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The temporal and spatial interpretation of China's health financing: what do Chinese' government 'do' in new healthcare reform?

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Abstract

Objective The analysis of health expenditure and its structure takes on a critical significance in national health policy research, and the public welfare of national health undertakings can be manifested by the government's investment in health. In this study, the aim was to analyze total health care costs, the structure of health financing, and the government's investment in health, so as to provide a reference for China's health policy adjustment.

Methods Description and cluster analysis were conducted using R language to analyze total health care costs and the structure of health financing of 31 regions in China between 1990 and 2020 to gain insights into the temporal and spatial changes total health care costs and the structure of health financing in China. The government's investment in health was analyzed using description and abundance heatmap to know the temporal and spatial changes of the government's health investment.

Results The total health expenditure per capita reached 5112.3 yuan in 2020, and the total health expenditure accounted for 7.10% of GDP. The government health expenditure took up a significantly lower share of the total health expenditure in 1993–2006 (17.09% [16.30,17.88]), whereas it has been nearly 30% (29.56% [28.73,30.3]) over the past few years. As to 31 regions in China, the government health expenditure per total health expenditure reached 67.94% in Tibet, whereas a level of 27.866% (25.629–30.103) were maintained in other regions. Beijing and Shanghai have achieved over 50.00% of social health expenditure per total health expenditure in recent five years, it was significantly higher than other regions. The per capita government expenditure as a fraction of GDP of Tibet (6.842%) was the highest region in 2011–2019, while Jiangsu (only 0.937%) was the lowest region.

Conclusions Sustainable increases in total health expenditure as a percent of GDP take on a critical significance to adequate health financing. Equity in health financing has been insufficient in China, and spatial and temporal differences of China's health financing structure are significant. The region' governments should adjust policy based on typical regions to weaken the differences.

Highlights

- Policy-oriented health systems is clear and firm in China's new healthcare reform.
- Health financing structure tends to be consistent with international standards.

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• Equity in health financing has been insufficient, and spatial and temporal differences of China's health financing structure are significant.

• The region' governments should adjust policy to weaken the differences.

Keywords Health financing, Total health care costs, Health financing structure, Government health expenditure

Background

It is well known that health financing lays a solid basis for the operation of health systems. Most of the real GDP growth and the growth of health spending worldwide are now occurring across emerging Eurasia nations. The fastest growth in health spending is in nations in the Western Pacific region, including the People's Republic of China [1]. Four out of the five BRICS countries have increased their total health expenditures substantially: Brazil for + 3%, China + 2%, South Africa + 1.5%, and Russia + 1.2% from 1995 to 2013 [2]. WHO has identified health financing as one of the six key building blocks of health systems [3, 4]. Governments have provided financial support for health systems, which is a common phenomenon [5]. The financial support provided by governments is the basic inputs of health systems, as well as the starting points for health systems to work. Consistently, raising sufficient financial resources can significantly safeguard Health financing systems. Health financing systems are tasked not only with raising sufficient financial resources to fund the health system, but doing so in a way that promotes equity [3]. Reasonable demands of health services serve as the important guarantees for meeting social members' health needs and can boost the development of health services.

Government health expenditure is a vital part of health financing structure [6]. The wide variation in the proportion of health spending that came from the government: 79.6% (78.2–81.1) of all spending in high-income countries in 2016, as did 53.9% (49.9–58.6) in upper-middle-income countries, 32.1% (28.4–36.1) in lower-middle-income countries, and 26.3% (23.3–29.5) in low-income countries [3]. China has gradually switched from a planned economy to a socialist market economy since late 20th century. Meanwhile, the Chinese government devoted great efforts to reform the health care system: total health care costs and the structure of health financing had been changing. Governments play a critical role in China's new health-care reforms emphasizing public welfare of medical service. Health financing's adequacy and equity are primary objective of health systems, and governments play an important role.

Through an overview of structure of health financing study, the following points have been summarized. In the first place, total health care costs and per total health care costs have been rising from year by year [7]. The total health expenditure as a percent of GDP continued to increase though it was at low growth rates [8]. Besides, the structure of health financing has undergone significant changes in past 30 years, while differences had been found among times and regions [9]. Moreover, government health expenditure per total health expenditure has showed a continuous increase [7]. Based on the literatures above, the government's attention in health system was annotated, and government's determinative role of health financing was emphasized once more. The above works had paved the way for in-depth study on China's health financing. However, adequacy and equity of government's health financings were affected by multiple factors, including the degree of health capital investments (total health expenditure as a percent of GDP), the degree of government support for total health expenditure (government health expenditure per total health expenditure) and demographic factors (population) [3, 6], etc. Notably, the above works have not included those indicators together, which is wrong for adequacy and equity research of government's health financings. It is imperative to include the above indicators together for adequacy and equity research of government's health financings.

