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Spatial Vertical Equity in Public General Hospitals: Towards a Sustainable Healthcare System

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Abstract: The accessibility of public general hospitals is essential for the well-being of urban residents and for more equitable urban planning. However, public general hospitals and the associated spatial vertical equity are still not well known in developing countries. The objective of our study is to propose a theoretical framework to investigate the accessibility of public general hospitals and spatial vertical equity based on demographic dimensions. The main urban area of Wuhan is a suitable and representative example to explore this issue. An enhanced Gaussian two-step floating catchment area method, the Lorenz curve, and the Gini coefficient are employed in this study. The results indicate significant spatial heterogeneity in the accessibility of public general hospitals due to the dramatic transformation of urban planning and heterogeneous spatial structure. From a spatial vertical equity perspective, the spatial distribution of most public general hospitals does not take into account communities with a high proportion of minors and seniors. Compared with seniors, minors face more serious inequities in access to healthcare. The spatial distribution of only a few public general hospitals is prospective and inclined. Evidence-based policy implications are portrayed as a more equitable urban form and a sustainable healthcare system.

Keywords: public general hospitals; spatial equity; accessibility; enhanced Gaussian two-step floating catchment area method; sustainable urban planning

Citation: Yu, P.; Jian, I.Y.; Yung, E.H.K.; Chan, E.H.W.; Wong, M.S.; Chen, Y. Spatial Vertical Equity in Public General Hospitals: Towards a Sustainable Healthcare System. *Land* **2023**, *12*, 1498. https://doi.org/10.3390/land12081498

Academic Editor: Thomas Panagopoulos

Received: 21 June 2023
Revised: 18 July 2023
Accepted: 27 July 2023
Published: 28 July 2023

1. Introduction

Public services are basic services that are closely related to health, education, culture, and sport, and they fall under the category of social nature services [1]. Numerous large-scale public facilities, especially large public general hospitals, have been located in densely populated areas in numerous metropolises [2]. Public general hospitals are public service facilities that have great relevance to the residents' life quality, and their layout and configuration are directly related to the residents' well-being [3]. However, current public general hospitals are struggling to meet the increasing demand of the population in terms of both quantity and quality, especially in developing countries. The inadequate supply and unreasonable allocation of public general hospitals within cities exacerbate social inequity [4,5]. In the context of the Sustainable Development Goals, ensuring equitable access to public general hospital services for residents with different demographic characteristics is an essential topic in the field of public service research [6,7]. Therefore, in light of rapid urbanisation [8], it is necessary to examine the spatial distribution of public general hospitals in order to inform future investment in healthcare facilities and contribute to human well-being.

Previous studies have focused on distribution efficiency to assess public general hospital layouts comprehensively and have developed a location allocation model to optimise spatial layouts [9,10]. For example, a study from Shenzhen, China, calculated the accessibility of high-level hospitals and analysed their spatial variation to ultimately identify underserved areas [11]. Another study explored the spatio-temporal distribution characteristics of nighttime hospitals and calculated their accessibility based on population density [12]. However, such studies have only looked at a single class of public service facility and have given less attention to evaluating the level of equity in different classes of public general hospitals. In addition, previous studies have focused on spatial units at the provincial, municipal, and street scales without sufficient consideration of more refined spatial units such as communities, thus affecting the accuracy of the evaluation results.

Commonly employed methods for accessibility measurements include the proportional method [13], kernel density estimation method [14], nearest neighbour method [6], two-step floating catchment area method [15], potential model [16], and others. Among them, the two-step floating catchment area method integrates supply and demand conditions and distance factors and is widely used in the evaluation of many facilities such as education [17], healthcare [18,19], and open spaces [20,21]. In subsequent research, the two-step floating catchment area method has been improved, involving four categories. The first category focuses on the distance-decay function and includes enhanced [22], gravity-style [23], kernel-density-style [24], and Gaussian-style models [25]. The second category concentrates on the delimitation of catchment areas and includes variable [26], dynamic [27], multi-catchment sizes [28], and nearest-neighbour models [29]. The third category emphasises the competition among demand nodes or supply nodes, and includes modified [30] and Huff models [9]. The fourth category focuses on the travel means of the demand side and includes multi-mode [31] and commuter models [32].

Spatial equity is the product of the Spatial Turn and New Social Movements and is an essential criterion for the development of public services [33]. Equity research in public general hospitals has undergone a transition from territorial equity to spatial equity. Kain first introduced the concept of ‘spatial mismatch’, and subsequent studies have looked at the allocation of public services in disadvantaged areas, i.e., whether public services are equitably distributed across regions, income, ethnicity, and age [34]. Due to differences in regions, scales, and measurements, there is no unified outcome, i.e., ‘unpatterned inequality’ [35]. Previous studies have mostly used questionnaires and semi-structured interviews to explore individual residents’ needs and satisfaction with public service facilities in order to determine the deprivation level of public service facilities. Insufficient attention has been paid to matching residents of different social attributes with public service facilities. Only limited literature has focused on examining their interactions with a spatial equity lens, especially in developing countries [36]. The spatial equity lens was initially described as an assessment of tax reform, including horizontal and vertical equity lenses [37,38]. The horizontal equity lens is widely described as a minimum rule of fairness that calls for equal treatment of all populations [39]. The vertical equity lens requires an appropriate differentiation pattern among those unequal groups, such as minors and seniors [40,41]. Applying the spatial vertical equity lens, space creates heterogeneity by embedding social divisions in public general hospitals, which results in space allocation that is not conducive to minors, seniors, and other vulnerable groups [42,43].

With the above background and the aspiration to fill the identified literature gap, the purpose of this paper is to assess the accessibility of public general hospitals using a spatial vertical equity lens. The main urban area of Wuhan, China, is selected as the case study. More specifically, this research attempts to answer three interrelated questions: (i) How to assess the accessibility of public general hospitals? (ii) How to visualise and map spatial vertical equity gaps based on age groups? and (iii) How to comprehensively identify the characteristics of spatial vertical equity? By gaining a comprehensive understanding of the evidence-based policy implications, this study aims to contribute to a more equitable and sustainable healthcare system. The remainder of this paper is structured as follows: the study area, data collection, and methods are explained in Section 2. The findings and discussions are presented in Sections 3 and 4. The conclusions are provided in Section 5.

