# Equity of Health Resource in Guangxi County: Evidence from an Ethnic Minority Region in Western China

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**Abstract.** Background: Equity and efficiency in the distribution of health resources are the fundamental principles defended by the World Health Organization. This study aims to evaluate the fairness of health resources in Guangxi County, an undeveloped ethnic minority region in Western China. Methods: The Lorenz curve and Gini coefficient were calculated to evaluate equity in the population, geographic and economic dimensions. The Theil index was used to measure the fairness of the health resource allocation between the three economic regions. Results: From 2016 to 2020, the total amount of health resources in Guangxi County has increased steadily, and there has been a relatively fair distribution of health resources. The degree of equity according to the geographical area is lower than the population. The equity of health technicians was better than that of hospitals. Conclusion: Distinct regional disparities has existed in the distribution of health resources in Guangxi County, which is mainly reflected in the geographic distribution of health resources. To increase the equity of health resources, the government should comprehensively consider the geographical and demographic factors together in different regions.

**Keywords:** health resource · Equity · County · Western China · ethnic minority

## 1 Introduction

China has the largest number of Primary healthcare institutions (PHCIs)in the world and has developed a primary healthcare system covering both urban and rural areas [1, 2]. Allocating health resources is a global challenge in the human health services market [3]. It is essential to consider both efficiency and equity when allocating health resources, both of which are of equivalent importance [1]. Health resource allocation not only influences the health status of residents but also plays a significant role in the sustainable development of health services [4]. China is confronted with a challenge in terms of equality and efficiency of health resource allocation [5]. The Government

of China is focusing on healthcare reform to improve the health of all residents of urban and rural areas [6]. The COVID-19 pandemic has highlighted severe weaknesses in Chinese healthcare systems and a lack of focus on health resource allocation [7]. Previous research has shown that inequalities still exist in the state of health and the use of health services in China [8–10]. Guangxi Zhuang Autonomous Region is an ethnic frontier and economically underdeveloped.

Equity of health resource allocation is defined as how health resource is allocated and distributed across healthcare sectors or region [11], which is a prerequisite for the achievement of health equity [12]. Therefore, equity in the allocation of health resources has attracted global attention [13]. In particular following the enactment of the historic Basic Medical Care and Health Promotion Law by the Standing Committee of the National People's Congress of China in 2019 [14]. Wang Xiangyu et al. analyzed the fairness of health workers [15]. Huang Wenhua et al. analyzed the Fairness of service utilization and allocation of mental health resources in medical institutions in Guangxi, China [16]. Huang Shangyuhui et al. analyzed the equity and efficiency of health resource allocation in Guangxi maternal and child health care institutions [17]. Kong Yan et al. analyzed the allocation and fairness of health human resources in hospitals in Guangxi County [18]. While a vast number of previous studies have provided strong support for policymakers, few studies have focused on underdeveloped county areas in western China.

In China's urban health service system, the county plays a central role in connecting the urban and rural areas and is a major spatial vector to promote urbanization. The economy in the county region is the basis of China's national economic development. Previous studies have found that, firstly, in recent years, domestic research on the combination of equity of health resource allocation is relatively scarce [19, 20]. Secondly, the research objects are mostly at the provincial and municipal levels, and there was a lack of research at the county level [3, 21]. Thirdly, the research on the county health resource allocation in Guangxi during the "13th Five-Year Plan" (2016–2020) is insufficient [22]. Guangxi is the only ethnic minority autonomous region bordering the sea in the west of China and the only coastal area in the west and a unique position in the strategic pattern of the large-scale development of the western region and the overall situation of the country's opening to the outside world. Numerous studies have proved that the equity and efficiency of health resource allocation still need to be improved [22]. Recently Equity in the allocation of health resources across China has improved, but there has been a bottleneck in improving equity among regions [23]. Since 2009, China has sought to expand health coverage and provide residents with equitable access to primary health care to improve health equity [24]. This study aimed to assess the equity of the health resources allocation in Guangxi County, to provide a basis for the allocation of health resources in developing countries.

