

# Geographic Variations in Stroke Inpatient Healthcare Utilization and Hospital Expenditure Equity in China

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## Research

**Keywords:** Stroke, Health equity, Health policy, Geographic variation, Theil index

**Posted Date:** May 18th, 2020

**DOI:** <https://doi.org/10.21203/rs.3.rs-28730/v1>

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# Abstract

**Background:** Stroke is a devastating disease that imposes a heavy financial burden on patients and their families and a significant economic cost on a nation's healthcare system. Under China's fragmented health insurance system, it was unclear whether geographic variations in healthcare utilization and hospital expenditures lead to healthcare inequities for stroke inpatients. This study assesses the geographic variations in stroke patients' healthcare utilization and hospital expenses and the potential geographical influencing factors.

**Methods:** Covering all municipalities and provinces in mainland China, our main data were a 5% random sample of stroke claims from the Urban Employees Basic Medical Insurance (UEBMI) and Urban Residents Basic Medical Insurance (URBMI) schemes from 2013 to 2016, totaling 217969 inpatients and 280804 admissions. The Theil index was employed to evaluate the (in)equity in healthcare utilization and hospital expenditures across all 31 mainland Chinese provinces. Using multiple linear regression analysis, the geographic influencing factors, comprising ability to deliver healthcare, geographical accessibility of health services, healthcare-seeking and economic factors, were explored.

**Results:** UEBMI stroke inpatients had higher hospital costs and longer ALOS, but lower OOP expenses than those with URBMI. UEBMI insurance had a lower Theil index value than the URBMI scheme. Stroke patients' healthcare utilization and hospital expenditures showed significant differences both within and between regions. The intra-region Theil (in)equality index value was higher than the inter-region Theil index, with the Theil index highest within eastern China, China's richest and most developed region. The ability to deliver healthcare, the enabling factors and the provincial-level economic factors had significant effects ( $P < 0.05$ ) on healthcare utilization and hospital expenses.

**Conclusions:** Our data revealed significant geographic variation in healthcare utilization and hospital expenditures for stroke patients. In addition to differences in the coverage and reimbursements of the UEBMI-URBMI schemes, disparities within regions were associated with the ability to deliver healthcare (open hospital beds per 100 patients), the enabling factors (regional reimbursement rate and regional education level) and the provincial-level economic factors (GDP per capita). China's fragmented urban health insurance schemes require further reform to ensure better equity in healthcare utilization and hospital expenses.

## Introduction

A devastating disease for individuals and families, stroke is the second most common cause of death globally, and one of the major causes of disability worldwide[1]. Across a variety of countries, between 2–4% of total healthcare expenditures are accounted for by stroke, imposing a heavy financial burden on the healthcare systems in many countries[2]. Compared to all other countries, China has the highest incidence of stroke[3], with stroke costing about \$US5.9 billion to China's healthcare system annually in 2010[4]. Imposing an economic burden on stroke patients, stroke family caregivers and stroke families[5-7], many face the risk of financial catastrophe and bankruptcy[8]. A previous study reported that 71% of the sample of 4739 stroke patients in China had suffered catastrophic out-of-pocket (OOP) expenditures, and workers with health insurance were seven times less likely to experience catastrophic payments than those without health insurance[9]. Clearly,

health insurance can effectively promote access to healthcare and reduce the incidence of catastrophic medical payment, especially for poor families[10].

In China, there were two health insurance schemes designed exclusively for urban residents: Urban Employee Basic Medical Insurance scheme (UEBMI) for the urban employed and the Urban Resident Basic Medical Insurance scheme (URBMI) for the urban unemployed, retired, children and students, who were not covered by the UEBMI[11]. Covering more than 95% of the residents in urban China during the 2013-2016 period, the two schemes covered roughly 750 million, or 54%, of the total Chinese population[12]. The basic differences between UEBMI and URBMI are set out in Table 1. UEBMI is funded both by employers (2% of wages) and employees (6% of annual wages)[13], while the revenue for the URBMI is from individual premium contributions and subsidies from central and local government. As shown in Table 1, UEBMI provides better financial protection and offers a more comprehensive coverage than URBMI, which focuses on inpatient services, catastrophic illness insurance, but with limited coverage of basic outpatient services [14].