2. Study Area

Wuhan is not only one of the largest cities in China but also the capital of Hubei Province. As of 2021, Wuhan has 13 districts with a total area of 8569.15 km^2 and a residential population of 1364.89 million. In this paper, the study area is the main urban area of Wuhan, which is demarcated in the Wuhan Urban Master Plan (2017–2035). This area is demarcated by the third ring road (length: 91 km) of Wuhan. It comprises seven administrative districts, namely Jianghan, Qiaokou, Jiang'an, Hanyang, Wuchang, Hongshan, and Qingshan (Figure 1). The area within the second ring road (length: 48 km) represents the urban centre of Wuhan. Within the first ring road (length: 28 km) is the old urban area.

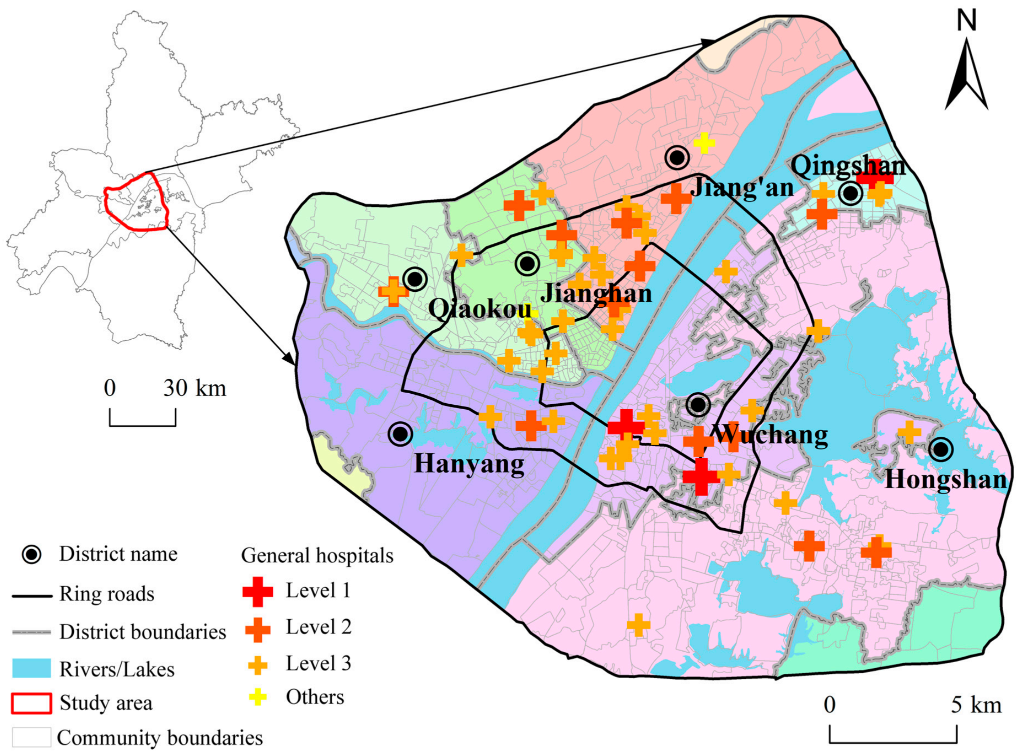

Figure 1. Study area: the main urban area of Wuhan.

3. Methodology

3.1. Overall Methodological Framework

The overall methodological framework includes three main components (Figure 2). First, we quantify the accessibility of public general hospitals by means of the enhanced Gaussian two-step floating catchment area method. Second, we map spatial vertical equity gaps based on age groups through the spatial matching method. Third, we elaborate in detail on the characteristics of spatial vertical equity via the Lorenz curve and Gini coefficient.