## 2 Material and Methods

### 2.1 Data Resources and Region Division

The data in this research were obtained from Guangxi Health Statistical Yearbook (2016–2021), and the County-related data were provided by the Health Statistics Information Center of Guangxi. The equity indicators included health technicians (practicing doctors, assistant practicing doctors, registered nurses, pharmacists, and technicians), hospitals (Hospital of Integrated Traditional Chinese and Western Medicine, General hospitals, Chinese medicine hospitals, maternal and child health hospitals, specialized hospitals and ethnic medicine hospitals) and bed numbers. Guangxi Zhuang Autonomous Region is an old revolutionary area, border, coastal and underdeveloped ethnic minority area in the west of China. There are 14 cities in Guangxi, with a total of 71 counties under its jurisdiction.

### 2.2 Methods

**Lorenz's curve and Gini coefficient.**
Lorenz's curve was initially proposed by renowned economist Max Otto Lorenz [25]. Gini's coefficient has been developed by Corrado Gini from Lorenz's curve. Both have been used extensively in determining the equality of the distribution of resources [20, 26]. The former can more intuitively show the difference in fairness in the allocation of health resources. The x-axis is the cumulative proportion of population or geography or economic (gross domestic product value), while the y-axis is the cumulative proportion of health resources. The diagonal of the square is regarded as the absolute equal curve. The Gini coefficient (Gini) ranges from 0 to 1, and the closer it is to zero, the fairer it is. Gini < 0.2 is absolutely fair, 0.2 ~ 0.3 is relatively fair, 0.3 ~ 0.4 is relatively fair, 0.4 ~ 0.5 is relatively unfair, and > 0.5 is fair with great difference. The specific calculation formula is:

$$XA = \frac{1}{2}a1c1 + \frac{1}{2}\sum_{i=1}^{n-1}(ci + ci + 1)(a_{i+1} - a_i), i = 1, 2, 3...n \quad (1)$$

$$Gini = 1 - a1c1 - \sum_{i=1}^{n-1}(ci + ci + 1)(a_{i+1} - a_i), i = 1, 2, 3...n \quad (2)$$

Where XA is the area of region A, $a_i$ is the cumulative percentage of population/economic/geographical area, and $c_i$ is the cumulative percentage of health resource.

**Theil index.**
As the Gini coefficient only reflects overall inequity, it is not possible to distinguish the cause of the difference that stems from inequity within or between regions [27]. Therefore, this study incorporates the Theil index to analyze the causes of the inequity. The Theil index ranges from 0 to 1, the closer it is to 0, the more equitable it is [28]. The closer to 0, the fairer. The formulas are as follows:

$$\text{Theil} = \sum_{n=1}^{n} \text{Pi*log}\left(\frac{\text{Pi}}{\text{Yi}}\right) \tag{3}$$

$$\text{T}_{\text{total}} = T_{\text{intra}} + T_{\text{between}} \tag{4}$$

$$\text{T}_{\text{within}} = \sum_{g=1}^{k} \text{Pg*Tg} \tag{5}$$

$$\text{T}_{\text{between}} = \sum_{g=1}^{k} \text{Pg*}\left(\frac{\text{Pg}}{\text{Yg}}\right) \tag{6}$$

where Pi is the share of population/economy/geographic area of each municipality in the total number of the region; Yi is the number of health resources of each municipality in a given dimension to about the total number. pg is the share of each region/economy/geographic area in the total number of the region; Yg is the share of total health resources of each region in the total number of the region; Tg is the Theil index of each region [29].

## 3   Results

### 3.1   Allocation of County Health Resources in Guangxi from 2016 to 2020

As shown in Table 1, from 2016 to 2020, the number of Hospital, Bed, Health technician and Health technical personnel per thousand population were all increased, the average annual growth rates were 9.2%, 9.2%, 6.0% and 5.7%.

### 3.2   Fairness Analysis

**Trends of Lorenz Curve and Gini Coefficient from 2016 to 2020**
As shown in Table 2, Gini coefficient from 2016 to 2020 were all below 0.3, which is in a relatively fair state. As shown in Fig. 1, from 2016 to 2020, the trend of the Gini coefficient of various health resources is not obvious. Except for health technicians, the Gini coefficient of other county health resources tends to fluctuate and decrease.