Table 1  
Comparison of UEBMI and URBMI policies

	UEBMI	URBMI
Inception year	1998	2007
Eligible population	Urban employed (employees; retirees)	Urban non-employed (children and full-time students; unemployed adults; elderly residents not covered by the UEBMI scheme)
Source of funding	Contributory (8% of annual payroll, 6% from employers, and 2% from employees)	Government subsidy and individual premium (varied by locations)
Per-capita fund (US\$) (2016)	\$523.7	\$94.3
Service package	Comprehensive	Limited
Percentage of counties (cities) reimbursed for general outpatient	100%	58%
Percentage of counties (cities) reimbursed for major and chronic diseases outpatient	100%	83%
Reimbursed ceiling	Six times of local employees' annual average wage per year	Six times of local household disposable income per year
UEBMI Urban Employee Basic Medical Insurance scheme; URBMI Urban Resident Basic Medical Insurance scheme;		

Patients with UEBMI usually utilize more health services and have higher expense than those with URBMI[15]. From aggregate studies of health insurance utilization, we know that the elderly's access to different insurance schemes results in different utilization rates between rural insurance schemes and urban insurance schemes within a single city, with disparities in health insurance benefits, health service expenses and healthcare

utilization equity[16-18]. These findings are consistent with the major differences between UEBMI and URBMI in Table 1. But UEBMI and URBMI were risk pooled across 333 municipalities(Beijing, Chongqing, Tianjin, Shanghai) and prefectures (administrative units within a province), with minor variations in the benefit package, reimbursement rate and reimbursement ceiling within each local UEBMI and URBMI scheme. Surprisingly, we know little about the impact of these variations across the 333 municipal-prefecture health insurance schemes. Did these municipal-prefecture urban health insurance scheme variations lead to geographic inequities in healthcare utilization and different healthcare expenditures by stroke inpatients?

Since John Snow's 1846 seminal analysis of geographic variations in English cholera cases, health studies have assessed geographic variations in healthcare provision. Geographical variations arise from a complex interplay of a region's health status, health resources and health services. Studies have assessed variation in the geographic distribution of health resources. For example, Wen Liu et al used data from the China Health Statistics Yearbook (2014) and the China Statistical Yearbook (2014) to evaluate the trends in equity of health resource allocation, revealing a huge gap in health resources across regions[19]. Second, studies have concentrated on geographic variation of diseases. Lee et al, for example, used China's National Health Information Database to examine geographic variation in morbidity and mortality of cerebrovascular diseases (CVDs), which revealed moderate geographic correlation between CVD morbidity and mortality[20]. Third, research has identified the geographic variation in healthcare services, where, for example, there exist marked geographic variations in the use of drugs for patients with prostate cancer[20] and health service expenses [21-23]. Other factors promoting geographic variations included differences in family income and the economic development level that varied across China's 31 provinces, municipalities and autonomous regions. For the 2013-2016 period, we conduct a cross-sectional assessment of the geographic inequities in UEBMI and URBMI inpatient stroke healthcare utilization and hospital expenses within and between three regions in China and explore the economic and health resource factors contributing to these geographic inequities.

## Methods

### Data resources and regional division

We collected a 5% random sample of UEBMI and URBMI insured stroke inpatients' claim data between January 1, 2013 to December 31, 2016 as well as supporting data from the China Labor Statistics Yearbook 2014-2017, the China Health Statistics Yearbook 2014-2017, the China Statistical Yearbook 2014-2017 and China's National Stroke Center. From the claims data, we have the medical information for each inpatient, including direct hospital costs, length of hospital stay, and OOP expenses. Our sample comprised 217969 inpatients and 280804 admissions. We studied all 31 provinces, and municipalities of mainland China, excluding Macao, Hong Kong and Taiwan. Based on their gross domestic product (GDP) per capita level, the 31 provinces were categorized into three groups, the eastern, central and western regions. The eastern region, including Beijing, Tianjin, Hebei, Liaoning, Shanghai, Jiangsu, Zhejiang, Shandong, Guangdong, and Hainan, had, on average, the highest average GDP per capita; the central region, including Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei and Hunan, had the next highest average per capita GDP; and the western region, including Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shanxi, Gansu, Qinghai, Ningxia, Xinjiang, had the lowest average per capita GDP.

# Measuring tool

The Theil index is a relative indicator measure of economic and other types of inequality [24]. The advantage of the Theil index is that it can calculate the contribution of intra-group and inter-group inequities to total inequities, thus avoiding the calculation of absolute values. The Theil index ranges between 0 and 1, where smaller values point to more equitable distribution of some economic phenomena, such as income, across a population [25]. While originally used to measure inequalities in economic data, the Theil index is increasingly used to evaluate (in)equities in health services, including healthcare utilization and health service expenses. The Theil index formula is:

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

where  $P_i$  is the proportion of insured population in one province accounting for the overall China insured population; and  $Y_i$  is the proportion of healthcare utilization/expenditure in one province accounting for the total utilization/expenses nation wide.

