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Research Article

The Equity of Pre-Hospital Emergency Care at the County Level in Guangdong, China: A Cross-Sectional Study, 2015

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Abstract

Background: This study aimed to evaluate equity in the utilization and resource distribution of pre-hospital emergency care in Guangdong province for 2015 by using the Concentration Index (CI), Gini index, and Theil index.

Methods: Concentration Index (CI) was used to estimate the equity of emergency calls and emergency ambulance dispatches as two utilization indicators. Gini index and Theil index was used to evaluate the equity of ambulances, first-aid stations, and dispatchers as three resources distribution indicators. We used EXCEL software to calculate indicators.

Results: This study suggests that inequities favoring the wealthy exist in the utilization and resource distribution of pre-hospital emergency care. Specifically, emergency ambulance dispatches, for which the CI ranged from 0.0651 to 0.1099, had a higher-grade pro-wealthy inequity compared with emergency calls, for which the CI ranged from 0.0461 to 0.0114. Moreover, the Gini indexes of ambulances, first-aid stations, and dispatchers were 0.2217, 0.2421, and 0.3011 based on population distribution, while they were 0.4402, 0.4696, and 0.4214 based on geographic area, which indicated that the equity of population distribution was superior to the equity of area distribution. Meanwhile, the Theil indexes represented these inequities were mainly attributed to intra-regional differences.

Conclusions: Pre-hospital emergency care utilization and resources distribution were inequitable in Guangdong. Not only comprehensive policies but also the equity of geographical area should be taken into account properly by the government.

Introduction

In order to realize the goals of its new medical reforms, the Chinese government has been striving to provide everyone with access to basic medical and health services. Although the Chinese economy is growing rapidly, the country's limited medical resources are unequally distributed, which restricts the ability to provide those in poor regions with adequate medical services [1].

Aggravated by the aging of the population, as well as by the increase in traffic and urbanization, the number of critical patients has been increasing. According to China's health statistics yearbook 2016, Cardiovascular Disease (CVD), respiratory disease, injury, and poisoning have become the leading threats to the health of the Chinese people. Together, these causes accounted for approximately 61% of urban deaths compared to approximately 65% of rural deaths.

Research has demonstrated that the mortality rate for patients whose breathing and heartbeats have stopped increases by 10% for every 1 minute that medical attention is delayed [2]. Moreover, the most effective time to provide on-site first aid to severe trauma patients is within the first ten minutes of trauma [3]. Some deaths of critical patients can be been prevented by timely and effective emergency measures [4-5]. In other words, response times and quality of pre-hospital emergency care significantly influence the survival rates and subsequent treatment of critical patients [6-7].

As an economically developed province, Guangdong accounted for 10.57% of China's Gross Domestic Product (GDP) in 2015. However, the province's pre-hospital emergency medical treatment system is not consistent with the vigorous development of the economy. Even worse, the province has a striking disparity in wealth, which has aggravated the inequity of pre-hospital emergency care. It has been shown that pre-hospital mortality largely depends on the patient's medical condition [8]. In order to save lives and enhance the quality of life of patients with severe illnesses, it is essential to measure the equity of the utilization and resource distribution of pre-hospital emergency care. It is equally essential to propose pertinent measures to solve these problems.

Studies in China have found disparities between poor regions and affluent areas in terms of the utilization and resource distribution of Emergency Medical Services (EMS). However, such studies have not distinguished between pre-hospital and in-hospital resources and services [9]. Furthermore, studies have used only the Gini index to evaluate the equity of resource distribution, an approach that is able to determine the overall disparity but cannot identify the sources of differences. To remedy this problem, this study has used the Gini index and the Theil index to analyze discrepancies derived from intra-region or inter-region comparisons.

Moreover, this study is the first to thoroughly explore the current situation of pre-hospital emergency care and to estimate the equity of its utilization and resource distribution in Guangdong since the introduction of China's new medical reforms in 2009. The findings of this study are of great practical importance, if China is to perfect the locations of its existing resources for medical emergencies.