**Table 1.** Health resource allocation trend from 2016 to 2020

| Year | Hospital | Bed | Health technician | Health technical personnel per thousand population |
|---|---|---|---|---|
| 2016 | 250 | 59992 | 131949 | 5.2 |
| 2017 | 277 | 65739 | 137818 | 5.4 |
| 2018 | 300 | 71196 | 143697 | 5.6 |
| 2019 | 328 | 79041 | 152138 | 6 |
| 2020 | 356 | 85277 | 166836 | 6.5 |
| The annual rate of growth | 9.2% | 9.2% | 6.0% | 5.7% |

**Table 2.** Gini coefficient from 2016 to 2020

| Dimension | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|
| By geographical | | | | | |
| hospital | 0.266 | 0.285 | 0.310 | 0.305 | 0.266 |
| Health technician | 0.208 | 0.264 | 0.247 | 0.240 | 0.298 |
| Bed | 0.254 | 0.285 | 0.283 | 0.286 | 0.283 |
| By population | | | | | |
| Hospital | 0.240 | 0.203 | 0.185 | 0.175 | 0.149 |
| Health technician | 0.093 | 0.099 | 0.095 | 0.075 | 0.117 |
| Bed | 0.119 | 0.090 | 0.096 | 0.098 | 0.118 |
| By GDP | | | | | |
| Hospital | 0.198 | 0.165 | 0.177 | 0.198 | 0.135 |
| Health technician | 0.158 | 0.146 | 0.167 | 0.138 | 0.139 |
| Bed | 0.155 | 0.141 | 0.200 | 0.153 | 0.134 |

As shown in Fig. 2, In 2016 and 2020, the Lorenz curve of health resources located by geography was the most curved, and the Lorenz curve of various county health resources allocated by GDP in Guangxi is closer to the absolute average line. Compared with 2016, in 2020, the degree of curvature reduction of the Lorenz curve in all dimensions was not obvious.
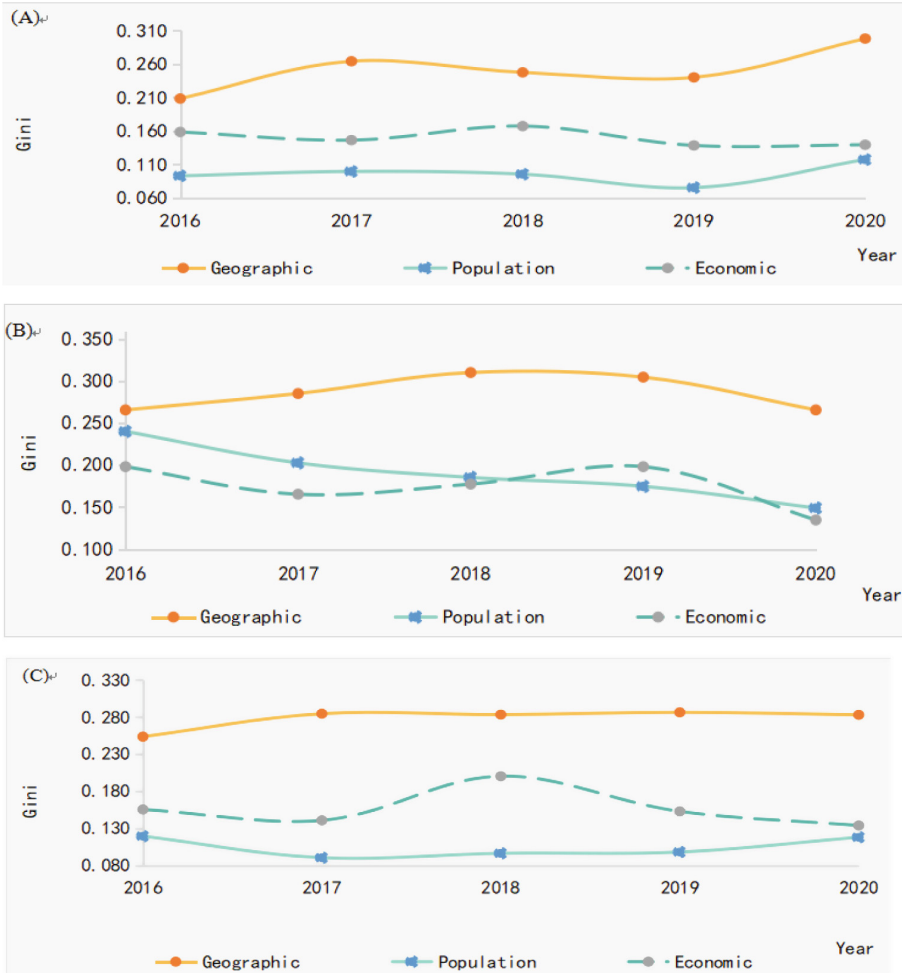
**Fig. 1.** Temporal trends in the Gini coefficient of health resources in Guangxi County. A. Gini coefficient of hospital from 2016 to 2020; B. Gini coefficient of Health technician from 2016 to 2020; C. Gini coefficient of Bed from 2016 to 2020