Since we divided the 31 provinces into three regions, the Theil index in formula (1) can also be decomposed into the  $T_{intra}$ , which measures utilization/expenditure inequality "within region"

$$T_{intra} = \sum_{i=1}^k P_g T_g \quad (2)$$

where  $P_g$  is the proportion of insured population in one region accounting for the total insured population and  $T_g$  is the Theil index of one region (eastern, central and western China). The Theil index (1) can also be decomposed into  $T_{inter}$ , which measures utilization/expenditure inequality "between regions"

$$T_{inter} = \sum_{i=1}^k P_g \log \frac{P_g}{Y_g}$$

where  $Y_g$  is the proportion of healthcare utilization/expense in one region accounting for the total healthcare utilization/expense. Higher  $T_{intra}$  and  $T_{inter}$  index values mean greater inequality, while lower index values mean more equality.

## Main indicators and multiple linear regression

The Theil index was calculated with two indicators of expenses, hospital costs and OOP expenditures, and healthcare utilization, measured as average length of stay (ALOS). Ordinary least squares (OLS) was used to

explore the potential geographical factors influencing geographic variation in healthcare utilization. To deal with the skewness of data, we converted the hospital costs, OOP expenses and ALOS to natural logarithms.

For the independent variables, standard behavioral healthcare models[26] suggest measures impacting healthcare utilization and hospital expenses, such as the ability to deliver healthcare, geographical accessibility of health services, enabling factors facilitating healthcare-seeking and economic factors[27-30]. In our study, the ability to deliver healthcare contains two aspects: the number of open beds per 1000 residents and whether the hospital is certified by the National Stroke Center, since certified centers usually have strong stroke medical care capacity. These data were obtained from the China Health Statistics Yearbook 2014-2017 and the website of National Stroke Center. The enabling factors facilitating or impeding the use of healthcare services comprised the regional reimbursement rate, regional education level and regional employment rate. Provincial-level economic factors were represented by the insurance fund per capita, measured by the total health insurance revenue divided by the insured population in that year, and GDP per capita. These data were collected from the China Labor Statistics Yearbook 2014-2017 and the China Statistical Yearbook 2014-2017.

Descriptive statistics were employed to illustrate the regional distribution and time trend of healthcare utilization for stroke inpatients, and statistical analyses were conducted using STATA version 14.0 (Stata Corp LP, College Station, TX), with statistical significance  $\alpha = 0.05$ .

## Results

### Healthcare utilization and hospital costs of stroke inpatients from 2013 to 2016

Table 2 shows changes in UEBMI and URBMI health service expense and healthcare utilization of stroke inpatients. Hospital costs, OOP expenses, and ALOS declined for both UEBMI and URBMI inpatients. The hospital costs of stroke inpatients fell roughly 20.4%, with UEBMI inpatient hospital costs declining from RMB14181.6 (US\$2135) to RMB13306.4 (US\$2003.3) and URBMI hospital costs declining from RMB10930.4 (US\$1645.6) to RMB8842.3 (US\$1331.2). URBMI OOP expenses declined 27.4% from RMB5243.5 (US\$789.4) to RMB3969.0 (US\$597.5). Reflecting the benefit and reimbursement schedule in Table 1, UEBMI inpatients had higher hospital costs and longer ALOS, but lower OOP expenses than those with URBMI. This confirms the inequalities in expenses and utilization between the two insurance schemes.

Table 2

Expenses and utilization of healthcare utilization of UEBMI and URBMI stroke inpatients, 2013 to 2016

Year	UEBMI			URBMI		
	Hospital cost <sup>□</sup>	OOP expenses <sup>□</sup>	ALOS <sup>□</sup>	Hospital cost <sup>□</sup>	OOP expenses <sup>□</sup>	ALOS <sup>□</sup>
2013	14181.6 <sup>d</sup>	3434.1 <sup>e</sup>	16.4 <sup>f</sup>	10930.4 <sup>a</sup>	5243.5 <sup>b</sup>	13.1 <sup>c</sup>
2014	13560.4 <sup>d</sup>	3332.0 <sup>e</sup>	15.4 <sup>f</sup>	8102.7 <sup>a</sup>	3392.2 <sup>b</sup>	11.7 <sup>c</sup>
2015	13789.7 <sup>d</sup>	3472.7 <sup>e</sup>	15.1 <sup>f</sup>	8629.0 <sup>a</sup>	4015.6 <sup>b</sup>	11.6 <sup>c</sup>
2016	13306.4 <sup>d</sup>	2927.3 <sup>e</sup>	15.2 <sup>f</sup>	8697.2 <sup>a</sup>	3808.2 <sup>b</sup>	11.7 <sup>c</sup>
Total	13690.6 <sup>d</sup>	3271.6 <sup>e</sup>	15.5 <sup>f</sup>	8842.3 <sup>a</sup>	3969.0 <sup>b</sup>	11.8 <sup>c</sup>