Methods

Data Sources

Depending on the characteristics of the pre-hospital emergency care under study, a self-designed questionnaire was developed, to be completed by the emergency center head or emergency staff who were well aware of all business processes. A survey was conducted from June 2016 to December 2016 at the district/county level in Guangdong. Ultimately, we collected 89 valid questionnaires; we had to exclude several districts in Foshan where the data on the population and geographic areas could not be utilized in our calculations because of the absence of information on utilization and resources. The information on per capita GDP, population, and geographic area of the 21 cities were derived from the Guangdong Statistical Yearbook 2016.

According to the default criteria and the Guangdong Statistical Yearbook, we divided Guangdong into four sections sorted by economic condition (from strongest to weakest) as follows: The PRD, the western region, the eastern region, and the mountainous region.

Main Indicators

The utilization of pre-hospital emergency care was represented by two indicators: emergency calls and emergency ambulance dispatches. Simultaneously, distribution of pre-hospital emergency care resources was reflected by three indicators, including ambulances, first-aid stations, and dispatchers. In addition, we analyzed the equity of utilization and resource distribution from the perspective of the distribution of the population and the geographical area.

Additionally, the inclusion and exclusion criteria of the above indicators were described as follows:

1. Emergency calls were the number of effective phone numbers after removal of invalid calls, such as harassing phone calls. It was stipulated that if there were multiple calls for an accident, we would calculate them as multiple calls.
2. Emergency ambulance dispatches were the number of valid times patients were taken to hospitals, excluding the number of transfer patients or hospital discharges.
3. Ambulances refer to the ambulances used for pre-hospital emergency care in the emergency network, not including the number of out-of-network and privately hired ambulances.
4. First-aid stations refer to the pre-hospital emergency institutions in the emergency network that had ambulances and pre-hospital emergency medical personnel, not including the pre-hospital emergency institutions that were only responsible for dispatching.
5. Dispatchers refer to the full-time and part-time employees, temps, and contractors who were engaged in the dispatching work of pre-hospital emergency care.

Measures

The Concentration Index (CI), Gini index and Theil index were used to reflect geographic differences and to measure income-related inequity.

The CI was a measure of the inequity of pre-hospital emergency care utilization; its value ranged from -1 to 1, with positive (negative) values representing the greater likelihood that affluent (impoverished) citizens would use pre-hospital resources. The smaller the absolute value of the CI, the better the equity. The formula of the CI is presented as follows:

$$Cl = \sum_{t=1}^{T} (P_t L_{t+1} - P_{t+1} L_t)$$

P shows the cumulative percentage of the population or geographical area ranked by social-economic conditions, while L represents the cumulative percentage of the utilization of pre-hospital emergency care, and t suggests the number of areas.

The Gini index and the Theil index were effective tools to analyze inequities in the distribution of pre-hospital emergency care resources; the values of these indices ranged from 0 to 1. The larger the value is, the worse the equity is.

The formula of the Gini index is presented as follows:

$$S = \frac{1}{2} \sum_{i=1}^{n} (Y_i + Y_{i+1})(X_{i+1} - X_i)$$

$$G = 2 \times (0.5 - S)$$

X_i (Y_i) represents the cumulative percentage of the population or geographical area (resources) ranked by per capita resources. At present, 0 to 0.4 is generally believed to be an indication of equity.

The formula of the Theil index is presented as follows:

$$T = \sum_{i=1}^{n} p_i In \frac{p_i}{y_i}$$

In the above formula, p_i (y_i) is the proportion of the population (resources) in an area that accounts for the total. The Theil index can be decomposed into intra-regional inequity and inter-regional inequity:

$$T_{intra} = \sum_{g=1}^{k} p_g t_g$$

$$T_{inter} = \sum_{g=1}^{k} In \frac{p_g}{y_g}$$

$$T = T_{intra} + T_{inter}$$

Table 1: Utilization rate and CI of emergency calls and emergency ambulance dispatches among the different regions in Guangdong for 2013 to 2015.