**Theil Index and the Changing Trend of Contribution Rate**

As shown in Table 3, from 2016 to 2020, the total Theil index of all kinds of health resources indicators was between 0.012 and 0.169, among which, all kinds of health resources in the economic dimension showed a fluctuating downward trend, which was the same as the Gini coefficient. As shown in Table 4, from 2016 to 2020, the intra-region difference was the main reason for the inequity of health resource allocation in Guangxi County.
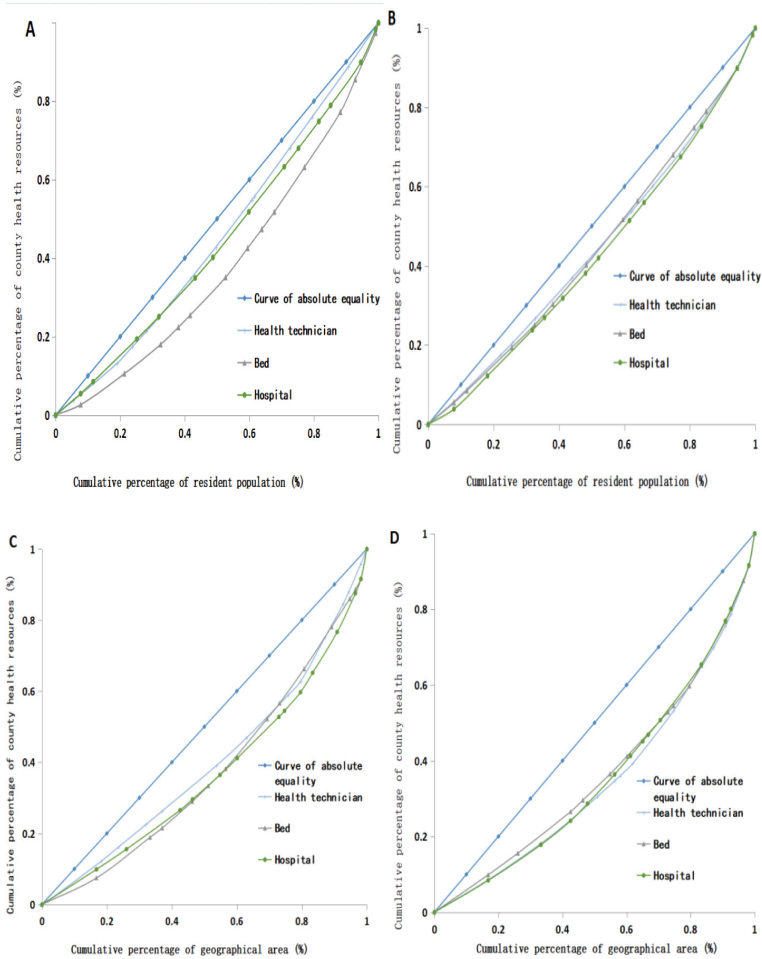
**Fig. 2.** Lorenz curves of health resources in 2016 and 2020. A. Lorenz curve of county health resources allocated by population in 2016; B. Lorenz curve of county health resources allocated by population in 2020; C. Lorenz curve of county health resources allocated by geographic area in 2016; D. Lorenz curve of county health resources allocated by geographic area in 2020; E. Lorenz curve of county health resources allocated by GDP in 2016; F. Lorenz curve of county health resources allocated by GDP in 2020.
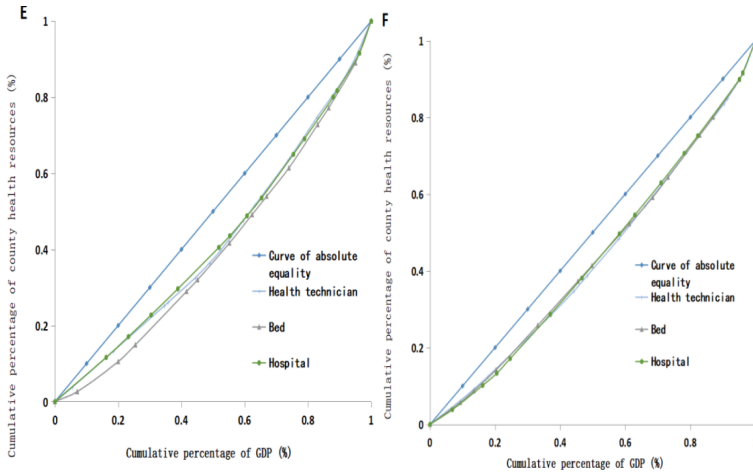
**Fig. 2.** (*continued*)