Therefore, this study is explored the Chinese government's responsibilities in health financing through combining multiple indicators from a temporal and spatial perspective. We focus on total health expenditure, government health expenditure per total health expenditure, per capita government expenditure by government from 1990 to 2020 in China. Then, the spatial interpretation of 31 regions is extended further. We use multiple factors to analysis adequacy and equity of government's health financings. This research to upper-income countries is enlightening and to low- middle-income countries is helpful.

Methods

Data sources an d research contents

The research data on the adequacy of health financing in this study were gathered via 2010–2012 China Health Statistics Yearbook, 2013–2017 China Health and Family Planning Statistics Yearbook, 2018–2021 China Health Statistics yearbook (e.g., total health care costs, per total health care costs, total health expenditure as a percent of GDP, proportion of government health expenditure,

proportion of social health expenditure, as well as proportion of personal health expenditure and population). The above data involved 31 regions, except for Taiwan, Hong Kong and Macao.

The adequacy index of health financing

The index of health financing include total health care costs, total health expenditure as a percent of GDP, proportion of government health expenditure, et al. However, the proportion of government health expenditure does not consider the effect of time and space. The levels of health financing may be different since an imbalanced economic development can occur at different locations in different regions [1]. Hence, the index of per capita health expenditure by government was introduced.

The index of per capita government health inputs

A standard demographic decomposition technique popularized by Das Gupta was adopted [10]. The standard demographic decomposition technique is the situation in which a rate can be expressed as the product of several factors. Das Gupta [10] believed that the decomposition deals with finding the additive contributions of the effects of the differences in the compositional or rate factors in two populations to the difference in their overall rates. The techniques have been extended to include any number of factors, various functional relationships of the factors with the overall rate.

In my study, the reference factors involve investment funding of health care (total health expenditure as a percent of GDP), financial support of government (proportion of government health expenditure), as well as demographic factor (population). The product of the above three factors is per capita government health inputs (Per Cap Gov Heal Inp):

$$\text{per capita government health inputs} = \frac{\text{Gov}}{\text{GDP} \times \text{Pop}} = \frac{\frac{\text{Health}}{\text{GDP}} \times \frac{\text{Gov Health}}{\text{Health}}}{\text{Pop}}$$

The above three factors form a comprehensive set, since all other factors for per capita government health inputs are required to operate through one or more of those factors.

Cluster analysis

In this study, cluster analysis by R language was conducted to analyze the total health expenditure composition from 1990 to 2020 and the total health expenditure composition in 31 regions from 2010 to 2020 in China based on three main indicators (including proportion of government health expenditure, proportion of social health expenditure, as well as proportion of personal health expenditure).

The hierarchical algorithm of cluster analysis is the most common approach. In this study, the hierarchical agglomerative clustering using Ward's method is performed, whereby the similarity between the two objects is calculated using the squared Euclidean distance.

Abundance heatmap

Abundance heatmap is to classify samples and variables according to the distance of similarity, so that the higher similarity in the same class. It shows differences in the abundance by mean ± standard deviation. Abundance heatmap was generated using R language in this study to show the trends of per capita government health expenditure in GDP over 31 regions in 2011–2019 (Missing data occurred in other years), so that it may better reflect changes in different times and places.

Results

Analysis of total health care costs in China from 1990 to 2020

The total health care costs and per capita health care costs showed a sustainable growth trend from 1990 to 2020 in China. Accounting current price by ignoring the time value of money, the total health care costs are 74.74 billion yuan and 7217.50 billion yuan in 1990 and 2020,this is a 96.57-fold increase between 1990 and 2020.Calculate the total health expenditure growth annually, we found that the average annual has increased 44.9 billion yuan from 1990 to 2003, however, up to 385.8 billion yuan annually in 2004–2020. The total health expenditure per capita is 5112.3 yuan in 2020,which is 78.17 times than 1990.

According to the changes over the past 30 years, the growth of total health expenditure and the per health expenditure have increased, with an average annual growth rate of 16.57% (95% uncertainty interval[UI]14.61–18.56). The growth ranges are clearly not the same, the total health expenditure growth fell to 9.58% in 2001, the lowest of all. The total health expenditure increased by 10–15% continuously from 2012 to 2020. In line with this, the growth rates of per capita health expenditure (15.74% [13.87–17.61]) have been changed consistently.

