

# Equity of Health Resources Allocation in Rural Guangxi from 2016 to 2019: An Empirical Analysis

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## Research Article

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## Abstract

**Background:** Since 2009, the main task of the new health reform in China is to increase the equity of health resources allocation in primary health care institutions. Health policies and strategies have been established to increase the capacity of PHC services, with improved equity as the most important goal. The objective of this study is to analyze the status quo and equity of health resources distribution in rural Guangxi from 2016 to 2019.

**Methods:** Descriptive statistics analysis was used to analyze the status quo of health resource allocation in rural health center in Guangxi from 2016 to 2019. Lorenz curve, Gini coefficient and Theil index were used to evaluate the equity of health resource allocation in rural health center in Guangxi from 2016 to 2019, from three dimensions of population, geography and economy.

**Results:** From 2016 to 2019, the total amount of health resources in rural health center in Guangxi was increased, but the professional title and education background of health workers is still low. In 2019, the Gini coefficient was 0.085-0.217 geographically, 0.080-0.367 demographically and 0.135-0.340 economically. The total Theil index was 0.13-0.211, and the majority of the contribution rate of within regions was greater than the between regions.

**Conclusion:** From 2016 to 2019, the distribution of health resources in rural Guangxi was uneven among regions, and with great differences within regions.

## Background

Since 2009, China has launch the new health reform, which has a strong focus on primary health care (PHC). Reasonable health resources allocation determine the efficiency of health care services [1]. The equity of health resources allocation in rural areas should be improved, which is the key of the new health reform in China since 2009 [2]. Furthermore, the current COVID-19 pandemic exacerbated the weaknesses of health care system. China has put forward higher requirements for PHC service. Revitalizing PHC systems is of great importance to improve health outcomes and be better prepare for the next global pandemic. Currently, the problem of difficult and high cost of medical service is still the central part and a prime concern of the new health reform in China, therefore, PHC system should be strengthened.

In China, Rural health center provides general medical care and basic public health services in rural areas. Rural health center is the main subject of PHC system and rural health prevention [3]. Rural health work is a focal point of health works, which concerns to protect rural productivity, revitalize rural economy and maintain overall situation of social development. It has great meanings in improving the whole nation's health. Previous studies shown that improving the equity of health resources allocation in rural and remote regions is of great significance for promoting health equity [4].

Guangxi Zhuang Autonomous Region is one of the five ethnic minority regions in China, with the largest number of ethnic minorities in China, which accounts for 37% of its population [4]. The majority of regions in Guangxi are economically underdeveloped remote mountainous and minority areas[5, 6]. There are 11 ethnic minorities in Guangxi including Zhuang, Yao, Miao, Dong, Mulam, Maonan, Hui, Yi, Shui and so on [7]. Guangxi located in the southern China, boarding on Vietnam. The economy development of Guangxi is lagging and the health resources are relatively deficient in frontier minority areas [8].

Inequity in the distribution of health resources seriously hinders the overall improvement of health, which is a concern in the health reform and Healthy Guangxi 2030 strategy. The gap in health resources allocation and health service capacity between rural and urban areas is becoming worse, despite the government's favorable investment policies for the rural areas [9]. Various studies have proved that the equity of health resources in rural areas needs to be optimized [10]. A similar study uses a countrywide Facility Survey to collected data in Saudi Arabia, found that health resources are more concentrated in urban areas than rural areas [11].

The evaluation of equity of health resources in rural areas could help health policy makers to identify the bottlenecks and the take appropriate actions to further optimize the equity of limited health resources in rural areas. Therefore, this study aims to analyze the current situation and equity of health resources allocation in rural Guangxi from 2016 to 2019, using Lorenz curve, Gini coefficient and Theil index, from three dimensions of population, geography and economy (Gross Domestic Product, GDP). Results from this study could contribute to the understanding and development of pro-equity policies that can strengthen national health systems and improve access to quality health services for the under-served areas to achieving universal health coverage.

## Methods

### Data sources

Demographic and geographic area data was sourced from Guangxi Statistical Yearbook 2017–2020 [12–15]. Data related to Rural health center was obtained from Guangxi Health Statistics Yearbook 2017–2020. Microsoft Excel 2019 was used to calculate the Gini coefficient, Theil index and drawn Lorenz curve.

### Equity assessment

#### Gini coefficient and Lorenz curve

Gini coefficient, Lorenz curve and Theil index has been identified as the superior tool for assessing the equity of resources allocation [16]. The Gini coefficient is derived from the Lorenz curve, which reflecting the ratio of the area between the curve and the diagonal line, to the whole area below the 45°line [17]. The following formula was used to calculate the Gini coefficient:

$$S_B = \frac{1}{2} p_1 q_1 + \frac{1}{2} \sum_{i=1}^{n-1} (q_i + q_{i+1}) (p_{i+1} - p_i), i=1, 2, 3, \dots, n \quad (1)$$

$$G = 1 - p_1 q_1 - \sum_{i=1}^{n-1} (q_i + q_{i+1}) (p_{i+1} - p_i), i = 1, 2, 3, \dots, n \quad (2)$$

Where  $S_B$  is the area bounded by the Lorenz curve and the axes;  $G$  standards for the value of the Gini coefficient,  $p_i$  is the cumulative percentage of population/GDP/geographical area in each group, and  $q_i$  is the cumulative percentage of health resources in each group.

$G$  ranges from 0 to 1, the lower the  $G$ , the higher the degree of equity. In addition,  $G < 0.2$  indicates absolutely equity in the allocation of health resources,  $G$  between 0.2 to 0.3 indicates relatively equality,  $G$  between 0.3 to 0.4 indicates lower equity level,  $G$  between from 0.4 to 0.5 indicates highly inequality,  $G > 0.5$  indicates extreme inequity [18].

#### Theil index

Based on the geographical location, 14 prefecture-level cities in Guangxi can be divided into 5 geographical regions as follows: eastern, southern, western, northern and middle part of Guangxi [19]. Northern Guangxi includes Guilin; Mid-Guangxi includes Liuzhou, Laibin; Eastern Guangxi includes Wuzhou, Hezhou, Yulin, Guigang; Southern Guangxi includes Nanning, Chongzuo, Beihai, Qinzhou, Fangchenggang; and Western Guangxi includes Baise and Hechi.

Compared with the Gini coefficient, Theil index could analyze the contribution rate between and within each group to the total, which is complementary to the Gini coefficient [20]. Theil index ranges from 0 to 1, the smaller the value, the higher the degree of equity [21]. The following formula was used to calculate the Theil index:

$$(1) T = \sum_{i=1}^n P_i * \log\left(\frac{P_i}{Y_i}\right)$$

$$(2) T_{total} = T_{within} + T_{between}$$

$$(3) T_{within} = \sum_{g=1}^k P_g * T_g$$

$$(4) T_{between} = \sum_{g=1}^k P_g * \left(\frac{P_g}{Y_g}\right)$$

Where  $T$  is the Theil index,  $T_{total}$  is the total Theil index,  $T_{within}$  is the within group Theil index,  $T_{between}$  is the between group Theil index;  $P_i$  is the proportion of population/economic (GDP) /geographical area of each city in the total of the region;  $Y_i$  is the ratio of the number of health resources of each city in the population/economy/geographical area to the total;  $P_g$  is the proportion of the population/economy/geographical area of each city in the in the total;  $Y_g$  is the proportion of the total health resources of each region in the total of the whole region;  $T_g$  is the Theil index of each region.