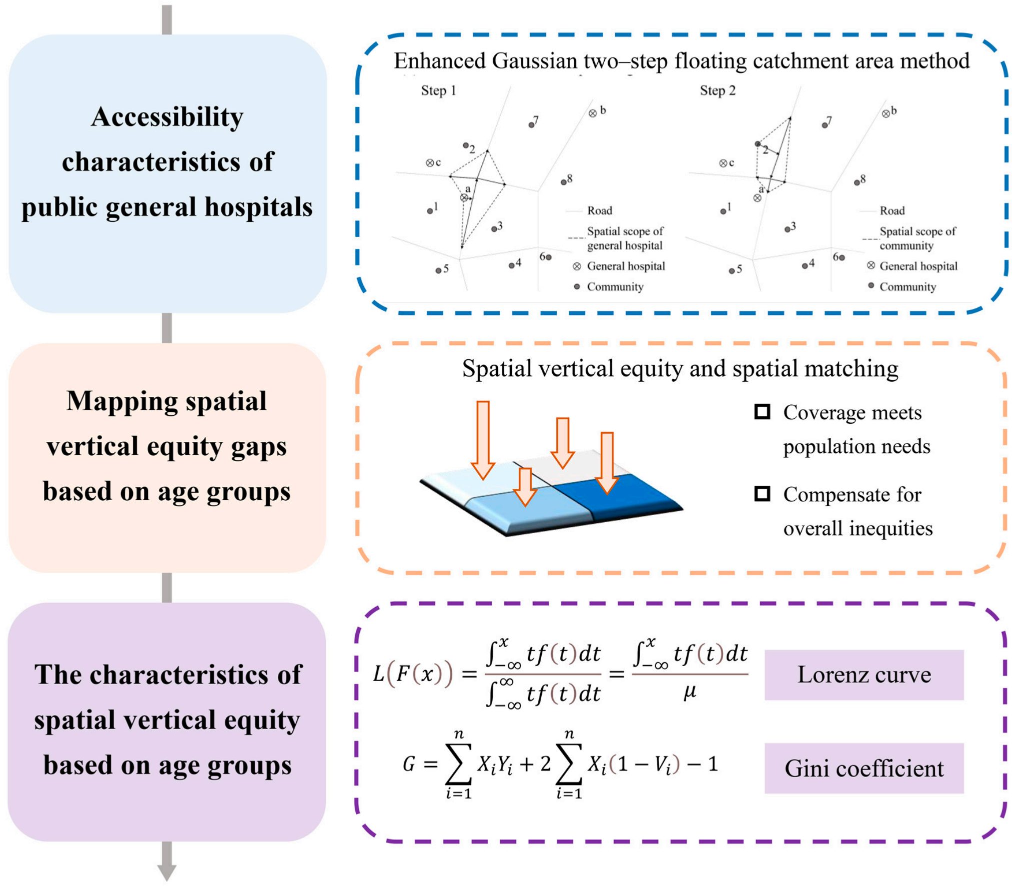

Figure 2. Overall methodological framework.

3.2. Data Sources and Data Descriptions

Multi-source data were integrated and utilised in our study. The data on public general hospitals was obtained from the Wuhan Health Statistical Yearbook 2020, which includes 55 public general hospitals in the main urban area of Wuhan. Here, public general hospitals are government-supported, not-for-profit general hospitals, which are classified as tertiary, secondary, primary, and other public general hospitals according to the Classification of Chinese hospitals. The road data was sourced from OpenStreetMap (http://www.openstreetmap.org, accessed on 1 December 2020). Community population data from the Wuhan Natural Resources and Planning Bureau (http://whonemap.zrzyhgh.wuhan.gov.cn:8020, accessed on 1 December 2020) was employed to inform the demographic dimensions. Housing price data for 2020 from Lianjia (http://lianjia.com, accessed on 1 December 2020) was used to characterise the economic dimension.

3.3. Enhanced Gaussian Two-Step Floating Catchment Area Method

The generalised two-step floating catchment area (2SFCA) method is a special case of the gravity model, first proposed by Radke and Mu [44] and later modified by Luo and Wang [45]. The 2SFCA method is based on demand and supply sites, and the mobile search is performed twice. It can simulate the actual situation as accurately as possible by limiting the threshold value. In recent years, it has been widely employed in the evaluation of the accessibility of urban public service facilities. However, the traditional 2SFCA method fails to consider the effect of distance attenuation on the radiation range, resulting in a uniform distribution of the radiation range at any location in the spatial domain [46]. Therefore, future research can overcome these shortcomings by introducing a distance decay function.

Based on this, Dai proposed to use the Gaussian function as the distance decay function within the search radius in the 2SFCA method, and this improved method is the Gaussian two-step floating catchment area (Gaussian 2SFCA) method [47]. The Gaussian 2SFCA method uses Euclidean linear distance as the search radius, but this method overestimates the accessibility of public general hospitals (Figure 3a). Therefore, this study introduces road network data to improve the Gaussian 2SFCA method, which is an enhanced Gaussian two-step floating catchment area method (Figure 3b).

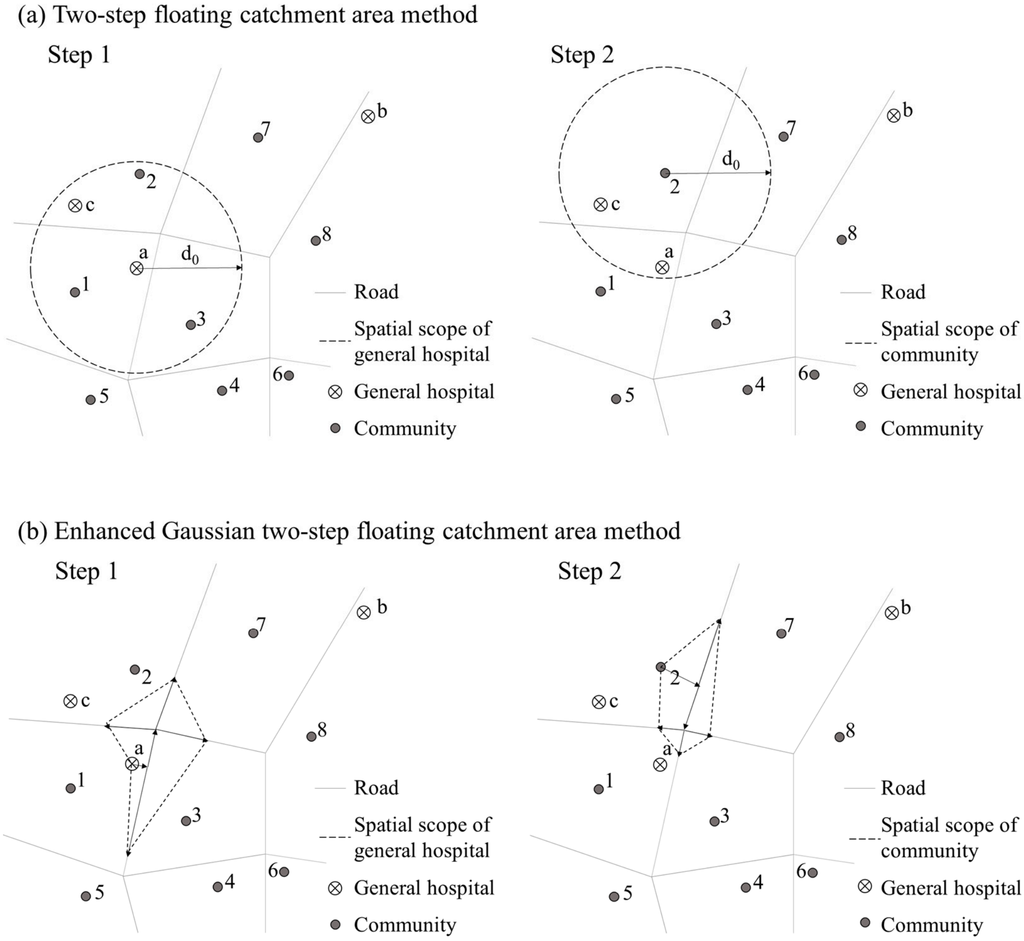

Figure 3. Diagram of the two calculation methods: two-step floating catchment area (**a**) and enhanced Gaussian two-step floating catchment area method (**b**).