Table 1 Total health expenditure in China from 1990 to 2020

Year	Total health expenditure (billion yuan)	Growth rates of total health expenditure (%)	Per health expenditure (yuan)	Growth rates of per health expenditure (%)	Total health expenditure as a percent of GDP (%)
1990	747.39	—	65.4	—	3.96
1991	893.49	19.55	77.1	17.89	4.06
1992	1096.86	22.76	93.6	21.40	4.03
1993	1377.78	25.61	116.3	24.25	3.86
1994	1761.24	27.83	146.9	26.31	3.62
1995	2155.13	22.36	177.9	21.10	3.51
1996	2709.42	25.72	221.4	24.45	3.77
1997	3196.71	17.99	258.6	16.80	4.01
1998	3678.72	15.08	294.9	14.04	4.32
1999	4047.50	10.02	321.8	9.12	4.47
2000	4586.63	13.32	361.9	12.46	4.57
2001	5025.93	9.58	393.8	8.81	4.53
2002	5790.03	15.20	450.7	14.45	4.76
2003	6584.10	13.71	509.5	13.05	4.79
2004	7590.29	15.28	583.9	14.60	4.69
2005	8659.91	14.09	662.3	13.43	4.62
2006	9843.34	13.67	748.8	13.06	4.49
2007	11573.97	17.58	876.0	16.99	4.29
2008	14535.40	25.59	1094.5	24.94	4.55
2009	17541.92	20.68	1314.3	20.08	5.03
2010	19980.39	13.90	1490.1	13.38	4.85
2011	24345.91	21.85	1804.5	21.10	4.99
2012	28119.00	15.50	2068.8	14.65	5.22
2013	31668.95	12.62	2316.2	11.96	5.34
2014	35312.40	11.50	2565.5	10.76	5.49
2015	40974.64	16.03	2962.2	15.46	5.95
2016	46344.88	13.11	3328.6	12.37	6.21
2017	52598.28	13.49	3756.7	12.86	6.32
2018	59121.91	12.40	4206.7	11.98	6.43
2019	65841.39	11.37	4669.3	11.00	6.67
2020	72175.00	9.62	5112.3	9.49	7.10

The total health expenditure was lower than 5% of GDP from 1990 to 2011, whereas it was more than 5% between 2012 and 2020. By 2020, it had reached to 7.10%. Details of the above dates are shown in Table 1.

The structure of health financing from 1990 to 2020

Three expenditures (government health expenditure, social health expenditure, and out-of-pocket health expenditure) have been increased year-by-year. Notably, all three are structurally quite different from one another. The government health expenditure as a percentage of total expenditure on health displayed a dumbbell-shape, and the percentages first decreased and then increased, which is noteworthy. The government health expenditure constituted a significantly lower share of the total health expenditure between 1993 and 2006(17.09% [95%UI 16.30-17.88]), while it has been up to 30% (29.56% [28.73–30.3]) in recent years. Dumbbell-shape was also visible in the social health expenditure as a percentage of total expenditure on health. The social health expenditure as a percentage of total expenditure on health was minimized between 1998 and 2005(27.50% [25.81–29.19]), whereas this percentage has been up to 40% (42.28% [40.72–43.84]) since 2016. The out-of-pocket health expenditure as a percentage of total expenditure on health appeared spindle-shaped. This percentage reached the highest value of 59.97% in 2001 and had fallen further since then. Out-of-pocket has contributed less than 30% (28.43% [27.85–29.02]) of the total health expenditure in recent five years.

We revealed three clusters about the structure of health financing from 1990 to 2020 by clustering analysis. The first stage was 1990–2007, it presented that: out-of-pocket health expenditure per total health expenditure > social health expenditure per total health expenditure > government health expenditure per total health expenditure. The second stage was 2008–2014, it showed that: social health expenditure per total health expenditure > out-of-pocket health expenditure per total health expenditure > government health expenditure per total health expenditure. The third stage was 2015–2020, the structure of health financing was expressed as social health expenditure per total health expenditure > government health expenditure per total health expenditure > out-of-pocket health expenditure per total health expenditure. Notably, the government health expenditure per total health expenditure has been increasing, and the above three expenditures' ratio was much closer to 3:4:3. See Table 2; Fig. 1 for the results of clustering analysis on the structure of health financing in 1990–2020.

The structure of health financing in different regions of China from 2010 to 2019

As depicted in Fig. 1, two stages were divided by the structure of health financing from 2010 to 2019 in different regions of China. To be specific, one stage was the years 2010–2014, and the other stage was between 2015 and 2019. We presented the recent stage of 2015–2019: four categories were set after the clustering analysis of 31 regions in the year 2015–2019 (Fig. 2).