Region	Year											
	2013				2014				2015			
	ECs	UR	EADs	UR	ECs	UR	EADs	UR	ECs	UR	EADs	UR
Eastern region	453740	2.72	67727	0.39	451735	2.7	72798	0.42	478711	2.87	77317	0.45
Western region	339258	2.42	80788	0.56	338560	2.42	81519	0.56	355245	2.54	85567	0.59
Mountainous region	276156	3.61	62352	0.81	326248	3.52	77997	0.84	402585	3.09	103542	0.79
Pearl River Delta	2779929	5.87	683206	1.39	2922738	5.95	731888	1.44	2951866	5.9	742549	1.43
CI	-0.0461		0.0651		-0.0253		0.0724		0.0114		0.1099	

ECs: Emergency Calls; EADs: Emergency Ambulance Dispatches; UR: Utilization Ratio (%).

T_{intra} represents the inequity within the region, and T_{inter} shows the inequity among different groups. The meanings of p_g and y_g were the same as p_i and y_i, and t_g was the Theil index of each area. The contribution of intra-regional inequity was T_{intra} / T, and the contribution of inter-regional inequity was T_{inter} / T.

Result

Equity in pre-hospital emergency care utilization

The rates of emergency calls and emergency ambulance dispatches showed a declining trend in the mountainous region, while the rates of calls and dispatches in other areas increased slowly from 2013 to 2015. On the whole, the utilization rates in wealthy regions were significantly higher than those in other areas. In order to reach a complete understanding, we estimated the equities of pre-hospital emergency care utilization as reflected by the CI. The CI of the emergency calls ranged from -0.0461 to 0.0114, which indicated that the central tendency of the emergency calls transferred from the poverty-stricken areas to the prosperous regions. Meanwhile, the CI of the emergency ambulance dispatches ranged from 0.0651 to 0.1099, which indicated that patients in affluent areas were more likely to use pre-hospital emergency care and that inequity was increasing over time (Table 1).

Distribution of pre-hospital emergency care resources in Guangdong for 2015

To arrive at a preliminary understanding of resource distribution in Guangdong for 2015 (Table 2), we calculated the pre-hospital emergency care resources per 1,000 population and per 1,000 square kilometers. In regard to population, the minimum for Maoming (0.164) and maximum for Yangjiang (2.111) of first-aid stations per 1,000population were in the western region, which had a 12.87-fold difference. Furthermore, the number of dispatchers per 1,000 populations was 0.602, and this number varied from 0.243 in Jiangmen to 1.336 in Meizhou, a 5.50-fold difference. The number of ambulances per 1,000 populations in Zhaoqing (2.636) was 5.23 times greater than that in Shantou (0.504); this was the smallest gap.

Table 2: Pre-hospital emergency care resources per 1,000 populations and per 1,000 square kilometers area in 21 cities and regions of Guangdong in 2015.

Region	Population	Area	Ambulances		First-aid stations		Dispatchers	
			Population	Area	Population	Area	Population	Area
Eastern Region	1727	15756	0.955	0.105	0.625	0.069	0.602	0.066
Shantou	555	2064	0.504	0.136	0.54	0.145	0.27	0.073
Shanwei	302	4838	0.86	0.054	0.53	0.033	0.397	0.025
Chaozhou	264	3614	0.833	0.061	0.568	0.042	0.454	0.033
Jieyang	606	5240	1.469	0.17	0.776	0.09	1.073	0.124
Western Region	1583	31757	1.396	0.07	0.808	0.04	0.568	0.028
Zhanjiang	724	12490	1.505	0.087	0.898	0.052	0.525	0.03
Maoming	608	11445	0.888	0.047	0.164	0.009	0.362	0.019
Yangjiang	251	7822	2.31	0.074	2.111	0.068	1.195	0.038
Mountainous Region	1663	77125	1.863	0.04	1.262	0.027	0.949	0.02
Shaoguan	293	18600	1.774	0.028	0.921	0.015	0.682	0.011
Meizhou	434	15925	1.705	0.046	1.267	0.035	1.336	0.036
Heyuan	307	15821	1.594	0.031	0.716	0.014	0.39	0.008
Qingyuan	383	19000	2.556	0.052	2.06	0.042	1.304	0.026
Yunfu	246	7779	1.504	0.048	1.097	0.035	0.732	0.023
Pearl River Delta	5385	51884	1.523	0.158	0.942	0.1	0.505	0.052
Guangzhou	1350	7434	1.111	0.202	1.015	0.184	0.652	0.118
Shenzhen	1138	1953	1.274	0.742	0.747	0.435	0.343	0.12
Zhuhai	163	1701	2.325	0.223	1.285	0.123	1.285	0.123
Shunde	254	806	2.293	0.67	0.671	0.211	-	-
Zhaoqing	406	15000	2.636	0.071	1.798	0.049	1.158	0.031
Jiangmen	452	9541	0.752	0.036	0.509	0.024	0.243	0.012
Huizhou	476	11200	2.629	0.112	1.03	0.044	0.631	0.027
Dongguan	825	2465	1.333	0.446	0.848	0.284	0.315	0.105
Zhongshan	321	1784	1.776	0.32	0.997	0.179	0.312	0.056
Total	**10358**	**176522**	**1.463**	**0.086**	**0.92**	**0.054**	**0.602**	**0.035**