P-values are based on the Mann-Whitney test, Compared with□, a P<0.05, compared with□, b P<0.05□ compared with□, c P<0.05□ compared with□, d P<0.05; compared with□, e P<0.05□ compared with□, f P<0.05□  
 UEBMI Urban Employee Basic Medical Insurance scheme; URBMI Urban Resident Basic Medical Insurance

## Regional distribution of healthcare costs and utilization for stroke inpatients in 2016

To assess inequalities in the regional distribution of health services expenses and healthcare utilization for stroke inpatients, we made a detail calculation of hospital costs, OOP expenses, and ALOS in each of the 31 provinces and municipalities and in each of the three regions. As shown in Table 3, there were significant differences in patients' healthcare utilization and expenditure both between regions and within regions. For example, within the Eastern region, Beijing had higher UEBMI hospital costs than all other Eastern provinces, except Zhejiang; higher OOP expenses except for Tianjin; and higher ALOS except Zhejiang, Shanghai and Guangdong. The URBMI pattern for Beijing was different: Beijing had higher hospital costs than all other provinces and higher OOP expenses, except for Guangdong and higher ALOS, except for Shanghai. There were similar differences in UEBMI and URBMI hospital costs and utilization within the Western and within the Eastern regions. Within region hospital expenses and utilization rates in Table 3 point to significant within region inequalities in healthcare.

Table 3 also shows significant between region inequalities in UEBMI and URBMI. Patients with UEBMI in Eastern China had higher hospital costs (RMB15566.4/US\$2343.5), OOP expenses (RMB3424.0/US\$515.5) and longer ALOS (16.4 days) than those covered by the UEBMI in central and western regions. Central URBMI patients had lower hospital costs (RMB7704.1/US\$1159.9) and OOP expenses (RMB3198.1/US\$481.5), but longer ALOS (11.8 days) than eastern and western region URBMI patients.

Table 3  
Regional distribution of healthcare utilization for UEBMI and URBMI stroke inpatients in 2016

Region	Provinces	UEBMI			URBMI		
		Hospitalization cost	OOP cost	ALOS	Hospitalization cost	OOP cost	ALOS
East	Beijing	22637.9	4649.6	16.0	23098.5	9734.6	16.9
	Tianjin	16299.7	5495.3	12.7	11518.6	6142.0	10.4
	Hebei	15584.3	2860.9	13.9	14272.4	5923.9	13.5
	Liaoning	11253.1	2336.2	12.5	7989.4	2905.9	10.5
	Jiangsu	13173.8	2979.0	13.9	8936.6	2584.5	11.2
	Zhejiang	29210.4	2341.9	28.2	12704.5	4661.7	13.4
	Shandong	12173.4	3058.0	16.2	7869.8	3683.1	10.6
	Guangdong	19356.4	4003.9	19.4	15281.2	12724.4	14.2
	Hainan	14402.2	2526.0	13.0	11484.2	4427.9	10.8
	Fujian	19083.4	4273.7	17.6	15495.2	6730.1	14.4
	Shanghai	20397.9	3806.9	28.0	15809.4	3813.8	26.1
	Total	15566.4	3424.0	16.4	9845.2	4535.9	11.6
	<b>P-value</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>
Central	Shanxi	11843.8	2308.8	14.4	10570.7	4104.0	13.8
	Jilin	11321.0	2674.6	14.3	9707.9	4599.5	12.8
	HeiLongjiang	9776.9	2861.9	11.9	9247.1	5451.3	12.1
	Anhui	12809.2	2729.6	14.2	11071.2	5208.3	11.7
	Jiangxi	12376.3	2674.4	16.5	11757.3	5404.8	13.3
	Henan	10674.5	2350.8	13.6	8946.7	3800.4	12.4
	Hubei	10140.9	2304.3	13.8	6291.6	2381.8	11.3
	Hunan	11160.7	1991.8	12.4	9500.0	4149.5	12.1
	Total	10635.2	2405.1	13.9	7704.1	3198.1	11.8
		<b>P-value</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>
West	Inner Mongolia	16434.3	4437.9	15.2	13483.0	5692.7	12.7
	Guangxi	18594.5	3109.8	18.2	12174.8	4278.7	14.0

UEBMI Urban Employee Basic Medical Insurance scheme, URBMI Urban Resident Basic Medical Insurance scheme; all P-values were based on Kruskal-Wallis test.