## Indicators

Previous study has been identified health worker, equipment as constituting quality of primary care [22]. Two groups of indicators were selected to reflecting the general information of health resources distributions and equity of health resources allocation, respectively [23, 24]. General information of health resources allocation was measured by the total number of rural health centers (institutions)/ health care beds in the rural health centers (beds)/ health workers in the rural health centers (health workers)/doctors in the rural health centers (doctors)/ nurses per 1,000 rural population, institutions/ beds/ health workers/ doctors/ nurses per square kilometer ( $Km^2$ ), and the ratio of doctors to nurses in Guangxi. Institutions, health workers and beds were selected as objects of equity assessment [17].

## Results

### General information of health resource distribution in rural Guangxi

#### 1. Comparative analysis of per capita health resource distribution in different regions

In 2019, the average number of institutions per 1,000 rural population in rural Guangxi was 0.03, which was lower than that of China, Eastern China, Mid-China and Western China regions. The number of beds per 1,000 rural population is 1.41, lower than that of China and western China regions. The number of health worker per 1,000 rural population is 1.59, lower than the average number of China, Eastern China and Western China regions. The number of doctors per 1,000 rural population was 0.4, lower than that of China, Eastern China, Mid-China and Western China regions. The number of nurses per 1,000 rural population was 0.046, lower than that of China, Eastern China, Mid-China and Western China regions. In Guangxi, the average number of institutions per 1,000 rural population in Yulin was the highest, while the average number of institutions per 1,000 rural population in Nanning was the lowest (Table 1).

#### 2. Comparative analysis of per square kilometer health resource distribution in different regions

In 2019, the average number of institutions, beds, health workers, doctors and nurses per  $Km^2$  in Guangxi were 0.005, 0.29, 0.33, 0.08 and 0.1, respectively, which were lower than the Mid-China region. In Guangxi, the average number of rural health resources per  $Km^2$  in Baise, Hechi, Laibin and Chongzuo were lower than the average number of Guangxi (Table 1).

Table 1  
Rural health resource allocation in Guangxi in 2019

Region	Institution		Bed		Health Workers		Doctor		Nurse	
	10 <sup>3</sup> population	10 <sup>3</sup> M <sup>2</sup>	10 <sup>3</sup> population	10 <sup>3</sup> M <sup>2</sup>	10 <sup>3</sup> population	10 <sup>3</sup> M <sup>2</sup>	10 <sup>3</sup> population	10 <sup>3</sup> M <sup>2</sup>	10 <sup>3</sup> population	10 <sup>3</sup> M <sup>2</sup>
China	0.07	0.004	1.48	0.14	1.56	0.15	0.91	0.05	0.71	0.04
Eastern China	0.05	0.005	1.34	0.22	1.68	0.28	1.02	0.1	0.72	0.07
Mid-China	0.06	0.011	1.43	0.48	1.34	0.45	0.91	0.16	0.67	0.12
Western China	0.09	0.002	1.68	0.01	1.71	0.07	0.84	0.02	0.76	0.02
Guangxi	0.02	0.005	1.77	0.29	1.99	0.33	0.29	0.08	0.32	0.1
Eastern Gui	0.04	0.007	2.98	0.48	3.38	0.54	0.89	0.14	0.99	0.16
Southern Gui	0.05	0.005	3.15	0.36	3.32	0.38	0.82	0.09	1.01	0.12
Western Gui	0.07	0.005	1.89	0.12	2.99	0.19	0.68	0.04	0.79	0.05
Nothern Gui	0.06	0.005	1.82	0.17	2.7	0.25	0.83	0.08	0.77	0.07
Mid-Gui	0.06	0.005	3.43	0.28	3.57	0.29	0.87	0.07	1	0.08
Nanning	0	0.005	0.4	0.43	0.41	0.45	0.11	0.12	0.13	0.15
Liuzhou	0.07	0.005	3.03	0.23	3.54	0.27	0.92	0.07	0.98	0.07
Guilin	0.06	0.005	1.82	0.17	2.7	0.25	0.83	0.08	0.77	0.07
Wuzhou	0.04	0.005	2.48	0.29	3.45	0.4	0.92	0.11	1.04	0.12
Beihai	0.03	0.006	3.31	0.58	3.29	0.57	0.9	0.16	1.05	0.18
Fangchenggang	0.07	0.005	2.85	0.18	3.48	0.22	0.88	0.06	0.98	0.06
Qinzhou	0.03	0.005	3.18	0.58	3.01	0.54	0.68	0.12	0.89	0.16
Guigang	0.03	0.007	2.52	0.52	3.22	0.66	0.92	0.19	0.84	0.17
Yulin	0.04	0.009	3.67	0.84	3.38	0.77	0.86	0.2	1.02	0.23
Baise	0.08	0.005	1.36	0.09	3.05	0.19	0.67	0.04	0.76	0.05
Hezhou	0.06	0.005	2.71	0.25	3.62	0.34	0.88	0.08	1.14	0.11
Hechi	0.07	0.004	2.46	0.16	2.94	0.19	0.68	0.04	0.83	0.05
Laibin	0.06	0.006	3.88	0.35	3.61	0.33	0.81	0.07	1.02	0.09
Chongzuo	0.07	0.005	2.18	0.16	2.83	0.21	0.63	0.05	0.77	0.06

### 3. Time trends of health resources allocation in rural Guangxi from 2016 to 2019

From 2016 to 2019, the average number of institutions, nurses per 1,000 rural population and the ratio of doctors to nurses in Guangxi were lower than that of China, Eastern China, Mid-China and Western China regions. The number of beds, health workers and doctors per 1,000 rural population in rural Guangxi were higher than that of China, Eastern China, Mid-China and Western China regions. Compared to the China, Eastern China, Mid-China and Western China regions, the average annual growth rate (AAGR) of beds and doctors per 1,000 rural population was the highest, while the ratio of doctors to nurses was the lowest (Table 2).