Table 2 The structure of health financing in 1990–2020

Year	government health expenditure		social health expenditure		out-of-pocket health expenditure	
	Costs(billion yuan)	Percent(%)	Costs(billion yuan)	Percent(%)	Costs(billion yuan)	Percent(%)
1990	187.28	25.06	293.10	39.22	267.01	35.73
1991	204.05	22.84	354.41	39.67	335.03	37.50
1992	228.61	20.84	431.55	39.34	436.70	39.81
1993	272.06	19.75	524.75	38.09	580.97	42.17
1994	342.28	19.43	664.91	36.62	774.05	43.95
1995	387.34	17.97	767.81	35.63	999.98	46.40
1996	461.61	17.04	875.66	32.32	1372.15	50.64
1997	523.56	16.38	984.06	30.78	1689.09	52.84
1998	590.06	16.04	1071.03	29.11	2017.63	54.85
1999	640.96	15.84	1145.99	28.31	2260.55	55.85
2000	709.52	15.47	1171.94	25.55	2705.17	58.98
2001	800.61	15.93	1211.43	24.10	3013.89	59.97
2002	908.51	15.69	1539.38	26.59	3342.14	57.72
2003	1116.94	16.69	1788.50	27.16	3678.66	55.87
2004	1293.58	17.04	2225.35	29.32	4071.35	53.64
2005	1552.53	17.93	2586.41	29.87	4520.98	52.21
2006	1778.86	18.07	3210.92	32.62	4853.56	49.31
2007	2581.58	22.31	3893.72	33.64	5098.66	44.05
2008	3593.94	24.73	5065.60	34.85	5875.86	40.42
2009	4816.26	27.46	6154.49	35.08	6571.16	37.46
2010	5732.49	28.69	7196.61	36.02	7051.29	35.29
2011	7464.18	30.66	8416.45	34.57	8465.28	34.80
2012	8431.98	29.99	10030.70	35.67	9656.32	34.34
2013	9545.81	30.10	11393.79	36.00	10729.34	33.90
2014	10579.23	29.96	13437.75	38.05	11295.41	31.99
2015	12475.28	30.45	16506.71	40.29	11992.65	29.27
2016	13910.31	30.01	19096.68	41.21	13337.90	28.78
2017	15205.87	28.91	22258.81	42.32	15133.60	28.77
2018	16399.13	27.74	25810.78	43.66	16911.99	28.61
2019	18016.95	27.36	29150.57	44.27	18673.87	28.36
2020	21941.90	30.40	30273.67	41.94	19959.43	27.65

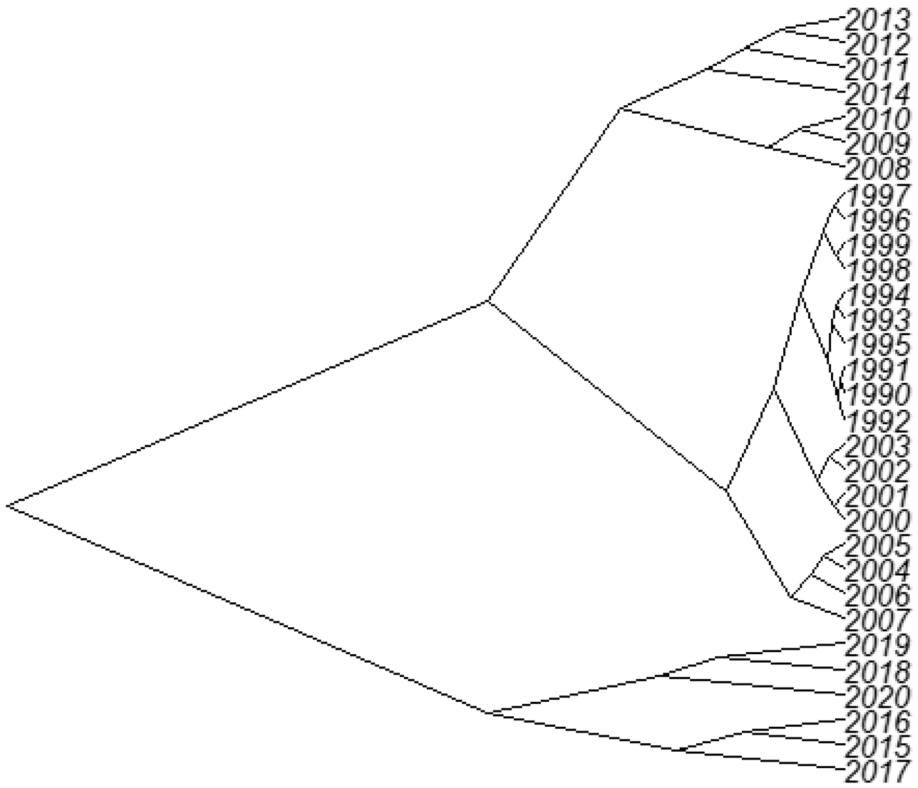

Fig. 1 The results of clustering analysis on the structure of health financing in 1990–2020