Chongqing	14177.4	3340.4	13.8	9090.0	4473.4	10.3
Sichuan	14860.1	2777.1	16.5	9552.3	3582.7	12.1
Guizhou	18185.2	3275.5	21.4	10191.4	4868.6	16.8
Yunnan	13147.4	1995.4	13.7	8144.3	3129.1	10.6
Xizang	18613.2	1794.7	14.2	12659.6	3108.0	10.8
Shanxi	11076.5	2364.2	12.4	7124.3	2712.5	10.0
Gansu	6635.3	1507.6	12.1	5006.6	2066.8	12.2
Qinghai	19764.9	4257.4	16.4	14083.2	6706.3	28.8
Ningxia	12724.4	2380.4	13.1	7444.2	2559.6	12.2
Xinjiang	12256.6	2616.1	13.2	9597.5	4313.2	11.5
Total	14853.1	3045.9	15.3	9063.9	3973.6	11.4
<b>P-value</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>
<b>P-value (between regions)</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>
<b>P-value (between provinces)</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>	<b>&lt;0.001</b>
UEBMI Urban Employee Basic Medical Insurance scheme, URBMI Urban Resident Basic Medical Insurance scheme; all P-values were based on Kruskal-Wallis test.						

## Theil (in)equality index

The Theil inequality index values in Table 4 shows that there were significant variations in hospital costs, OOP expenses and ALOS under both UEBMI and URBMI. Table 4 shows that Theil index values were significantly higher than the Theil index of health expenditure per capita in China, which was reported to range from 0.0583 to 0.0686 between 2013 and 2016[31]. As shown in Table 4, the year-by-year UEBMI Theil hospital cost index fluctuated significantly, from 0.1256 in 2013 to 0.1700 in 2014, then back to 0.1214 in 2016. While the URBMI hospital cost index fluctuated up and down year-by-year, URBMI ALOS inequality rose every year. To further capture changes in the Theil index between UEBMI and URBMI, Table 4 calculates the difference in the Theil UEBMI and URBMI index values, which shows that URBMI inpatients suffered higher expenses and utilization than UEBMI inpatients, with higher numbers showing higher inequality. Second, the differences in Table 4 also show that these differences varied significantly year-by-year.

Table 4  
Theil index of health insurance benefits for stroke inpatients from 2013 to 2016

Year	UEBMI			URBMI			D <sub>1</sub>	D <sub>2</sub>	D <sub>3</sub>
	Hospital cost <sup>□</sup>	OOP expenses <sup>□</sup>	ALOS <sup>□</sup>	Hospital cost <sup>□</sup>	OOP expenses <sup>□</sup>	ALOS <sup>□</sup>			
2013	0.1256	0.1238	0.1397	0.2651	0.2208	0.1918	0.1395	0.0970	0.0521
2014	0.1700	0.1998	0.1388	0.2061	0.1756	0.2090	0.0361	-0.0243	0.0702
2015	0.1433	0.1585	0.1424	0.2794	0.3322	0.2134	0.1361	0.1737	0.0710
2016	0.1214	0.0929	0.1444	0.2352	0.2401	0.2371	0.1038	0.1473	0.0927

UEBMI Urban Employee Basic Medical Insurance scheme, URBMI Urban Resident Basic Medical Insurance scheme; D1=□-□; D2=□-□; D3=□-□

An alternative illustration of inequalities in expenses and utilization is shown in Figure 1, which plots for each region the year-by-year Theil index for URBMI and UEBMI expenses and utilization. In the UEBMI and URBMI group, the eastern region had the highest Theil index of hospital costs, OOP expenses, and ALOS over the four years, and the highest Theil index values between regions. The central and western region Theil inequality index values were broadly similar, but displayed some, mainly small, different year-by-year fluctuations. The inter-region inequality index in Figure 1 shows significant year-by-year fluctuations for UEBMI expenses and utilization, with the inter-region URBMI showing a more dampened year-by-year fluctuations in expenses and utilization. There were no significant trends in Figure 1 towards greater equality of hospital expenses and utilization within regions, between regions and between UEBMI and URBMI.