Table 3: Theil index of pre-hospital emergency care resources distribution in Guangdong for 2015.

Index	Ambulances		First-aid stations		Dispatchers	
	Population	Area	Population	Area	Population	Area
Intra-regional	0.0083	0.0605	0.0101	0.0667	0.0312	0.0608
Inter-regional	0.0082	0.0755	0.0094	0.0673	0.0104	0.0473
Overall Theil index	0.0165	0.136	0.0195	0.134	0.0416	0.1081

Regarding geographical area, first-aid stations had the largest gap, ranging from 0.009 in Maoming to 0.435 in Shenzhen, a 48.33-fold difference. Additionally, the number of dispatchers ranged from 0.008 in Heyuan to 0.124 in Jieyang, which is occupied by 0.035 people per 1,000 square kilometers, a 15.50-fold difference. The number of ambulances per 1,000 square kilometers was 0.086, while in Shenzhen (0.742), this number was 26.50 times more than that in Shaoguan (0.028).

From the regional point of view, the mountainous region had the lowest number of resources, at 3 resources per 1,000 square kilometers, whereas it had the majority of pre-hospital resources per 1,000 populations.

Equity in the distribution of pre-hospital emergency care resources

Based on the distribution of population, the Gini indexes of ambulances, first-aid stations, and dispatchers were 0.2217, 0.2421, and 0.3011, respectively, which indicates relative equity. In contrast, based on geographic area, the Gini indexes were 0.4402, 0.4696, and 0.4214, which represents a significant gap. The Theil index demonstrated a similar trend. By and large, the majority of intra-regional disparities have contributed greater than or equal to 50% of the overall discrepancies, which means that the main cause of the inequity is intra-regional differences (Table 3).

Discussion

The utilization ratio of pre-hospital emergency care resources in the PRD was higher than that in other 3 regions, while the CI of the emergency calls converted from negative to positive, and there was an increased difference in inequity among areas with regard to emergency ambulance dispatches. These results suggested that the utilization of pre-hospital emergency care favored the wealthy, which is consistent with previous studies [10-11]. A study on the equity of EMS in Chongqing city indicated that the wealthy had more access to EMS than the poor, and this inequity increased from 2008 to 2012. Moreover, Wilunda's study found that the wealthy were favored in the utilization of Emergency Obstetric Care in Oromiya.

In contrast, a study on the equity of EMS in Taiwan found a negative value for the CI, which indicated the utilization of EMS in favor of the poor [12]. The reason may be that ambulance services in Taiwan were offered for free to patients with emergency medical needs, which released pent-up demand for access to pre-hospital emergency care among poorer patients. However, in Guangdong, the charge for ambulances was relatively high and could not be reimbursed by medical insurance. Furthermore, the shortage of emergency physicians and nurses, equipment, and drugs was so universal in economically disadvantaged regions, which reduced the utilization of ambulances and lengthened response times [13]. Generally, the emergency response time associated with the survival rates of patients [14].Thus, reducing the costs of ambulances, improving the utilization of ambulances, and reducing response times should be the top priorities of the government in the future.

