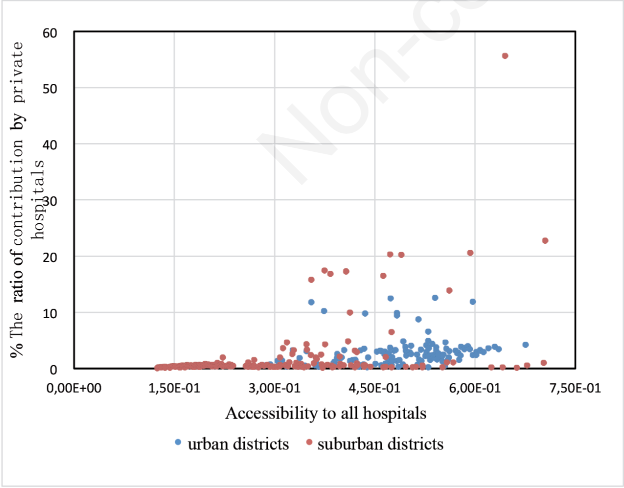

Figure 3. The contribution of private hospitals to total accessibility for each sub-district in Beijing. The X-axis represents the normalised accessibility values for each urban and suburban sub-district and the Y-axis the proportion of accessibility offered by private hospitals within the accessibility offered by all hospitals within that sub-district.

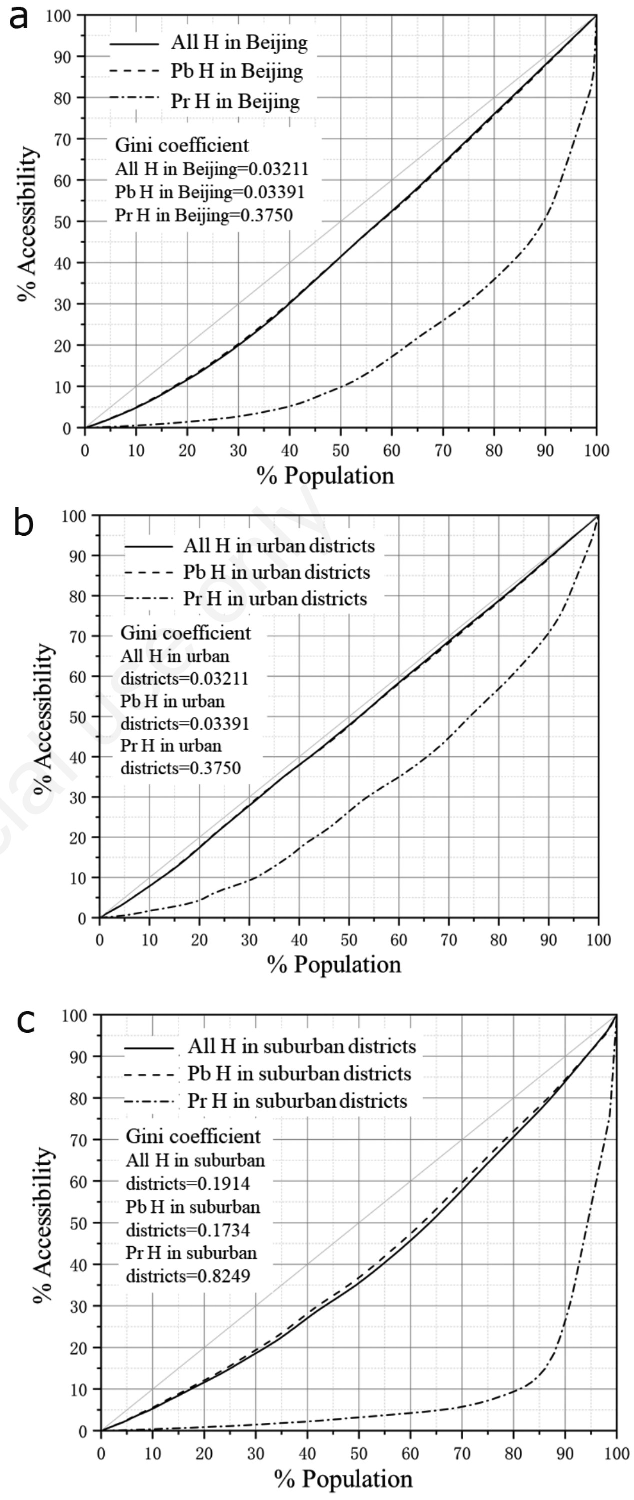

Figure 4. Lorenz curves and the corresponding Gini coefficients of accessibility to all hospitals. (All H) = all hospitals; (Pb H) = public hospitals; (Pr H) = private hospitals. a) Lorenz curves and the corresponding Gini coefficients of accessibility in Beijing; b) Lorenz curves and the corresponding Gini coefficients of accessibility in urban districts; c) Lorenz curves and the corresponding Gini coefficients of accessibility in suburban districts.

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Owing to the overall relatively large total amount and density of population in urban districts, the newly emerged private hospitals could fill the market niche in urban Beijing (without necessarily being located close to the existing public hospitals), this will result in their positive effects on the spatial healthcare equality in urban districts, and suggests that the location strategy of private hospitals in urban districts of Beijing diverge from that of public hospitals and slightly enhance the spatial equality. This is contrary to the overall finding that private and public hospitals co-locate with each other in Australian cities (Brown and Barnett, 2004), and might be related to the large-scale, high-density population in urban Beijing.

In contrast, the selection of location of private hospitals in suburban districts is restrained by the relatively small amount of total medical demand, which may lead to similar location strategy of covering a wider suburban population among both private and public hospitals (Pan *et al*. 2016). This in turn enhances the rivalry between public and private hospitals and rises spatial inequality in suburban districts. Also, private hospitals in suburban districts might need to gain the spill over benefit of human resources from being geographically proximate to high-level public hospitals. In comparison, the studies on Chinese cases by Pan *et al.* (2016) and Zhu *et al.* (2016) reported that private hospitals enlarged the inequality of geographical accessibility to primary hospitals in remote areas, which is consistent with our results in suburban districts though we focused on city-level and county-level hospitals. Without specific concerns on spatial equality, the policies of encouraging private hospitals in suburban districts, stated in the aforementioned "non-capital functional dispersal" policy, may not definitely promote the equality across the geographical space.

This study also has some limitations. First, it was restricted by data availability, the number of sub-districts and the standard free-floating travel time were used. However, the incorporation of travel time within sub-district and the variation of travel time across peak hours will influence the accessibility scores. Secondly, we only considered the spatial accessibility of hospitals in this paper. Nevertheless, some people's actual behaviours of seeking medical services still consider the minor differences in services and costs, thus may bias the accessibility value. Thirdly, since the market share is not the single factor in the location choice among private hospitals, future research should further explain the underlying complex rationale of location decisions among private hospitals both theoretically and empirically. In addition, the Gini coefficient only reflects the minimization of spatial differences, i.e. equality instead of equity, future studies should contribute to investigate the role of private hospitals in spatial equity. Lastly, given the increasing trend of privatization in the hospital system in China, future studies on other Chinese cities or regions are needed to examine the effects of private hospitals on spatial equality.

While hospital privatization is strongly promoted expecting an increase in overall efficiency, private hospitals may not promote spatial equality in urban and suburban districts in the same way. This side-effect might enlighten policy makers in more tailored future spatial planning, when promoting the overall accessibility of healthcare services. On the one hand, private hospitals in suburban districts should be given incentive to implement different location strategies. On the other hand, healthcare services provision in private sectors within urban Beijing should be further encouraged to fill the urban market niche where spatial accessibility is relatively poor.

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