Table 2  
Health resources allocation in rural Guangxi from 2016 to 2019

Health resources	Region	2016	2017	2018	2019	AAGR% <sup>①</sup>
Institutions per 1,000 rural population	Guangxi	0.02	0.02	0.02	0.02	0
	China	0.07	0.07	0.07	0.07	0
	Eastern China	0.05	0.05	0.05	0.05	0
	Mid-China	0.06	0.06	0.06	0.06	0
	Western China	0.09	0.09	0.09	0.09	0
Beds per 1,000 rural population	Guangxi	1.49	1.56	1.65	1.77	5.91
	China	1.26	1.35	1.43	1.48	5.51
	Eastern China	1.14	1.21	1.26	1.34	5.54
	Mid-China	1.24	1.32	1.37	1.43	4.87
	Western China	1.42	1.52	1.57	1.68	5.76
Health workers per 1,000 rural population	Guangxi	1.74	1.81	1.91	1.99	4.58
	China	1.36	1.42	1.49	1.56	4.68
	Eastern China	1.45	1.51	1.56	1.68	5.03
	Mid-China	1.24	1.27	1.27	1.34	2.62
	Western China	1.41	1.5	1.56	1.71	6.64
Doctors per 1,000 rural population	Guangxi	0.85	0.89	0.92	0.96	4.14
	China	0.82	0.84	0.87	0.54	-13.00
	Eastern China	0.92	0.94	0.97	0.63	-11.86
	Mid-China	0.86	0.88	0.88	0.53	-14.90
	Western China	0.7	0.74	0.77	0.47	-12.43
Nurses per 1,000 rural population	Guangxi	0.24	0.25	0.26	0.29	6.51
	China	0.58	0.62	0.62	0.71	6.97
	Eastern China	0.61	0.64	0.69	0.72	5.68
	Mid-China	0.55	0.57	0.59	0.67	6.80
	Western China	0.59	0.66	0.7	0.76	8.81
Ratio of doctors to nurses	Guangxi	0.91	0.88	0.85	0.82	-3.41
	China	0.7	0.73	0.97	0.78	3.67
	Eastern China	0.66	0.69	0.95	0.71	2.46

Mid-China	0.64	0.65	0.95	0.74	4.96
Western China	0.84	0.9	1.02	0.91	2.70

## 4. Structure of health workers in rural Guangxi

In 2019, the proportion of Junior college degree was accounted for the largest (44.72%), followed by the Technical secondary school degree (43.77%), while the Senior High school and below degree was accounted for the least (0.57%). The proportion of No titles/ unknown was accounted for the largest (40.87%), while the proportion of Senior professional title was accounted for the least (0.04%) (Table 3).

Table 3  
The proportion of education background and professional titles (%)

Structure/ Personnel	Doctor	Nurse	Health technical personnel	Health worker
Degree				
Postgraduate	0.18	0.01	0.06	0.06
Undergraduate	20.32	5.01	10.79	10.79
Junior college	54.33	42.16	44.72	44.72
Technical Secondary school	24.82	52.57	43.86	43.77
Senior High school and Below	0.34	0.18	0.57	0.57
Professional titles				
Senior	0.09	0.03	0.04	0.04
Middle	3.44	1.17	1.45	1.45
Junior	16.1	13.15	9.91	9.91
Technical expert	30.35	19.89	17.82	17.82
Assistant	24.82	33.18	29.92	29.92
No titles/unknown	25.2	32.58	40.87	40.87

## Fairness assessment

### 1. Changes of Lorenz curve and Gini coefficient from 2016 to 2019

From 2016 to 2019, G against GDP size was higher than that of population and geographic size. Compared with 2016, except for institutions, G by geographic size in 2019 was greater than 0.3. G by population was 0.068 - 0.217: where 0.187 - 0.217 for institutions, 0.118 - 0.160 for beds, 0.068 - 0.088 for health workers, which means that the distribution of the health resources was relatively equity. In addition, the G by geographic area was 0.080 - 0.367: where 0.080-0.081 for institutions, 0.289-0.357 for beds, 0.266-0.367 for health workers, indicating that the distribution of the health resources was the lower equity level. Moreover, G by GDP was 0.135 - 0.354: where 0.336 - 0.340 for institutions, 0.249 - 0.354 for beds, 0.135 - 0.276 for health workers, indicating that the distribution of the health resources exhibits lower equity level (Table 4).

By the population size, the Lorenz curves of the health workers was closest to the absolute equity curve, while the institutions was the farthest (Figure 1-2). This finding affirmed that the equity of health workers was the best while the institutions was the worst against population dimension. By the geographic size, the Lorenz curve of the institutions was the closest to the absolute equity curve, while the beds was the farthest (Figure 3-4). This finding verified that the equity of institutions was the best and that of the health workers was the worst in terms of the geographical dimension. By the GDP size, the Lorenz curve of the health workers was

the closest to the absolute equity curve, while the institutions was the farthest (Figure 5-6). This finding verified that the equity of health workers was the best and that of the institutions was the worst in terms of the GDP dimension. Furthermore, the trends of G of health workers fluctuated the most, dropping from 0.276 in 2016 to 0.135 in 2019. G of institutions in geographic and population size fluctuated slightly, and all of them were less than 0.2 (Figure 7-9).

Table 4

Gini coefficient of health resources in rural Guangxi from 2016 to 2019				
Dimension /Year	2016	2017	2018	2019
Population size				
Institution	0.215	0.187	0.216	0.217
Bed	0.118	0.125	0.16	0.147
Health Workers	0.088	0.086	0.068	0.085
Geographic size				
Institution	0.081	0.08	0.08	0.08
Bed	0.289	0.289	0.363	0.357
Health Workers	0.266	0.205	0.257	0.367
GDP size				
Institution	0.336	0.338	0.338	0.34
Bed	0.283	0.354	0.249	0.289
Health Workers	0.276	0.223	0.166	0.135

## 2. Theil index and contribution rate from 2016 to 2019

By population size,  $T_{total}$  was lower than 0.1. By geographic size, except for beds,  $T_{total}$  showed a decreasing trend from 2016 to 2019. By GDP size, except for health worker,  $T_{total}$  showed a trend of increasing year by year. By population and geographic size, except for institutions, the contribution rate of Theil index of health resources in rural Guangxi was  $T_{between} < T_{within}$ . In GDP size, except for beds, the contribution rate of Theil index of all health resources was  $T_{within} > T_{between}$ . The trends Theil index from 2016 to 2019 were similar as that of the Gini index. Overall, there was no significant change in the inter-group and intra-group differences in the contribution rate of Theil index (Table 5 and Figure 10-12).

Table 5

Theil index and contribution rate (%) of health resources in rural Guangxi from 2016 to 2019

Dimension /Year	Institutions			Beds			Health Workers		
	T <sub>total</sub>	T <sub>between</sub>	T <sub>within</sub>	T <sub>total</sub>	T <sub>between</sub>	T <sub>within</sub>	T <sub>total</sub>	T <sub>between</sub>	T <sub>within</sub>
Population size									
2016	0.08	54.95	45.05	0.029	24.94	75.06	0.019	19.27	80.73
2017	0.08	54.77	45.23	0.031	26.78	73.22	0.019	20.34	79.66
2018	0.08	54.81	45.27	0.03	30.35	69.65	0.018	23.37	76.63
2019	0.081	53.51	46.49	0.041	26.54	73.46	0.018	25.97	74.03
Geographic size									
2016	0.013	47.11	52.89	0.134	60.03	39.97	0.111	69.97	30.03
2017	0.013	47.36	52.64	0.135	63.75	36.25	0.106	69.56	30.44
2018	0.014	47.8	52.2	0.136	60.18	39.82	0.104	69.21	30.79
2019	0.013	53.29	46.71	0.211	64.48	35.52	0.107	68.87	31.13
GDP size									
2016	0.186	61.62	38.38	0.132	48.15	51.85	0.129	55.71	44.29
2017	0.188	61.55	38.45	0.139	49.14	50.86	0.13	56.18	43.82
2018	0.188	61.75	38.25	0.133	47.67	52.33	0.129	57.69	42.31
2019	0.19	61.64	38.36	0.136	38.16	61.84	0.128	58.89	41.11