## Results of regression analysis

The regression analysis explored the geographical factors influencing the geographical variation of patients' healthcare utilization and expenditure. We found that the ability to deliver healthcare (open beds), the enabling factors (regional reimbursement rate and regional education level) and the provincial-level economic factors (GDP per capita) all had a significant influence on inpatients hospital expenses and healthcare utilization. Importantly, influencing factors varied by insurance type. As shown in Table 5, the ability to deliver healthcare, represented by the density of open beds, had a negative influence on inpatients' hospital costs both in the UEBMI and URBMI group. For ALOS and OOP expenses, the UEBMI independent variables were not significant. For the URBMI group, open beds, education level and reimbursement rates were negatively, and per capita GDP was positively, significantly associated with hospital costs; reimbursement rates were negatively and per capita GDP was positively associated with OOP expenses; and education level was negatively associated with ALOS.

Table 5  
Factors associated with health service expense and healthcare utilization

Variables	UEBMI			URBMI		
	b	P-value	95% CI	b	P-value	95% CI
<b>Hospitalization cost</b>						
Beds	-0.167	0.015	[-0.298, -0.036]	-0.024	0.031	[-0.171, -0.022]
Stroke centers	0.001	0.852	[-0.004, 0.005]	-0.001	0.387	[-0.005, 0.002]
Education level	0.071	0.284	[-0.063, 0.206]	-0.145	0.012	[-0.256, -0.035]
Employment rate	-0.035	0.677	[-0.211, 0.140]	0.015	0.846	[-0.149, 0.180]
Reimbursement rate	0.019	0.187	[-0.010, 0.049]	0.005	0.029	[-0.008, -0.001]
Fund per capita	0.000	0.178	[-0.000, 0.000]	0.001	0.165	[-0.000, 0.000]
GDP per capita	2.30 <sup>e-06</sup>	0.484	[-0.000, 0.000]	8.40 <sup>e-06</sup>	0.040	[4.40 <sup>e-07</sup> , 0.001]
<b>OOP cost</b>						
Beds	-0.209	0.056	[-0.005, 0.340]	-0.014	0.811	[-0.041, 0.105]
Stroke centers	-0.004	0.911	[-0.074, 0.067]	-0.001	0.483	[-0.016, 0.041]
Education level	0.011	0.942	[-0.302, 0.324]	-0.054	0.454	[-0.203, 0.094]
Employment rate	-0.142	0.333	[-0.441, 0.157]	-0.104	0.820	[-0.256, 0.048]
Reimbursement rate	-0.011	0.658	[-0.064, 0.041]	-0.007	0.008	[-0.011, -0.001]
Fund per capita	-0.000	0.120	[-0.000, 0.000]	-0.000	0.742	[-0.000, 0.000]
GDP per capita	0.000	0.541	[-0.000, 0.000]	8.77 <sup>e-6</sup>	0.006	[0.000, 0.000]
<b>ALOS</b>						
Beds	0.014	0.732	[-0.071, 0.099]	0.044	0.210	[-0.027, 0.114]
Stroke centers	-0.013	0.447	[-0.047, 0.022]	-0.015	0.250	[-0.043, 0.012]
Education level	0.009	0.903	[-0.145, 0.163]	-0.179	0.031	[-0.342, -0.055]
Employment rate	-0.028	0.693	[-0.175, 0.119]	-0.032	0.650	[-0.179, 0.114]
Reimbursement rate	0.008	0.528	[-0.018, 0.034]	-0.002	0.332	[-0.007, 0.003]
Fund per capita	0.000	0.326	[-0.000, 0.000]	0.000	0.335	[-0.000, 0.000]
GDP per capita	0.000	0.723	[-0.000, 0.000]	0.000	0.059	[-0.000, 0.000]

Beds: the number of actual open beds per 1000 residents; Availability= (The number of hospitals certified by National Stroke Center) / (Size of the geographical area);UEBMI Urban Employee Basic Medical Insurance scheme, URBMI Urban Resident Basic Medical Insurance scheme

## Discussion

For urban insurance schemes, this study provides a comprehensive nationwide exploration of equity in stroke inpatients' healthcare utilization and expenses. Using the Theil (in)equality index to measure "horizontal equity", we found significant geographic variation in stroke inpatients' healthcare utilization and hospital expenses. Furthermore, the ability to deliver healthcare (open beds), the enabling factors (regional reimbursement rate and regional education level) and the provincial-level economic factors (GDP per capita) were found to have a significant impact on healthcare equity.