(i) The spatial scope is given according to the different classes of public general hospitals. The population of each community within the spatial scope is weighted using the Gaussian equation. The weighted population is also summed to obtain the number of all demands on the public general hospitals, i.e., the resident population of the community. The size of the public general hospitals is divided by the number of demands to obtain the supply-demand ratio.

$$R_j = \frac{S_j}{\sum_{k \in \{d_{ij} \le d_0\}} D_k W_r} \quad (1)$$

where R_j is the ratio of supply and demand. S_j is the scale of a public general hospital j, expressed in the number of beds. d_{ij} is the distance from the community i to the public general hospital j. d_0 is the distance of the spatial scope. D_k is the resident population of the community k within the spatial scope ($d_{ij} \le d_0$) of a public general hospital j is the Gaussian equation considering space friction, and the calculation method is as follows:

$$W_r = \begin{cases} e^{-\frac{1}{2}\times\left(\frac{d_{kj}}{d_0}\right)} - e^{-\left(\frac{1}{2}\right)} \Big/ 1 - e^{-\left(\frac{1}{2}\right)}, & \text{if } d_{kj} \le d_0 \\ 0, & \text{if } d_{kj} > d_0 \end{cases} \quad (2)$$

where e is a constant. d_{kj} is the spatial distance from the community k to the public general hospital j.

(ii) Given another spatial scope for the unit, the supply and demand ratios for each public general hospital within the spatial scope are weighted using a Gaussian equation, and the weighted supply and demand ratios are summed. The accessibility of public general hospitals within each community is determined. The greater the spatial accessibility, the less obstruction there is to public general hospitals for inhabitants within the scope. The smaller the accessibility difference in different spatial domains, the more balanced the spatial layout of public general hospitals.

$$A_i = \sum\nolimits_{k\in\{d_{ij}\le d_0\}} R_j W_r \quad (3)$$

where A_i is the accessibility of public general hospitals at all levels within the community i.

Specifically, the OD cost matrix analysis is established using the actual road network data. The shortest walking time from each community to the public general hospital is calculated to obtain an average value of 0.4 h. Considering the average human walking speed of 5 km/h, a spatial scope of 2 km is taken. The centre of mass for each community is extracted, and subsequently, the distance between the public general hospital and the community's centre of mass based on the actual road network is calculated. This distance is then utilised to calculate the demand for public general hospitals by applying Gaussian equation weighting, summing, and calculating the supply/demand ratio by the community's centre of mass. In addition, the public general hospitals within the spatial scope of each community's centre of mass are extracted, and the distance between the community and the extracted public general hospitals is calculated based on the actual road network. Subsequently, community demand weighted based on Gaussian equations was measured to obtain the accessibility of the public general hospitals by summing up the proportion of supply and demand according to the centre of mass of the community.

3.4. Lorenz Curve

The initial purpose of the Lorenz curve was to look at the distributional equity of the national economy; that is, the curve is formed by the accumulated income of the corresponding percentage of the population as the level of wealth increases [48]. The Lorenz curve allows the analysis of the distribution of public general hospitals corresponding to different age groups and provides a measure of spatial vertical equity [16,29]. The horizontal axis is the population proportion, and the vertical axis is the cumulative proportion of the accessibility of the public general hospitals. The 45° line is the absolute mean line, on which all levels of the population receive exactly equal values for the spatial equity indicator. The closer the public general hospital distribution curve is to the absolute mean line, the closer the spatial distribution is to equity. In addition, according to the age standards of the Law of the People's Republic of China on the Protection of Minors and the Law on the Protection of Rights and Interests of the elderly, minors (under 18 years old), young and middle-aged people (18–60 years old), and seniors (over 60 years old) are classified.

3.5. Gini Coefficient

Initially, the Gini coefficient was introduced to quantify the concept of income inequality and evaluate the income disparity in a specific area [49]. Furthermore, the Gini coefficient could be employed to evaluate the spatial equity of public general hospital distribution [50,51]. The Gini coefficient ranges from 0 to 1. The closer the Gini coefficient is to 0, the more equitable the distribution of public general hospitals among the population.

$$G = \sum_{i=1}^{n} X_i Y_i + 2\sum_{i=1}^{n} X_i (1 - V_i) - 1 \quad (4)$$

where G represents the Gini coefficient. n is the number of communities. X_i stands for the ratio of the population of the ith community to the total population. Y_i denotes the ratio of the public general hospital accessibility value of the ith community to the total value. V_i indicates the cumulative value of the ith community's public general hospital accessibility, sorted from smallest to largest.

4. Findings

4.1. Accessibility Characteristics of Public General Hospitals

The supply and distribution of public general hospitals significantly affect the level of accessibility (Figure 4). In terms of grade, tertiary public general hospitals account for a larger proportion, mainly concentrated in Wuchang, Jiang'an, and Qiaokou districts. Wuchang district has the highest number of public general hospitals, at 14. Jiang'an and Qiaokou districts are the next in number. In terms of spatial distribution, public general hospitals are mainly concentrated within the second ring road, with large concentrations in the northern part of the Yellow Crane Tower Scenic Zone, Wuguang Commercial Area, Wuhan Tiandi Commercial Area, and Qingshan Industrial District. There is a relative lack of public general hospitals between the second and third rings, especially in the Hanyang and Hongshan districts. Overall, the public general hospitals within the second ring road tend to be saturated, which may lead to over-concentration of patients, over-staffing, increased management difficulties, declining healthcare circumstances, and inefficiencies.