## Discussion

From the absolute number point of view, compared to the China, Eastern China, Mid-China and Western China regions, the AAGR of beds and doctors per 1,000 rural population was the highest. Furthermore, from 2016 to 2019, the number of health resources per 1,000 rural population in Guangxi is higher than that of China, Eastern China, Mid-China and Western China regions. Illustrating that the health service capacity in rural Guangxi has been improved from 2016 to 2019. However, the ratio of doctors and nurses in rural Guangxi was decreased from 0.91 in 2016 to 0.82 in 2019. This may be partially due to the fact that China attaches great importance to the training of doctors, while neglecting the nurses [25]. Furthermore, from 2016 to 2019, the primary health investment in Guangxi was mainly used for the infrastructure construction of primary medical institutions, while ignoring the introduction and training of health workers in rural health centers to some extent, which was consistent with the findings of other study [26]. In terms of the structure of health workers in rural Guangxi, the proportion of Junior college degree (44.72%) was the largest, while the Postgraduate degree was the least (0.06%). Furthermore, the proportion of No titles/unknown was the largest (40.87%), while the proportion of High professional title was the least (0.04%). In rural areas in China, health workers are badly qualified, due to the lack of the training opportunities, which was consistent with the findings of Zhu and Xiao [27].

Studies in China also found that the quality health resources tend to be concentrated in the general hospitals [28, 29]. On account of the "Siphon effect", the majority of the health resources are concentrated in Nanning, the most developed city in Guangxi, while the underdeveloped rural areas are lack of health resources, this observation was in line with other studies [8, 19, 30]. Low wages and restricted career development have often been blamed for the loss of health workers in rural health centers [31]. Meanwhile, general hospitals developed far more rapidly than rural health centers [32]. It may impose a risk of further enlarging the health service capacity gap between developed areas and remote poor regions, which is against the governmental effort to strengthen primary health service capacity in the new health reform. Although the government has invested heavily in PHC, the health service capacity of rural health centers still lags behind the hospital sector [6].

From 2016 to 2019, G of population size (0.068-0.217) was lower than that of geographic size (0.080-0.367). Moreover, the trends of Theil index and Gini coefficient were similar from 2016 to 2019. The Chinese government were based on the number of population to allocating health resource, while ignoring the different geographical factors of each region [24]. Correspondingly, the fairness of health resource allocation by population size was much better than geographic size, which was consistent with the findings of other researches [33, 34]. By GDP and geographical size, the contribution rate were:  $T_{\text{between}} > T_{\text{within}}$ . It suggests that the regional economic differences might be the main reason for the unfairness of health resources in rural Guangxi, which was in line with the other study [19].

Furthermore, Baise, Hechi, Chongzuo and Laibin are the cities inhabited by ethnic minorities in Guangxi, where the population of ethnic minorities accounts for more than 75% of the total [5]. In 2019, the health resources per  $\text{Km}^2$  in the ethnic minorities region in Guangxi was higher than the average level of Guangxi. In recent years, the government has formulated documents and increased investment for PHC to promote the development of health services in ethnic minorities regions. Currently, the health workers working in rural health centers have several encouragements: short-term centralism training, more wages and welfare, and cash bonuses. Furthermore, "Internet + medical" model was implemented in remote poor ethnic regions to promote the sharing of health resources, and encouraged the hospitals in the developed cities in Guangxi such as Nanning and Liuzhou, to provide health support for poor and remote ethnic minority regions, including technological resources, health manpower and financing.

Based on our analysis, several policy implications to improve the overall equity of health resources allocation in rural Guangxi was as follows. First of all, the government guidance should be strengthened and increase the financial support to further reducing the gap between the urban and rural areas. Secondly, the geographic of health resource allocation in vast and sparsely populated areas need to be addressed. Moreover, the health institutions are supposed to introduce adequate health workers in remote and economically underdeveloped areas by giving extra subsidies and other preferential policies to ameliorate the inequity status. Last but not least, health workers determined the prosperity and decline of rural health centers to some extent. The salary and welfare of health workers in rural areas should be improved gradually. In order to reduce the inequity of health resources allocation in Guangxi, stakeholders, including policymakers, governments, health workers and patients, should strive to cooperate jointly in order to ameliorate the situation. In addition, investments for PHC needs to be increased significantly in underdeveloped regions.

## Conclusion

In conclusion, this study provides suggestive evidence for the equity in the distribution of health resources in rural Guangxi by elucidating the changing trends of health resources allocation from 2016 to 2019. The continuous growth in the number of health resources in rural areas would further meet the health needs of rural residents. This study found that the equity of health resources in rural Guangxi is significantly higher by population than by geographic area and GDP, which substantiates the results of previous studies [8, 21]. In addition, the equity status in the distribution of the institutions, beds and health workers in rural Guangxi have deteriorated since 2016. Current development of health manpower practice in multiple sites and telemedicine are very encouraging, which would greatly improve the PHC service capacity and alleviate the problem of shortage of health resources in rural areas. In addition, the assessment for fair distribution of other health resources needs to be performed by using multiple analysis methods.

## Declarations

## Acknowledgement

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## Declarations

The data used in this study is publicly available and no permission is required to access the data.

## Funding

This study was supported by the Health Committee of Guangxi Zhuang Autonomous Region (03301219007D).

## Availability of data and materials

The database generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

## Authors' contributions

QF formulated the research concept and developed the primary framework of the study; SH contributed to the final manuscript; all authors were involved in data collection. The final manuscript submitted for publication was read and approved by all authors.

## Ethics

Not applicable. This study was not a study on human beings and the data collected has no relationship with patients' medical records data, therefore, ethics statement was not needed.

## Consent for publication

Not applicable.

## Data sharing:

No additional data are available.

## Competing interests

All authors have no competing financial interest.

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## Figures

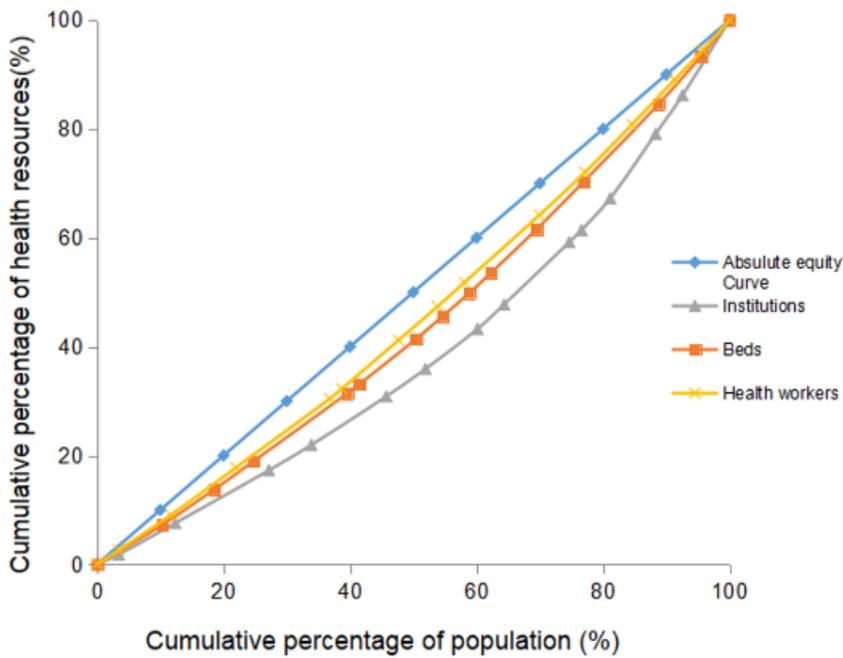


Fig. 1: Lorenz Curve of distribution of the health resources by population in 2016

### Figure 1

Please See image above for figure legend.