A steady rise in the Theil index of ALOS both in UEBMI and URBMI group, indicated the growing inequity in ALOS. For all patients in China, Xie et al [32] also found that the overall geographical inequity in healthcare utilization rose from 2011 to 2015. We speculate that the increasingly geographical difference in UEBMI and URBMI ALOS might be attributable to policy factors. Since the ALOS was one of the important performance assessment indexes, public hospitals in China actively reduced patients' ALOS, by encouraging, for example, patients to be discharged early, to improve their performance [33]. Previous studies report that multimorbidity, specifically hypertension, was a strong predictor of longer ALOS for stroke patients [34]. There were considerable geographic variations in prevalence of hypertension in China, and high hypertension prevalence zones, which extended from parts of the southeast to the northern and northeast [35, 36]. These different geographical hypertension prevalence zones would impact the geographical utilization rates of UEBMI and URBMI in Table 3. We also expect that different regional stroke prevention and treatment systems were an important factor leading to the geographic variation in patients' ALOS. A well-functioning stroke prevention and treatment system could send stroke patients into a qualified hospital for a shorter time and provide more effective treatment than regular hospitals. Delayed medical checks and treatment, and the limited treatment capacity of a hospital, could dramatically contribute to longer ALOS for stroke patients [37, 38]. Previous studies noted the large geographic variation in stroke prevention and treatment system in China [39], which may explain some of the regional variation in stroke patient healthcare utilization. We recommend that public hospitals in China establish a unified and more scientific assessment index system for stroke patients and improve their capacity for treating stroke patients. The government should further strengthen the stroke prevention and treatment system, especially in poor areas with diminished healthcare delivery.

Our empirical evidence clearly revealed that the UEBMI group had an overall smaller Theil index of hospital costs, OOP expenses and ALOS than the URBMI group from 2013 to 2016. That means stroke inpatients with URBMI experienced greater inequity in healthcare utilization and expenditure than those with UEBMI. Examining the equity of health services utilization in different regions, Zhang [40] also found patients covered by UEBMI had greater geographical variation in healthcare utilization than those covered by URBMI. As shown in Table 1, The UEBMI scheme provided more generous benefits, more comprehensive service coverage, as well as stronger financial protection [41]. Since the UEBMI scheme provided stronger financial protection than the URBMI scheme, UEBMI patients would seek a more comprehensive treatment than URBMI patients [42]. With lower levels of benefits and financial protection, URBMI patients would economize on their level of health services utilization subject to their family's financial status [42]. This would contribute to geographical variations in healthcare utilization and hospital expenses. Importantly, patients covered by UEBMI had stable incomes due to their employment status and usually had a better financial situation than URBMI unemployed, retiree, student and child inpatients. Without worrying about the occurrence of catastrophic health expenditure, patients in

different regions would receive treatment as required, but UEBMI patients could incur higher OOP expenses and longer hospital stays[43]. Furthermore, a large proportion of patients covered by the URBMI were unemployed and children, with lower education levels than UEBMI patients. Education level was considered an important factor which would affect the ALOS for stroke inpatients[38]. There were significant regional variations in education level, with people in eastern China having the highest education level, followed by the central and western regions<sup>59</sup>. These regional education level differences probably interacted with the type of insured patient to contribute to inequity in UEBMI-URBMI healthcare utilization and hospital expenses.

Figure 1 displays the inequity in healthcare utilization and health service expenses. We found that the internal differences within regions were the major factors contributed to inequity of healthcare utilization and health service expenses. Internal differences in the eastern region accounted for the largest part of the Theil index. When the gap of socio-economic development level between the richer eastern region and poorer western and northern regions was significant, it seemed counterintuitive that the richest region had the greatest inequity in healthcare utilization and health service expenses. The coastal areas and strong economic zones in eastern China had advantages of export-linked and foreign investment industry, enhanced infrastructure and benefited most from economic policy reforms that transformed China's economy, but widened the economic gap between different cities in eastern China. Differences between cities in the central and western provinces were relatively smaller than within the eastern region. Therefore, socio-economic factors may be an important reason for the greater healthcare inequity within the eastern region. Another possible reason for the inequalities within the eastern and between the eastern and other regions was healthcare resource allocation. Previous studies reported that the eastern region had been experiencing the worst equity in health resource allocation[19], which was reflected in <sup>20,62</sup>inequities in healthcare delivery. We recommend that the government should not only make policies to improve the medical system in central and western regions, but also take the less developed provinces and prefectures in eastern China into account.