Additionally, the quality of pre-hospital emergency care was strongly influenced by the adequacy of emergency medical resources [15]. In recent years, the configurations of human and material resources for pre-hospital emergency care have been improved. However, this study has discovered some disparities in the allocation of pre-hospital emergency care resources in Guangdong. Specifically, the largest gap was found for first-aid stations, whether based on population or geographic area. This might be due to the shortage of medical personnel and the universal inadequacy of experience and training in emergency medicine in impoverished regions, such that many medical institutions could not be included in the emergency network. Additionally, medical institutions have sent ambulances without being subsidized, despite already having a general deficit; this fact cannot be disputed, and it might contribute to the refusal of some medical institutions to join the emergency network. Furthermore, the instability of the dispatching teams has increased because the two-child policy has allowed more dispatchers to have children, thus creating even more demand for dispatchers.

The largest geographic area in the mountainous region had more resources than other regions when its resources were calculated per 1,000 populations. Nevertheless, most mountainous regions still lack resources [15].

Research has suggested a direct relationship between the distribution of health resources and the level of economic development [16]. We found that equity based on population was superior to equity based on area - a finding similar to that of other studies [17-18]. Implementation of population-based resource distribution in China was one reason why equity (based on population) was best in the mountainous region. However, if equity based on geographical distribution is ignored, the median distance from patients to the closest hospital is longer in remote areas than in densely populated areas, a disparity that hinders citizens' access to equitable services and increases the burdens on medical institutions [19].

Simultaneously, this study found that the inequity of pre-hospital emergency care resources was caused mainly by intra-regional differences. This could be because some cities are located within regions that lack strong economic support or sufficient fiscal capacity, which might prevent them from meeting the standard criteria required in the province or country.

This study found some inequities between the utilization and allocation of pre-hospital emergency care resources in Guangdong, a distribution that favors the wealthy. Hence, we make the following proposals:

First, there should be rational allocation and equalization of pre-hospital emergency care resources. Above all, we should promote the construction and development of the emergency network to strengthen the four-stage emergency network, including provincial, city-level, county-level, and township-level medical institutions. Only when competent primary health institutions are incorporated into the emergency network can we reduce the service radius between first-aid stations. Next, looking at the local physical geographical situation and the disease spectrum, the locations of first-aid stations, models of ambulances, types of first-aid kits and categories of drugs should be allocated appropriately.

Second, the government should increase the investment. Provincial finance departments could subsidize those cities and counties in financial straits through transfer payments. In the meantime, those cities with favorable economic situations in a region should actively promote the development of other cities rather than consume too many resources. Eventually, the government could adopt preferential policies, raise salaries based on performance, and increase the authorizations of dispatchers.

Then, the willingness of people to use pre-hospital emergency medical care should be enhanced. Basic information on medical emergencies and the cost of the ambulance were influential factors in patients' decisions to seek or reject pre-hospital emergency medical care [20]. In response to this phenomenon, the government should take steps to further disseminate "120" emergency phone numbers. Simultaneously, the relevant sectors of emergency medicine ought to standardize charges for emergency treatment at each stage of the process to control emergency medical expenses. Ultimately, the government could use favorable policies to help those with lower incomes, such as by reimbursing (via medical insurance) part of the costs of ambulance transportation.

Finally, we should improve the utilization ratio of resources. Emergency medical technicians ought to strengthen the specialty training of emergency response staff to prevent situations in which there are surplus ambulances without emergency services professionals. Furthermore, we ought to improve the usage and efficiency of ambulances by enhancing management and maintenance. Meanwhile, emergency centers could attempt to promote the Medical Priority Dispatch System (MPDS).

We should also note that there were several limitations to this study. First, it was a cross-sectional investigation that measured equities and issues in the distribution of pre-hospital emergency care resources in Guangdong for 2015; it could not reveal variation trends in the equity of resource allocation. Second, some indicators that have influenced equity might not have been extracted, but we believe that the indicators in this study can relatively comprehensively reflect the utilization levels and the equity of the distribution of pre-hospital emergency care resources in Guangdong. Finally, as the data came from Guangdong, they might not reflect the overall situation in China or other provinces. Hence, further studies that have a greater geographical range and use time series data are essential.

Conclusion

This study has found that the distribution and utilization of pre-hospital emergency care resources are inequitable in Guangdong, and the distribution seems to favor the wealthy. Meanwhile, the geographical distribution of pre-hospital emergency care resources was worse than the distribution based on population, and these discrepancies mainly stemmed from intra-regional difference. Therefore, the government should close the gaps that are based on many factors.

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