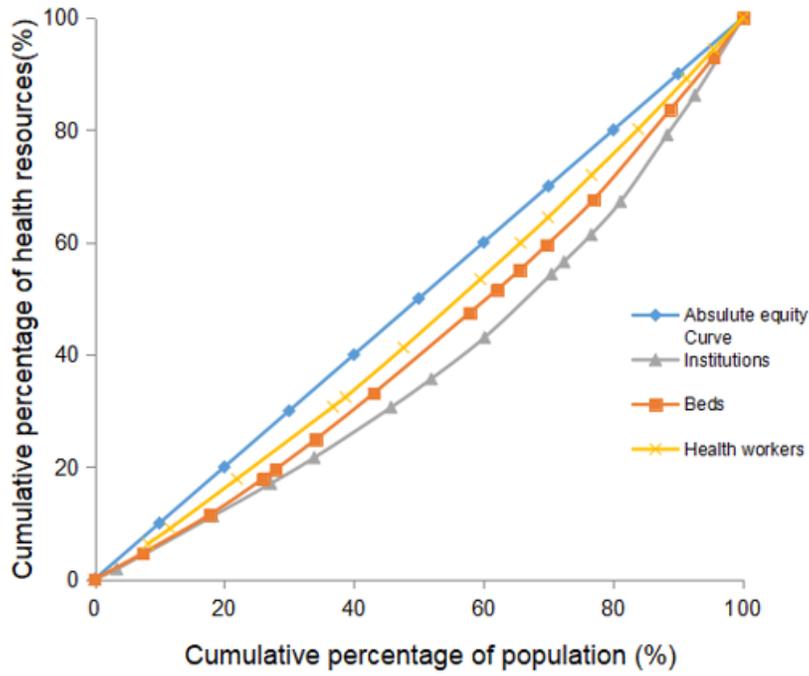


Fig. 2: Lorenz Curve of distribution of the health resources by population in 2019

Figure 2

Please See image above for figure legend.

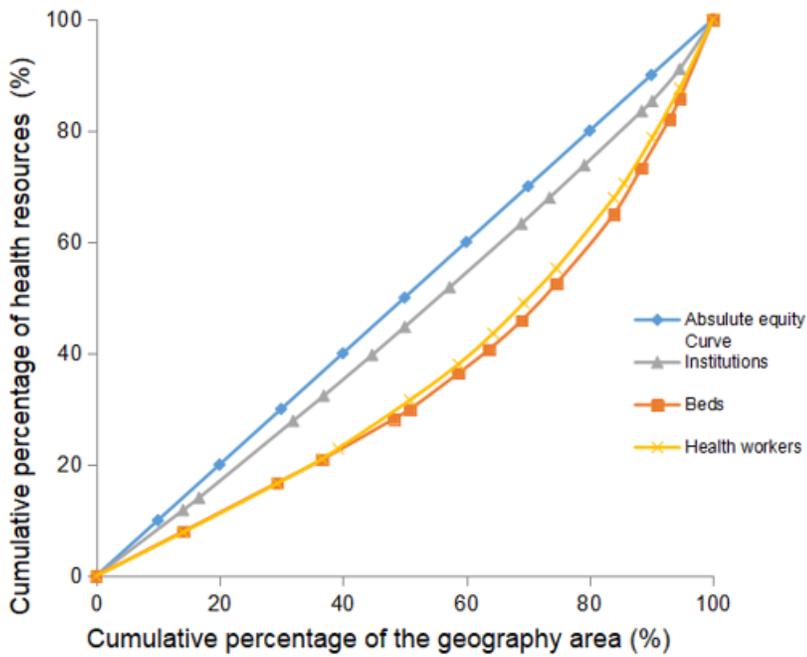


Fig. 3: Lorenz Curve of distribution of the health resources by geographic area in 2016

Figure 3

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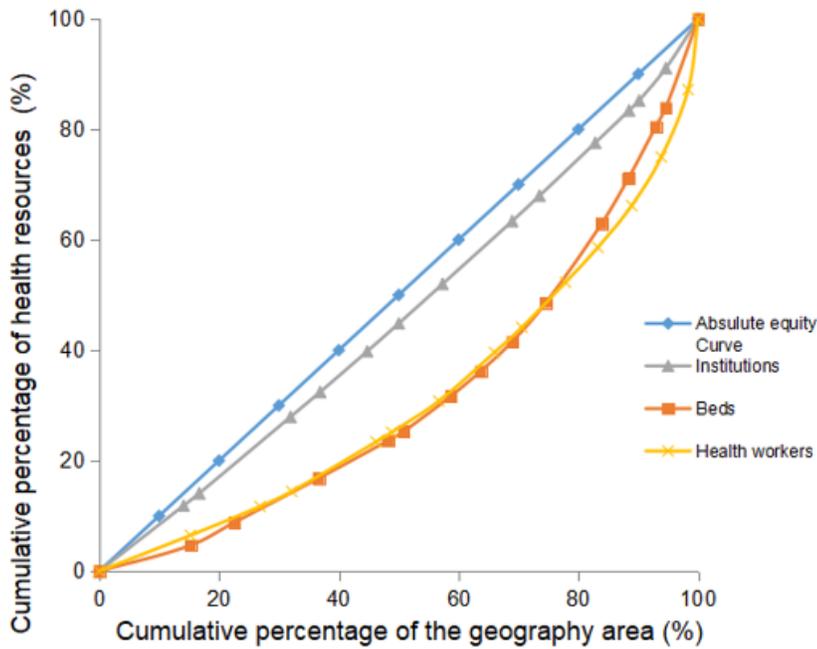


Fig. 4: Lorenz Curve of distribution of the health resources by geographic area in 2019

Figure 4

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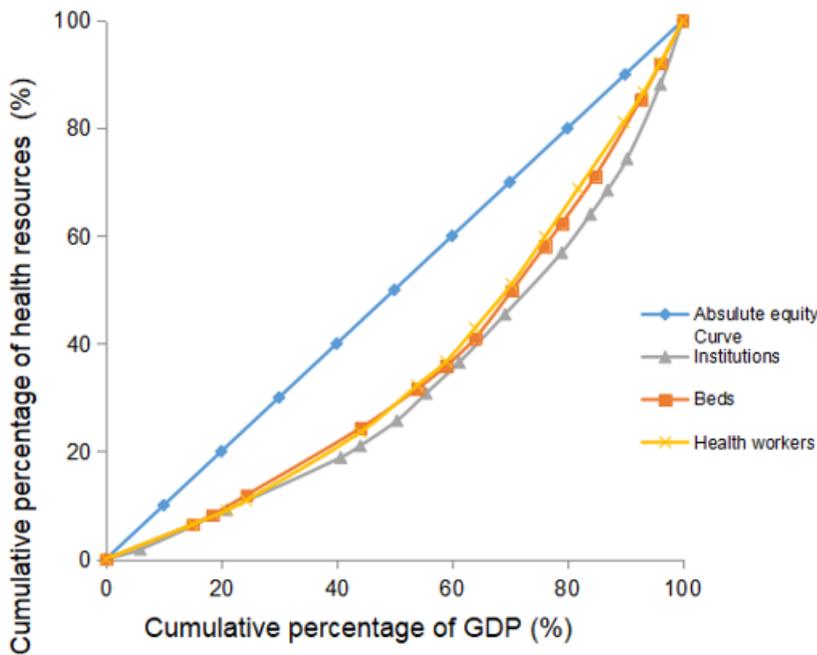