Figure 4. Statistics on the number of public general hospitals in each district.

The accessibility evaluation results of public general hospitals are divided into lower, lower-middle, middle, upper-middle, and upper classes (Figure 5). Overall, the accessibility values of public general hospitals in the main urban area of Wuhan show higher values on the west bank of the Yangtze River and lower values on the east bank. There are significant variations in the accessibility of communities to public general hospitals. The faster the commercial development, the higher the accessibility of the area, the more abundant the public general hospitals, and the more convenient the road network. In terms of administrative districts, accessibility is at the middle, upper-middle, and upper levels, which are mainly concentrated in Jianghan, Jiang'an, Qiaokou, and Wuchang districts. The accessibility areas in Hongshan and Hanyang districts are unevenly distributed, with lower and lower-middle accessibility areas, which is nearly consistent with the distribution characteristics of public general hospitals. In terms of clusters, the high-value areas beyond the second ring road form four clusters of varying sizes, one on the west bank of the Yangtze River and three on the east bank of the Yangtze River. The cluster on the west bank of the Yangtze is close to the Central Activity Area and extends around Han River Bay. In terms of the ring road, accessibility values tend to decrease from the centre to the periphery of the ring road. The areas with upper-middle-class and upper-class accessibility are mainly concentrated around the second ring road. The west bank and east bank of the Yangtze River show a uniform and fragmented distribution, respectively.

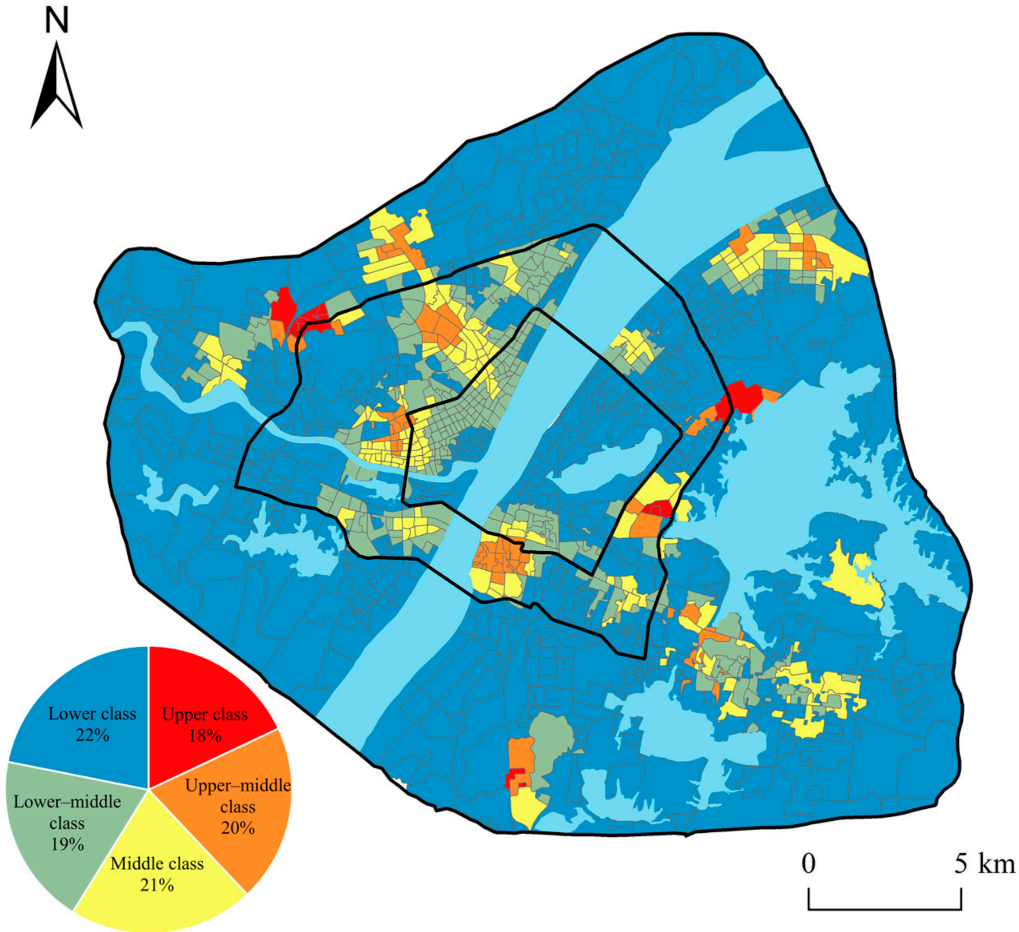

Figure 5. Spatial distribution of accessibility based on the enhanced Gaussian two-step floating catchment area method and the five classes and their percentage of accessibility.

4.2. Mapping Spatial Vertical Equity Gaps Based on Age Groups

The allocation of public service facilities should correspond to the density distribution of the urban residential population. That is, the scale and layout of public service facilities correspond to the number and distribution of the residential population; if they do not correspond to each other, it is an imbalance or a non-equitable relationship. The community is the basic unit of daily life, and when it contains a large number of minors and seniors, the configuration and layout of the public general hospital should take into account the high incidence of these diseases so that they can be treated and cared for nearby in case of emergency. High accessibility not only safeguards the rights of minors to health care but also provides a powerful guarantee of healthy living for seniors. Thus, the spatial equity of minors (<18 years old) and seniors (>60 years old) was evaluated at the community level based on population density and the spatial distribution of public general hospital accessibility. Figure 6 shows that the high-density communities for minors and seniors are concentrated within the second ring road, particularly in the Yangchunhu sub-centre and Luxiang sub-centre near the Hankou Historical District and Shahu Park. Compared to the second ring road, the population density near the third ring road is lower.