**Table 3.** Total Theil Index of county Health Resources in Guangxi from 2016 to 2020

| Dimension/year | Bed | Hospital | Health technician |
|---|---|---|---|
| By population | | | |
| 2016 | 0.012 | 0.098 | 0.017 |
| 2017 | 0.014 | 0.072 | 0.020 |
| 2018 | 0.014 | 0.057 | 0.020 |
| 2019 | 0.017 | 0.053 | 0.011 |
| 2020 | 0.020 | 0.041 | 0.024 |
| By geography | | | |
| 2016 | 0.095 | 0.112 | 0.075 |
| 2017 | 0.122 | 0.134 | 0.111 |
| 2018 | 0.039 | 0.137 | 0.097 |
| 2019 | 0.111 | 0.138 | 0.097 |
| 2020 | 0.169 | 0.131 | 0.143 |
| By GDP | | | |
| 2016 | 0.043 | 0.073 | 0.041 |
| 2017 | 0.034 | 0.055 | 0.033 |
| 2018 | 0.043 | 0.049 | 0.047 |
| 2019 | 0.032 | 0.047 | 0.034 |
| 2020 | 0.039 | 0.037 | 0.035 |

**Table 4.** Theil Index contribution rate of county health resources in different economic zones in Guangxi from 2016 to 2020 (%)

| Dimension/year | Bed | | Hospital | | Health technician | |
| --- | --- | --- | --- | --- | --- | --- |
| | Inter-Region (%) | Intra-Region (%) | Inter-Region (%) | Intra-Region (%) | Inter-Region (%) | Intra-Region (%) |
| By population | | | | | | |
| 2016 | 10.57 | 89.43 | 11.90 | 88.10 | 30.99 | 69.01 |
| 2017 | 18.81 | 81.19 | 4.45 | 95.55 | 25.39 | 74.61 |
| 2018 | 23.51 | 76.49 | 5.42 | 94.58 | 10.53 | 89.47 |
| 2019 | 26.80 | 73.20 | 6.21 | 93.79 | 22.25 | 77.75 |
| 2020 | 13.11 | 86.89 | 10.20 | 89.80 | 22.56 | 77.44 |
| By geography | | | | | | |
| 2016 | 55.21 | 44.79 | 24.13 | 75.87 | 56.65 | 43.35 |

(*continued*)