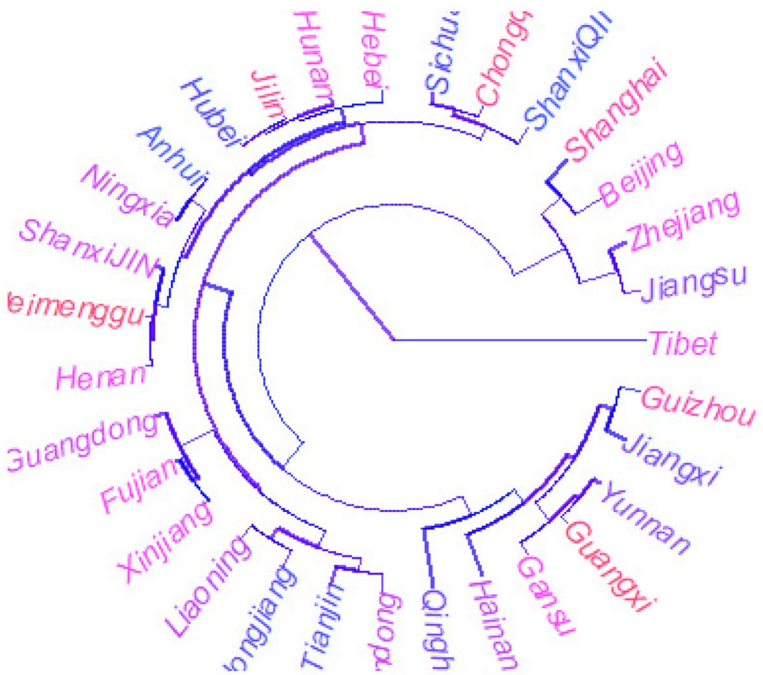

Fig. 2 The results of clustering analysis on the structure of health financing in 31 regions of China in the year of 2015-2019

The first one was that government health expenditure per total health expenditure significantly exceeded any other health expenditure. Only one region belongs to this category: Tibet. Its government health expenditure per total health expenditure reached 67.94%, while its social health expenditure per total health expenditure and out-of-pocket health expenditure per total health expenditure reached 26.39% and 5.65%, respectively.

The second one was that social health expenditure per total health expenditure reached 47.87% (95%UI 33.44–62.30), significantly higher than the sum of two other. Beijing, Shanghai, Jiangsu and Zhejiang belong to this category. Government health expenditure per total health expenditure reached 27.51% (15.59–39.43), and out-of-pocket health expenditure per total health expenditure accounted for 24.45% (12.00-36.90).

The third one was presented as government health expenditure per total health expenditure > social health expenditure per total health expenditure > out-of-pocket health expenditure per total health expenditure, it included Qinghai, Guizhou, Jiangxi, Hainan, Gansu, Guangxi and Yunnan. The specific performance was government health expenditure for 37.33% (32.08–42.57) of total health expenditure, social health expenditure for 34.40% (31.48–37.33) of total health expenditure, and out-of-pocket health expenditure for 28.27% (25.39–31.15) of total health expenditure.

The fourth category included the remaining regions, which was presented as social health expenditure per total health expenditure (42.861% [39.893–45.830]) was higher than two other, and out-of-pocket health expenditure per total health expenditure (29.278% [27.477–31.078]) was slightly higher than government health expenditure per total health expenditure (27.866% [25.629–30.103]).

The per capita government health inputs

We first performed univariate and multivariate analysis of the per capita government health inputs, total health expenditure as a percent of GDP, proportion of government health expenditure, population were found to be the influential factors ($P < 0.05$). So, three relevant indicators were calculated by the formulas.

Nationally, government health expenditure accounted for 7.156% (95%UI 6.713–7.599) of total government expenditure, the ratio increased from 6.312 to 8.931% in the year of 2009–2020. Moreover, government health expenditure as a fraction of GDP increased from 1.381 to 2.158% (1.698%% [1.557–1.839]).