Fig. 5: Lorenz Curve of distribution of the health resources by GDP in 2016

Figure 5

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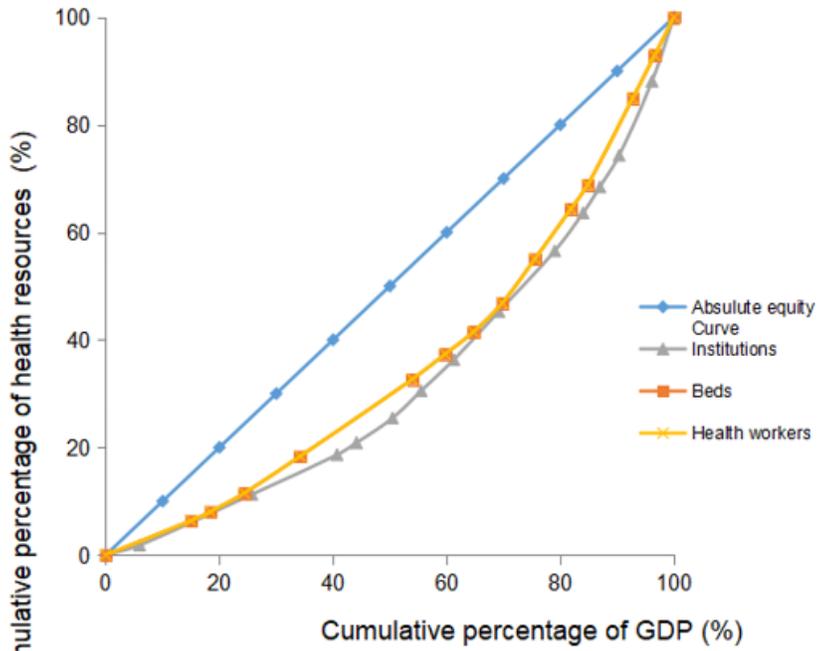


Fig. 6: Lorenz Curve of distribution of the health resources by GDP in 2019

Figure 6

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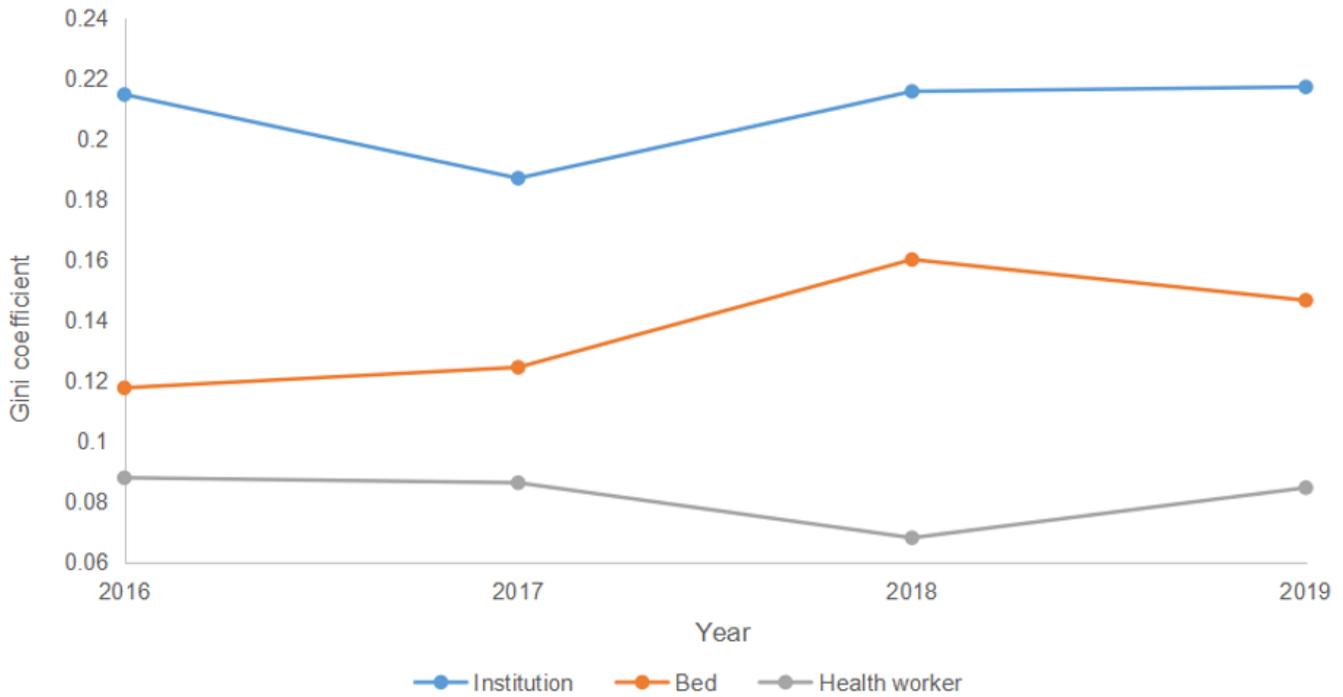
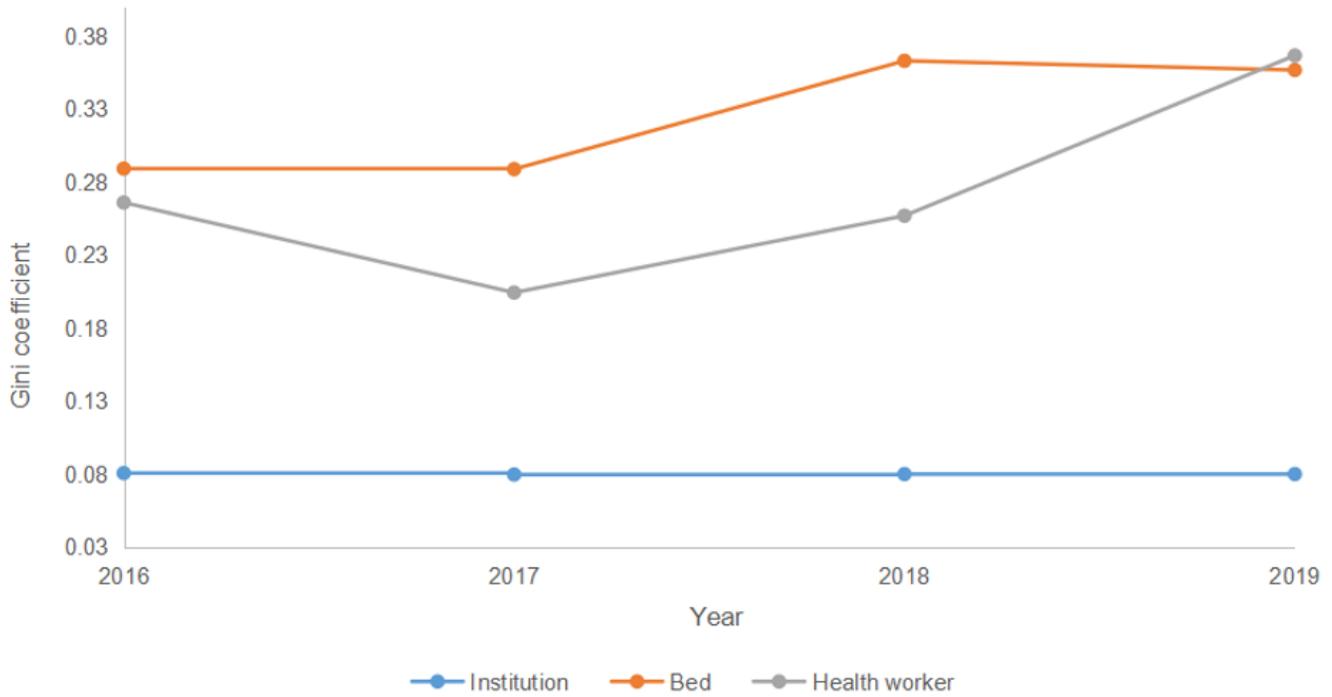