Our results demonstrated that the ability of healthcare delivery (represented by number of actual open beds per 1000 residents) had a significant negative impact on the hospital expenses both in the UEBMI and URBMI group, where more beds improved the equity of hospital expenses. Similarly, Kim et al[44] found that better nurse staffing levels had a significantly negative association with the ALOS and medical expenses of patients with hip or knee procedures. We believe that patients in areas with a stronger ability to deliver healthcare have easier access to high quality healthcare. To improve delivery, we suggest that an effective treatment protocol could reduce ALOS and hospital expenses[45]. The enabling factors (regional reimbursement rate and regional education level) were identified as important factors influencing healthcare utilization and hospital expenses in the URBMI group, but not in the UEBMI group. First, higher reimbursement signified an insurance fund's stronger financial protection, encouraging patients to utilize more health services and benefit more from central subsidies. This is reflected in our data that shows UEBMI patients enjoying higher reimbursement rates and usually higher total expense, but fewer OOP cost than URBMI patients[42]. Second, education level had a significant negative impact on URBMI inpatients. Since education level was considered an important factor causing prehospital delay in stroke treatment, better educated UEBMI patients sought stroke treatment earlier, with reduced ALOS, than URBMI patients[46]. This is consistent with Milagros et al[47] who reported that low levels of education had a strong relationship with longer length of hospital stays. Our results also revealed that GDP per capita was significantly associated with hospital costs and OOP. Economic factors are universally acknowledged as a main factor affecting healthcare utilization. We speculate patients with UEBMI had high

incomes, consequently, the reimbursement rate and GDP per capita were not significant explanatory variables for healthcare utilization and hospital expenses. URBMI patients with higher incomes were probably more willing to follow recommendations from doctors in the utilization of health services, thus GDP per capita was associated with higher health expenditure[48].

This study has a number of limitations. Our data applies to healthcare utilization and hospital expenses of urban stroke inpatients, not the whole stroke patient population in China. Due to data limitations, we used ALOS to reflect healthcare utilization of stroke patients, but healthcare utilization based on need and demand cannot be easily divided, therefore, the results should be interpreted with care. We recommend that other potential factors influencing the equity in healthcare utilization and hospital expenses, such as regional health investment be considered in future studies.

## Conclusion

Under the fragmented health insurance system in China, there were significant geographical variations in health service utilization and hospital expenses within and between regions for stroke inpatients. The UEBMI group enjoyed greater equity in healthcare utilization and hospital expenses than the URBMI group. The differences were mainly caused by the disparities within regions and not between regions. The ability to deliver healthcare, the enabling factors and the provincial-level economic factors were found to be significant. We recommend that the government improves the regional ability to deliver healthcare, establish strong regional stroke prevention and treatment networks and further develop the capacity of stroke treatment. We also recommend strengthening health education on stroke, especially for URBMI patients, to shorten the prehospital delay by stroke victims. It is also essential to further reform the urban health insurance schemes, such as increasing the reimbursement rate for URBMI stroke patients to narrow the considerable gap in healthcare utilization and expenditure between the UEBMI and URBMI group.

## Abbreviations

UEBMI: Urban Employee Basic Medical Insurance scheme; URBMI: Urban Resident Basic Medical Insurance scheme; OOP: out-of-pocket; ALOS: average length of stay; Beds: the number of actual open beds per 1000 residents;

## Declarations

## Ethics approval

Since the claims data we used was an anonymized database and had no impact on patients' health and care, the informed consent was exempted. This study was approved by the Ethics Committee of Beijing University of Chinese medicine (No.2019BZHILL0201).

## Consent for publication

Not applicable

# Competing interests

The authors declare that they have no competing interests.

# Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

# Availability of data and materials

Data in our study are third party data, and were provided by China Health Insurance Research Association. Authors in this study have the right to use this dataset, but not the right to share and distribute. The datasets used during the current study are available from the corresponding author on reasonable request.

# Contributors

YY and XFS participated in the design of this study, analyzed data and drafted the original manuscript. SN and EN participated in interpretation of data and revised the paper; ZWH and XPC analyzed the data and drafted the manuscript, YM collected research data and critically revised the manuscript, all authors have read and approved the final manuscript.

# Acknowledgments

We thank the support of the China Health Insurance Research Association, for providing the valuable data. We would also like to thank Beijing University of Chinese Medicine, for providing in-kind support.

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