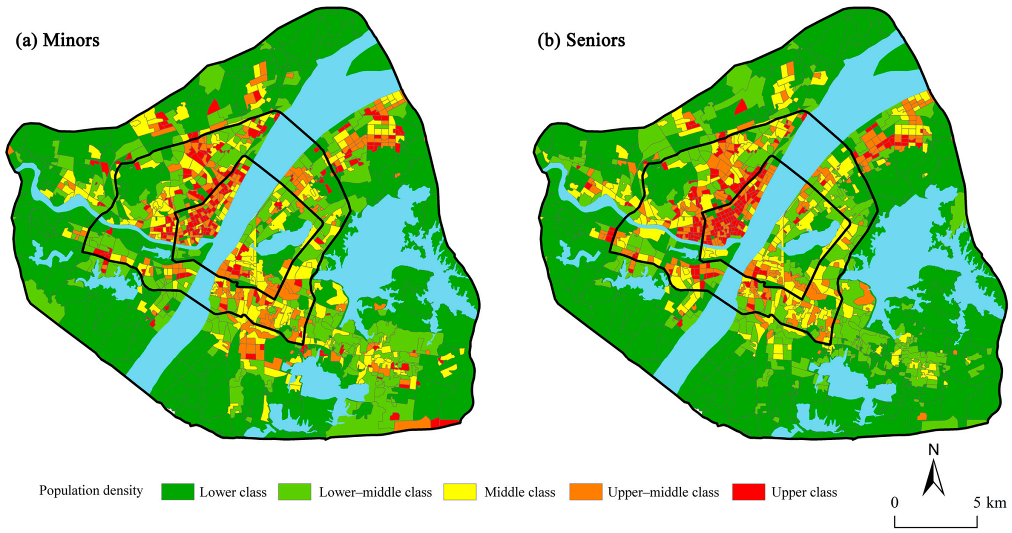

Figure 6. Spatial distribution density of different populations in the main urban area of Wuhan: (**a**) minors and (**b**) seniors.

Overlaying the spatial pattern of population density and accessibility of public general hospitals, it has been found that the population density of minors and seniors generally corresponds to the level of accessibility in the Yellow Crane Tower Scenic Zone, Wuguang Commercial Area, Jianghan Road Commercial Area, and Linjiaohu Wanda Commercial Area (Figure 7). The Hankou Historical District, where these three shopping areas are located, is within the old urban area. The Hankou Historical District has been developed over a long period, and with a dense population and compact hospital layouts, these areas are generally able to meet the healthcare needs of both groups. The Yellow Crane Tower Scenic Zone is surrounded by convenient road networks and a large number of public general hospitals, especially tertiary hospitals. Around Shahu Park and the western side of South Lake, both show a noticeable phenomenon of low accessibility and high population density. This characteristic is more evident in communities with concentrations of minors than in those with seniors. This area is clustered with universities such as the Wuhan University of Technology and the Wuhan University of Science and Technology, with a large number of young and middle-aged staff and their children living nearby. However, there are not enough public general hospitals in the area due to the barrier of lakes, and there is a mismatch between accessibility and densities among the two populations. The surroundings of the Luxiang sub-centre and the Qingshan Industrial District are characterised by high accessibility and low population density. The Luxiang sub–centre, as the core of the Optics Valley, attracts a concentration of universities, scientific and technological resources, and a population structure that is more inclined towards middle-aged and young people. With the rapid development of the economy and technology in this area, the availability and accessibility of public general hospitals provide some convenience for young people of childbearing age, minors, and seniors. Similarly, the Qingshan Industrial District is supported by a number of enterprises and institutions, with public general hospitals located nearby to ensure adequate healthcare services for minors and seniors. However, overall, there are still relatively few forward-looking and tendentious public general hospitals in the study area.

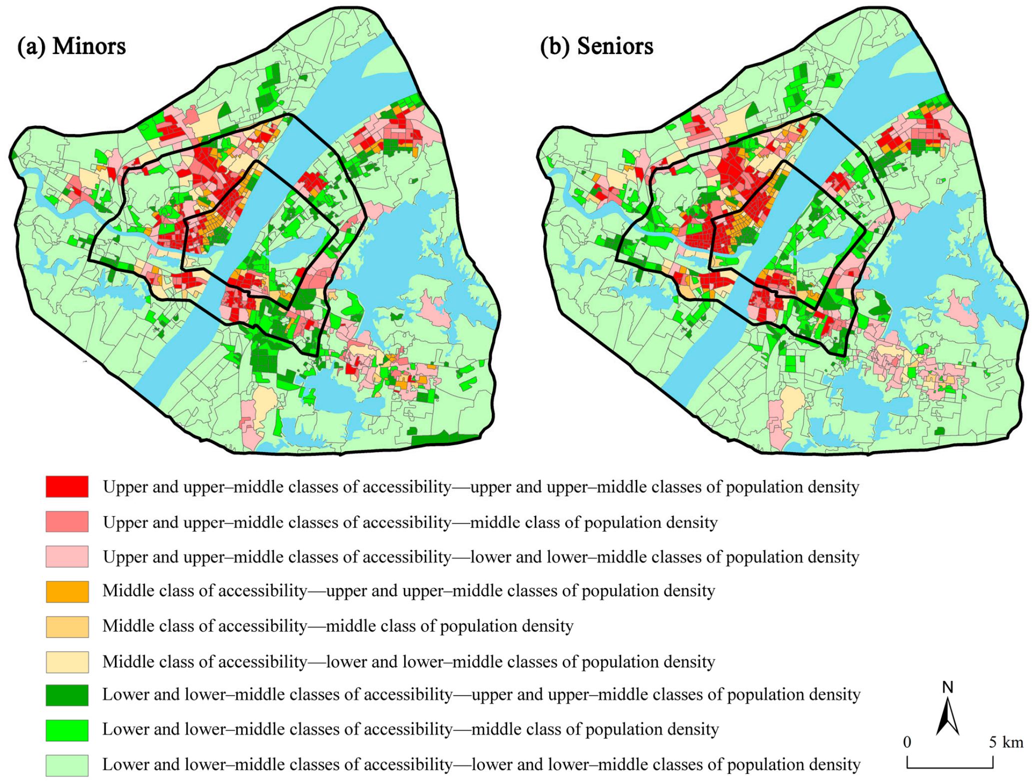

Figure 7. Spatial matching of accessibility and population density of public general hospitals in the main urban area of Wuhan: (**a**) minors and (**b**) seniors.