Fig.7 Gini coefficients for health resources in rural Guangxi by population from 2016 to 2019

**Figure 7**

Please See image above for figure legend.



**Fig.8 Gini coefficients for health resources in rural Guangxi by geography area from 2016 to 2019**

**Figure 8**

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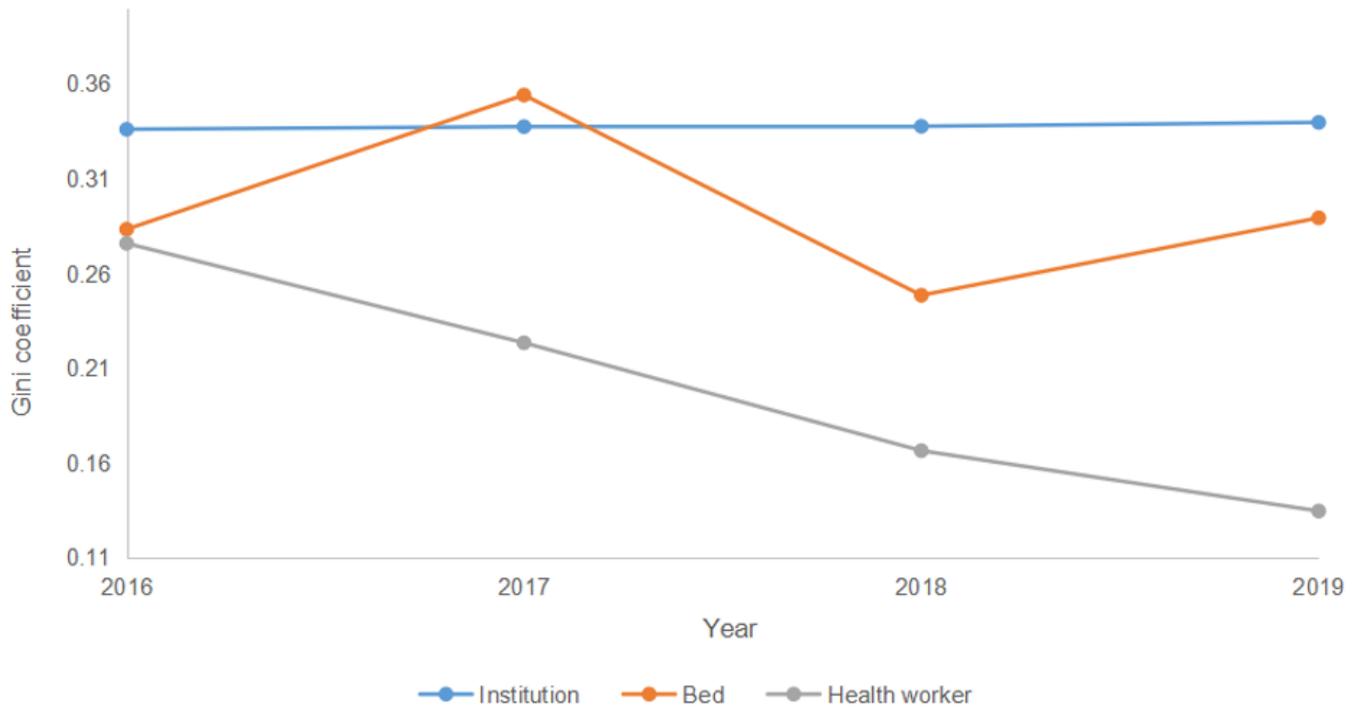


Fig.9 Gini coefficients for health resources in rural Guangxi by GDP from 2016 to 2019

Figure 9

Please See image above for figure legend.

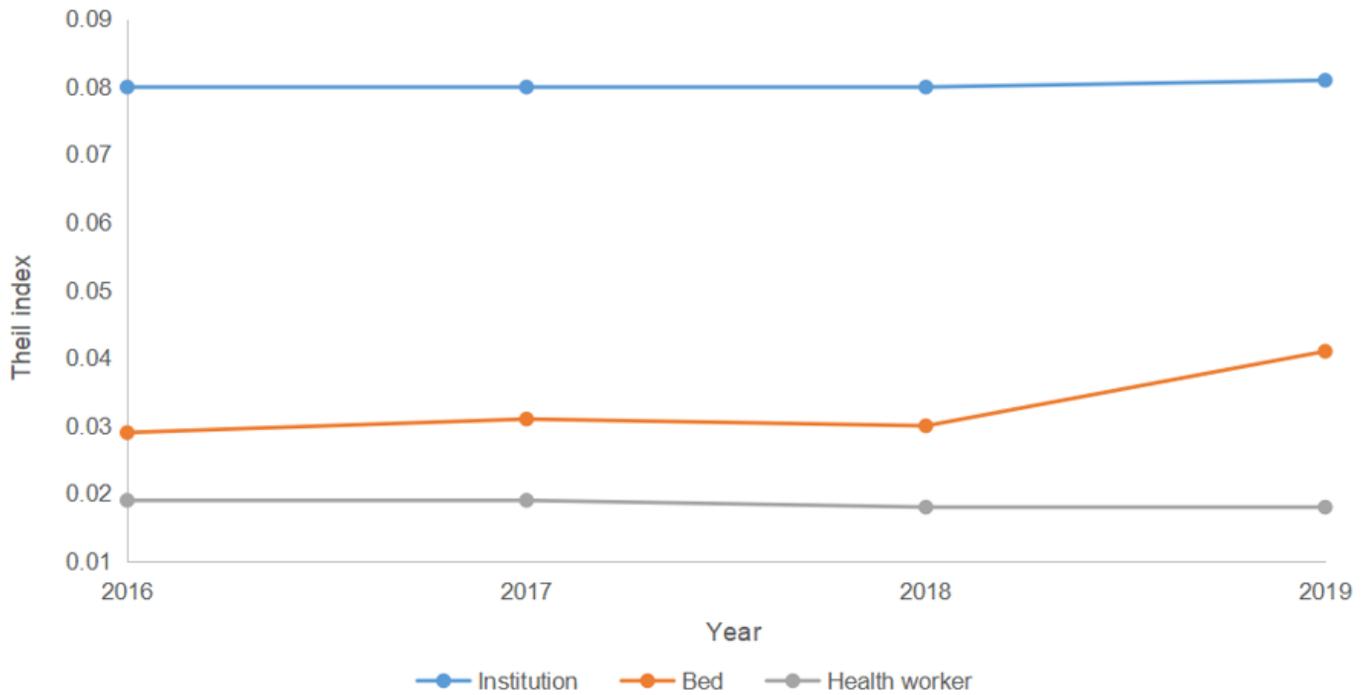


Fig.10 Theil index for health resources in rural Guangxi by population from 2016 to 2019