**Table 4.** (*continued*)

| Dimension/year | Bed | | Hospital | | Health technician | |
| | Inter-Region (%) | Intra-Region (%) | Inter-Region (%) | Intra-Region (%) | Inter-Region (%) | Intra-Region (%) |
|---|---|---|---|---|---|---|
| 2017 | 60.80 | 39.20 | 31.94 | 68.06 | 69.21 | 30.79 |
| 2018 | 20.72 | 79.28 | 38.05 | 61.95 | 67.69 | 32.31 |
| 2019 | 59.76 | 40.24 | 39.65 | 60.35 | 59.83 | 40.17 |
| 2020 | 46.59 | 53.41 | 48.04 | 51.96 | 50.68 | 49.32 |
| By GDP | | | | | | |
| 2016 | 18.18 | 81.82 | 22.92 | 77.08 | 37.07 | 62.93 |
| 2017 | 19.43 | 80.57 | 10.91 | 89.09 | 30.93 | 69.07 |
| 2018 | 8.92 | 91.08 | 10.77 | 89.23 | 4.16 | 95.84 |
| 2019 | 9.83 | 90.17 | 11.05 | 88.95 | 5.21 | 94.79 |
| 2020 | 6.11 | 93.89 | 15.26 | 84.74 | 18.20 | 81.80 |

## 4   Discussion

A vast number of the previous studies on resource allocation in China has focused on the country as a whole or on a particular province, while few studies have paid attention to the county areas in China [30]. This study complements the analysis of health resource allocation in Guangxi County and provides preliminary data and rational research evidence for the policymakers in developing countries. This study found that the Gini coefficient by population was lower than geographic area, which was in line with the previous studies [21, 29, 31]. A possible explanation for that conclusion is that the government takes the number of populations, instead of geographic area, as the priority for health resources allocation [1]. Theil index analysis was effective at identifying the sources of inequality, which included the rate of contribution within and between groups [29]. The Theil index analysis has shown that the intra-group difference was the main reason for the inequity of health resource allocation in Guangxi County, which was in line with the previous studies [3, 29]. There are great differences in the internal economic development of the three economic zones in Guangxi. Differences in the level of economic development within economic areas have led directly to differences in the allocation of county health resources [20]. Suggesting that in the future, when formulating the county health planning in Guangxi, the economic differences within the region and the influence of geographical factors in different regions should take into account [20]. The least equitable was hospitals [32]. The possible reason is that the medical and health service capacity of county hospitals in Guangxi is generally low, and residents generally believe that large urban general hospitals have better health service capacity than county hospitals, so they choose large hospitals for treatment [33]. As a result, county hospital allocations are less equitable than health technicians and beds in Guangxi County. County-level public hospitals shoulder the important task of medical treatment for county residents and play an important role in graded diagnosis and treatment in China. Therefore, the government should give timely guidance to support the further development of county-level hospitals and promote the construction of a medical alliance model between county-level public hospitals and urban public hospitals.

## 5   Conclusion

The rational distribution of health resources should be a "regular triangle" [5]. The health resources in county hospitals should be significantly higher than that in urban areas, to meet the principle of fairness in health resource allocation [27]. The study found that there were distinct regional disparities in the distribution of health resources within Guangxi County. As a result, we recommend that policymakers take full account of geographic and demographic factors in different regions when allocating health resources. This study has some limitations. There are many methods to analyze the equity of health service resource allocation, but each method has some limits or deviations. The evaluation of equality of health resources allocation was used the Gini coefficient and Theil Index, more research methods should be used. Some indicators, such as patient benefits, for assessing the equality of health services were inadequate, which may have an impact on the completeness of the assessment. While this study found a progressive improvement

in equity of health resource allocation in Guangxi from 2016 to 2020, the improvement in medical needs cannot yet be measured based on the methodology used in this study and the data currently available. However, due to the limited availability and integrity of the data collected, the above questions were not further explored in this research.

**Author Contributions.** SYH H conceived the idea of the study. SYH H. performed the experiments. JY. L, SYH H and T.J. analyzed the data and wrote the paper.

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