4.3. The Characteristics of Spatial Vertical Equity Based on Age Groups

As shown in Figure 8, the Lorenz curve and the Gini coefficient were applied to the spatial vertical equity evaluation of public general hospitals. There are significant differences in the allocation of public general hospitals among various age groups. The Gini coefficient between the accessibility of public general hospitals and the distribution of minors is 0.72 in the study area, which is slightly larger than that of seniors (GC = 0.64), suggesting that inequalities in public general hospitals are particularly significant for minors. Overall, the allocation of public general hospitals in the main urban area of Wuhan is relatively unbalanced, and there is a certain spatial mismatch with the distribution of population resources.

The distribution of most public general hospitals has no obvious bias towards communities with a high proportion of minors or communities with a high proportion of seniors. We have compiled data on the proportion of the population with different age structures in relation to accessibility (Table 1). The results show that communities with low accessibility represent 61.2% and 61.0% of the high proportion of communities in both groups, respectively, and these proportions are higher than those corresponding to all communities. In contrast, the proportion of communities with high accessibility is 23.5% and 22.5% for both groups, which is lower than the overall level. These suggest that the spatial distribution of public general hospitals does not have a greater bias towards the two groups. Minors and seniors are groups that are more sensitive to public general hospitals, and the high proportion of both groups in the community means that there is a greater demand for access to healthcare. Some public general hospitals tend to cluster near urban centres or communities with high overall population density, ignoring the overall age composition of the community population. In particular, communities with higher than average proportions of both minors and seniors have a high demand for healthcare, resulting in longer wait times to reach public general hospitals, such as those located near South Lake. In addition, sudden strokes caused by underlying chronic diseases such as hypertension and diabetes have become one of the top five causes of premature death in China, especially among seniors. Due to mobility constraints, minors and seniors prefer to seek medical attention at nearby public general hospitals. If the number of public general hospitals in the vicinity of the communities is in short supply and of a lower grade, it will be challenging to meet the hospitalisation needs of seniors in times of routine care or sudden illness.

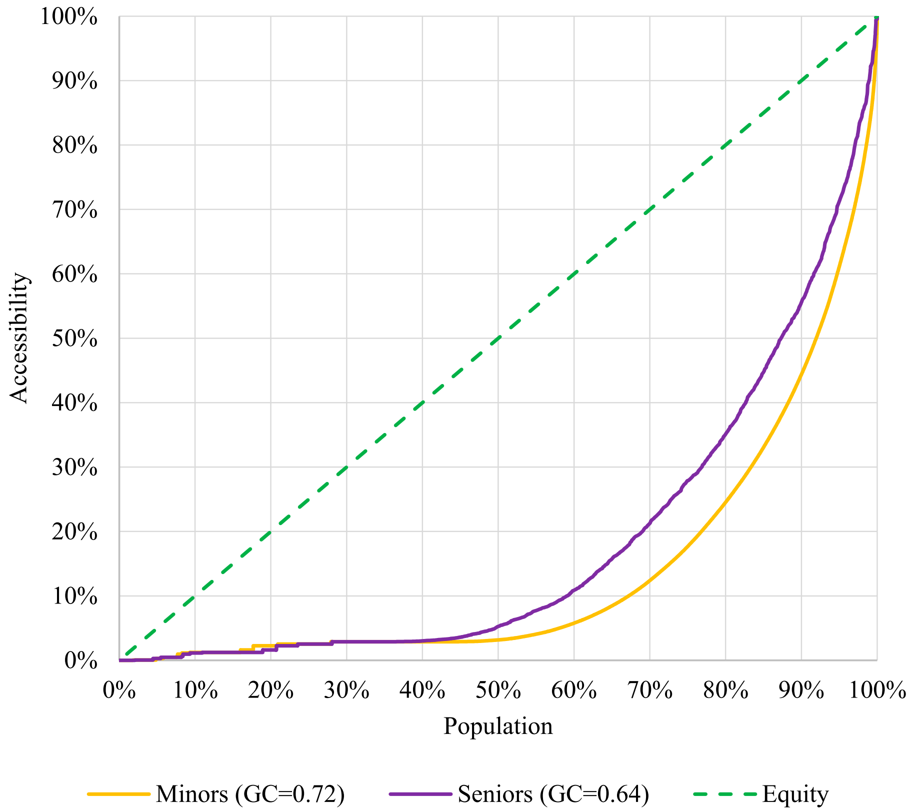

Figure 8. Lorenz curve and Gini coefficient of various age groups and accessibility of public general hospitals in the main urban area of Wuhan.

Table 1. Statistics on population proportion and accessibility of different age structures in the main urban area of Wuhan.

Interaction Relationship	All Communities	Communities with a High Proportion of Minors	Communities with a High Proportion of Seniors
Upper and upper-middle classes of accessibility	31.7%	23.5%	22.5%
Middle class of accessibility	15.6%	15.3%	16.5%
Lower and lower-middle classes of accessibility	52.7%	61.2%	61.0%

Minors face serious inequities compared to seniors. According to statistics, communities with a high proportion of minors and seniors account for 32.8% and 25.9% of all communities, respectively. To some extent, it indicates a noticeable lack of attention to minors in the configuration of public general hospitals. Communities with a high proportion of minors will need to be taken into account in the planning of future healthcare provisions. Along with the rapid urban expansion, a large number of real estate projects have settled near the third ring road, while housing prices in urban centres have also risen. Under the pressure of high housing prices, young people of childbearing age and the migrant population often choose to settle near the third ring road, where public services are less well-supported and less accessible. Seniors generally prefer to live in older urban areas where public general hospitals are well equipped to meet their healthcare needs. In capitalization-driven urban space production, public general hospitals are clustered near commercial areas, the spatial distribution pattern is gradually alienated, and the disadvantaged groups, especially minors, tend to be crowded out by capital. Both minors and seniors need constant attention.