From the 31 regions' data perspective, the per capita government health inputs were counted by total government expenditure as a fraction of GDP, government health expenditure per total health expenditure and population from 2011 to 2019.

Changes inconsistencies were identified on per capita government health inputs among 31 regions from 2011 to 2019.Tibet (6.842%) was the highest region, the second one was Qinghai (4.359%), the next one was Gansu and Guizhou, the per capita government health inputs were 3.564% and 3.377%, respectively. The last one was the remaining regions, the per capita government health inputs was1.847% (95%UI 1.627–2.068). To be specific, Yunnan, Hainan, Xinjiang and Ningxia were at relatively high level regions, whereas Jiangsu (only 0.937%) was the lowest region (Table 3).

We focused on 31 regions' per capita government health inputs in 2011–2019, then displayed the increasing and decreasing by applying R language, a visualization tool, to establish the abundance heatmap. For years, per capita government health inputs could be divided into two parts, which the year 2015 was the watershed. The per capita government health inputs were significantly higher after than before. For regions, was also for two parts.18 regions from Tianjin to Ningxia in Fig. 3 belonged to the class, the per capita government health inputs had increased year on year. This class presented "climbing shape", especially the year 2018 and 2019, the increase was more significant.13 regions from Beijing to Hubei (Fig. 3) belonged to the other class, presented "peak shape". The per capita government health inputs showed a first increasing and then decreasing, although was not evident in some regions.

Discussion

Sustainable increases in total health care costs and total health expenditure as a percent of GDP are essential to adequate health financing

Total health expenditure, per total health expenditure and total health expenditure as a percent of GDP are a vital measure of adequate health financing. Although not as high as in upper-income country(a percent of GDP was 5.0% (95%UI 4.7–5.3)), total health expenditure as a percent of GDP increased in lower-middle-income countries and BRICS (Brazil, Russia, China, South Africa) in particular [2]. Moreover, the growth of per total health expenditure in China has been higher than the global average (8.52%), whereas it has been lower than upper-middle-income countries ($158 per year) [3]. Total health expenditure as a percent of GDP has been continuously risen in China with this indicator reaching 7.10% in 2020. The strategic plan of Healthy China 2020 issued by the Ministry of Health of China has set the goal that the key health indicators should reach the average level of developed countries by 2020 [11], and total health expenditure as a percent of GDP has reached 6.5-7.0% in China, which has reached the target. Notably, the total health expenditure in China

Table 3 31 regions' per capita government health inputs from 2011 to 2019 in China(%)

Regions	2011	2012	2013	2014	2015	2016	2017	2018	2019	Mean
Beijing	1.695	1.792	1.827	1.850	1.942	1.823	1.811	1.751	1.988	1.848
Tianjin	0.932	0.937	1.010	1.089	1.677	1.183	1.084	1.619	1.545	1.268
Hebei	1.382	1.387	1.517	1.558	1.855	1.769	1.712	2.173	2.054	1.753
ShanxiJIN	1.625	1.707	1.819	1.961	2.335	2.374	2.102	2.287	2.265	2.106
Neimenggu	1.302	1.287	1.324	1.356	1.522	1.675	2.067	2.012	1.989	1.654
Liaoning	0.943	0.936	0.974	1.012	1.020	1.423	1.469	1.518	1.521	1.234
Jilin	1.484	1.461	1.520	1.538	1.791	1.893	1.861	2.660	2.523	1.906
Heilongjiang	1.487	1.397	1.433	1.614	1.886	1.869	1.879	2.400	2.422	1.863
Shanghai	1.125	1.152	1.162	1.168	1.274	1.528	1.467	1.410	1.479	1.330
Jiangsu	0.829	0.896	0.928	0.894	0.962	0.973	0.942	0.933	0.967	0.937
Zhejiang	1.014	0.988	1.049	1.105	1.167	1.181	1.156	1.102	1.276	1.128
Anhui	1.976	2.125	2.183	2.086	2.261	2.255	2.238	1.864	1.894	2.113
Fujian	1.081	1.132	1.233	1.232	1.375	1.349	1.320	1.160	1.136	1.242
Jiangxi	2.003	2.078	2.271	2.285	2.521	2.533	2.390	2.602	2.604	2.410
Shandong	0.937	0.996	1.044	1.043	1.146	1.195	1.161	1.376	1.353	1.164
Henan	1.554	1.657	1.745	1.754	1.971	1.963	1.879	1.874	1.882	1.841
Hubei	1.416	1.378	1.492	1.519	1.796	1.871	1.765	1.396	1.393	1.576
Hunan	1.434	1.531	1.604	1.605	1.745	1.776	1.719	1.923	1.785	1.711
Guangdong	0.943	1.030	1.073	1.186	1.312	1.434	1.473	1.436	1.548	1.312
Guangxi	2.221	2.196	2.244	2.291	2.301	2.595	2.546	2.824	2.767	2.470
Hainan	2.206	2.341	2.458	2.538	2.773	2.875	2.900	3.007	3.438	2.791
Chongqing	1.656	1.717	1.796	1.788	2.058	1.915	1.879	1.764	1.661	1.822
Sichuan	1.975	1.985	2.080	2.077	2.316	2.381	2.276	2.082	2.190	2.173
Guizhou	3.611	3.540	3.471	3.349	3.539	3.423	3.255	3.163	3.279	3.377
Yunnan	2.873	2.793	2.747	2.808	3.126	3.199	3.352	2.794	2.784	2.950
Tibet	5.805	6.208	5.886	6.249	7.055	7.427	7.287	7.187	7.439	6.727
ShanxiQIN	1.799	1.779	1.832	1.796	2.096	2.019	1.938	1.935	1.874	1.909
Gansu	3.222	2.991	3.002	3.108	3.814	3.943	3.803	3.924	3.928	3.564
Qinghai	2.851	3.256	3.723	3.787	4.430	4.347	4.852	5.152	5.325	4.359
Ningxia	2.162	2.216	2.358	2.454	2.650	2.702	2.899	3.089	3.003	2.671
Xinjiang	2.741	2.537	2.498	2.509	2.820	3.099	2.922	2.675	2.536	2.699