Figure 10

Please See image above for figure legend.

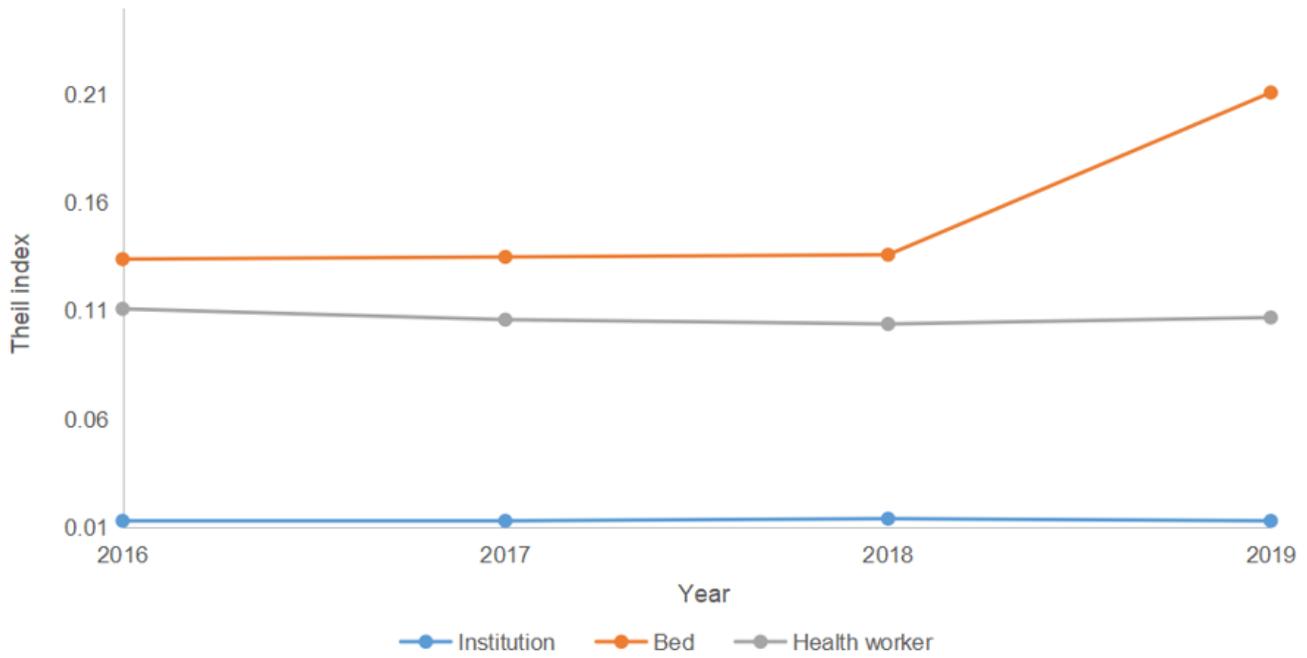


Fig.11 Theil index for health resources in rural Guangxi by geographic area from 2016 to 2019

Figure 11

Please See image above for figure legend.

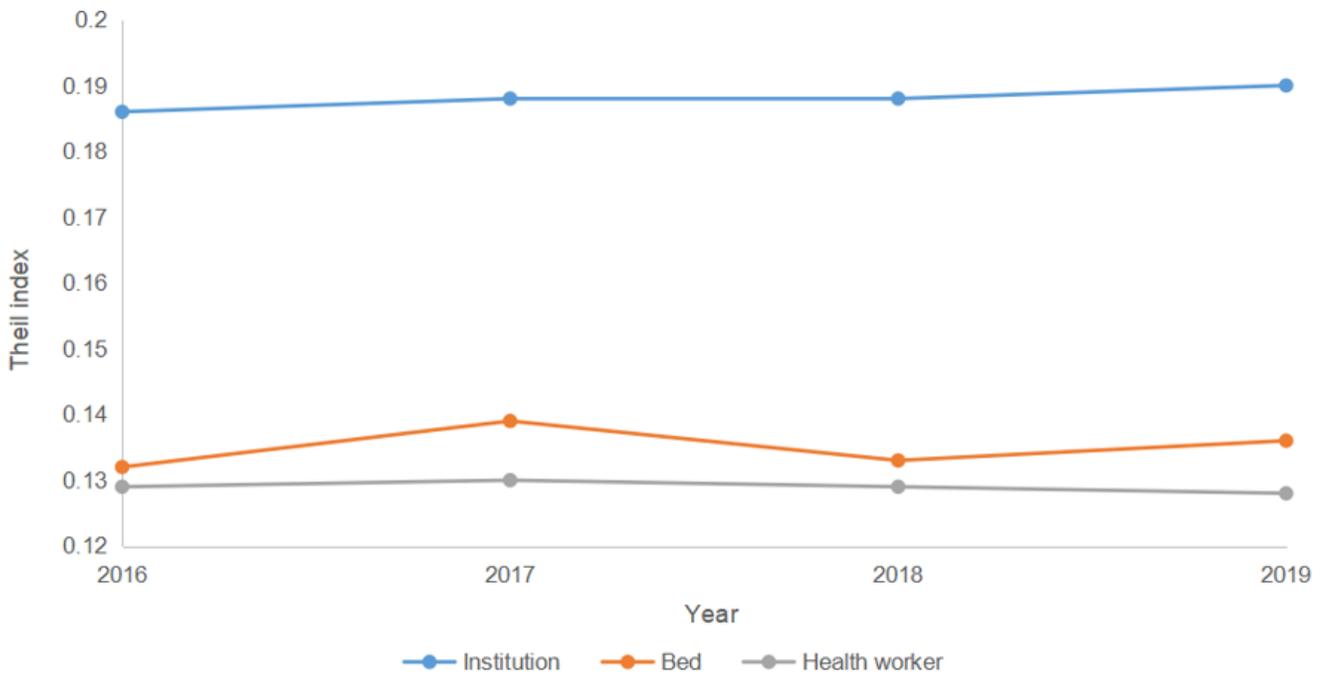


Fig.12 Theil index for health resources in rural Guangxi by GDP from 2016 to 2019

**Figure 12**

Please See image above for figure legend.