5. Discussion

5.1. Implications for a Sustainable Healthcare System

In terms of age, our study not only validates previous findings on spatial vertical equity in access to public general hospitals for disadvantaged age groups but also contributes further by providing a new finding that while both minors and seniors are susceptible to health problems [38], minors face more disadvantage and inequities in accessing public general hospitals [52]. This finding aligns with the UNICEF Report, which states that few countries accord each child the right to feel safe and secure in the built environment and to have access to basic services [53].

The findings provide the following implications for a sustainable healthcare system: First, it is necessary to make appropriate provisions for public general hospitals in urban planning, taking into account the dynamic changes in the urban population. For communities with low accessibility and high population density, it is suggested that the urban master plan appropriately direct the relocation of some services from areas with an excessive concentration of public general hospitals to the vicinity of these communities. For communities with high accessibility, the number of beds and medical staff could be increased appropriately. Consideration may be given to upgrading secondary public general hospitals to tertiary public general hospitals under certain circumstances. Second, it is recommended that the planning and layout of public general hospitals be integrated with transport planning. Tertiary public general hospitals are more densely distributed within the second ring road, especially in areas with well-developed road networks and rapid economic development. In contrast, some areas close to the third ring road have a sparser transport road network, which has a significant impact on residents' access to health care. For public general hospitals with higher grades, more beds, and better medical services, it is recommended to improve the linkage between the various public general hospitals. Third, urban policymakers and planners urgently need to increase attention to access to healthcare for vulnerable groups. It is essential to investigate and predict the travel mode, medical tendency, physical health status, and disease incidence of vulnerable groups such as minors and seniors. Fourth, it is suggested that the rational layout of public general hospitals should be guided by policies to improve healthcare service quality. Strengthening policy formulation and legislative protection for healthcare services, improving mechanisms for the construction and management of public general hospitals, and strictly enforcing site planning and construction standards for public general hospitals. Tertiary public general hospitals could be adopted as growth poles to drive the development of primary and secondary public general hospitals. This approach could relieve the pressure on tertiary public general hospitals within the second ring road and establish a rational and sustainable urban healthcare system.

5.2. Contributions and Limitations

Our work contributes to pushing the boundaries of public general hospital accessibility and the associated spatial vertical equity, both theoretically and methodologically. Theoretically, we propose a theoretical framework that emphasises an interdisciplinary and integrated approach to investigating the relatively uneven relationship between the distribution of public general hospitals and the population within the context of spatial vertical equity. With this integrated approach, evidence of an inequitable distribution of public general hospitals based on demographic dimensions is identified. The vulnerability of minors and seniors, who are more excluded by society, is effectively revealed. In comparison to seniors, minors face more severe inequities in access to healthcare. Methodologically, this study constructs a more practical, systematic, and intelligent approach based on walking movement, including an enhanced Gaussian two-step floating catchment area method, the Lorenz curve, and the Gini coefficient at the community scale. In contrast to previous relevant studies that needed many resources, labour, and time to scale up, our approach relies solely on publicly available data. Considering that similar data could be easily collected, this approach is not limited to our case study but also introduces a new opportunity for research in other cities around the world. As such, our procedure allows for universal knowledge to be generated, which could serve as a baseline for subsequent studies.

Although our study addressed some investigation issues related to spatial vertical equity in public general hospitals, there is still much room for further reflection and improvement. First, some disadvantaged groups have not been adequately considered due to data limitations, and future research could combine questionnaires, interviews, and other data for a more comprehensive assessment. Second, future research could examine the level of spatial equity change over time on a time scale. Third, it is of urgent importance that the clustering effect and spatial equity for different types and levels of public services be considered in future research. In the future, it will be possible to understand more thoroughly how the accessibility of public general hospitals and related spatial vertical equity affect the well-being of urban residents by considering social differences, time scales, and related policies according to different age groups.

6. Conclusions

This study introduces a new framework to examine the accessibility of public general hospitals and spatial vertical equity based on demographic dimensions. Following this framework, this study employs an enhanced Gaussian two-step floating catchment area method, the Lorenz curve, and the Gini coefficient. The main urban area of Wuhan, China, is chosen as a suitable and representative case study. The key conclusions obtained are as follows:

The supply and distribution of public general hospitals obviously affect the level of accessibility. The accessibility values of public general hospitals in the main urban area of Wuhan show higher values on the west bank of the Yangtze River and lower values on the east bank. The distribution of public general hospitals is relatively unbalanced, and there is a certain spatial mismatch with the distribution of population resources. There are still relatively few prospective and tendentious public general hospitals in the study area. The distribution of most public general hospitals does not demonstrate a clear preference for communities with a high proportion of minors or seniors. In an urban landscape driven by capitalization, public general hospitals tend to cluster around commercial areas, leading to gradual spatial segregation and the potential marginalisation of disadvantaged groups, especially minors. Both minors and seniors require sustained attention. These findings provide practical references for the development of a sustainable healthcare system.

Author Contributions: Conceptualisation, P.Y. and Y.C.; methodology, P.Y., E.H.K.Y. and E.H.W.C.; software, P.Y.; validation, P.Y. and Y.C.; formal analysis, P.Y. and I.Y.J.; investigation, P.Y. and M.S.W.; resources, P.Y.; data curation, Y.C.; writing—original draft preparation, P.Y.; writing—review and editing, and I.Y.J., E.H.K.Y., E.H.W.C., M.S.W. and Y.C.; visualisation, P.Y. and I.Y.J.; supervision, E.H.W.C. and E.H.K.Y.; project administration, M.S.W. and Y.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the General Research Fund (Grant No. 15603920) and the Collaborative Research Fund (Grant No. C5062-21GF) from the Research Grants Council, Hong Kong, China.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

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