has reached to upper-middle-income countries. In other words, health financing systems are sufficient in China. Thus, it is imperative for China to grasp the first principle of steady improvement in the field of health financing.

Total health expenditure as a percent of GDP in China maintained a slightly higher than upper-middle-income country over the past few years, whereas it has not reached the level of the high-income country. Nevertheless, it is not necessary to achieve high levels in a short period in China since excessively fast growth proportionality of total health expenditure as a percent of GDP has imposed pressures to the government [12]. Lastly, it will affect the sustainable development of health financing. As a result, an appropriate control is recognized as the important principle. In general, under the premise of government health sustainability, an appropriate control of proportionality of total health expenditure as a percent of GDP is a wise choice.

The Chinese government has been committed to achieving health financing

As other countries in southeast Asia, Chinese' health financing structure evolved from the Bismarck style of risk-sharing [2]. Of course, the national policies varied in each country. For China, the structure of health financing varied in various phases, especially for government health expenditure per total health expenditure. Government health expenditure per total health expenditure has been changing significantly in China in recent 30 years. Health financing structure trended to international standards (3:4:3) in recent six years [13], which is more reasonable for Chinese' health financing. Government health expenditure per total health expenditure

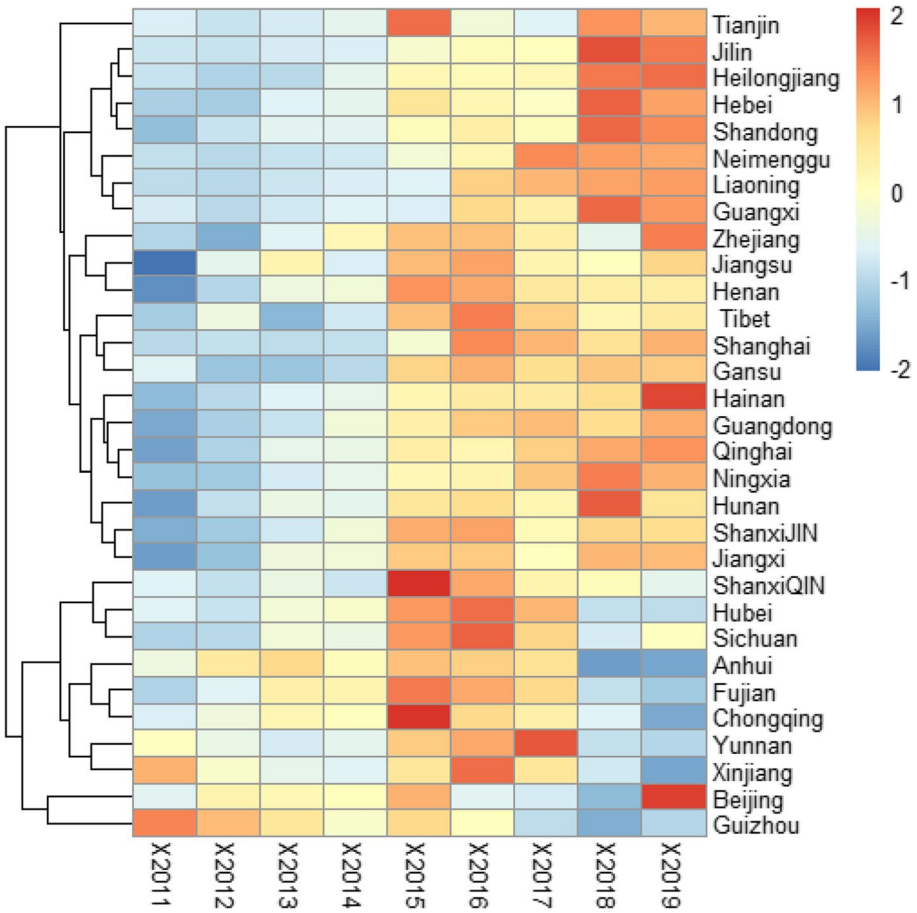

Fig. 3 The abundance heatmap of 31 regions' per capita government health inputs in 2011-2019

is a metrics of level of government health spending and priority degree of recurrent financial expenditures. This metrics is not only the performance for government's adequacy on health financings, but also the evaluation metrics of official public welfare. The Chinese government launched a new round of healthcare reform in 2009, Government health expenditure per total health expenditure has maintained at 29.56% (95%UI 28.73–30.30). Compared to the lower percent in 1993–2006 (17.09%), public welfare character of new health care reform was apparent. The Chinese government has invested 1920.1 billion yuan on healthcare in 2020. Despite during the COVID-19 outbreak, the percent of government health expenditure increased to 30.40% in 2020. From this, the Chinese government's public welfare character did not weaken. By contrast, the government's share is still negligible in India [14]. Thus, policy-oriented Chinese government health systems is clear and firm.

In addition to this, social health expenditure per total health expenditure increased year over year in the latter two parts. It had been up to 40% (42.28% [40.72–43.84]), especially in 2015–2020. Social health expenditure per total health expenditure is health-care funding invested by social, including social insurance expenditures, commercial insurance and social donations. In China, social insurance expenditures are the most. We take measures to build social security system from 1993, for example, basic pension insurance, basic medical insurance and employment injury insurance, had been established currently. The Chinese social security system has been achieved over many years.

A reasonable health financing structure is a valid method for residents' medical risk avoidance at the present stage. Out-of-pocket health expenditure per total health expenditure is an important indicator of financing structure risk protection [15]. In respect of structural optimization, the Chinese public health expenditures were more than 70% of all health spending, private expenditure on the contrary reduced to less than 30%.As the private expenditure accounting continue to decrease, residents disease burden could be reduced, therefore, the patient experience of "expensive medical treatment"

changed, but remain significantly higher than other countries [16].So, we should continue to deepen government-led model and reduce private expenditure, in order to maintain in reasonable proportion for health financing structure. This change reflects an improved structure of health financing [17].

Taken in context with the data, social health expenditure per total health expenditure tended to steadily increase. As seen from that, social health expenditure per total health expenditure is large in scale. In reality, social health expenditure finance lever is high in healthcare fields. The social health funding potential plays an important role in health spending, its funding potential is far beyond the social health expenditure and out-of-pocket health expenditure. It is the most source of funding in healthcare fields, this seems to become possible in the future. The social health expenditure can resolve the contradiction between poor government investment and an increasing demand of patients. At the same time, it can relieve the contradiction between for-profit and not-for-profit of hospitals.

Equity in health financing has been not sufficient in China, spatial and temporal differences in China's health financing structure are significant

The per capita government health inputs are the equity-related indicators to measure regional difference. Per capita government health inputs is the standard of criterion for equity in government health financing based on the standard demographic decomposition technique popularized by Das Gupta and the formula of government health spending per capita [3]. Although a uniform reference is lacking, regional differences may reflect level of government health spending in 31 regions in China. This regional differences were evident. Similarly, it is appeared in India and in inner rural areas of all BRICS countries [1]. We believe that economic is one of the most important factors. Per capita government health inputs are lower in high levels of economic development, was represented by Jiangsu and Guangdong. In contrast, per capita government health inputs are higher in low levels of economic development, which are closely associated with region economy and population [3, 6]. Jiangsu and Guangdong are the two most populous provinces in China, per capita government health inputs have not been among the best, although its high-economy levels in Jiangsu and Guangdong. However, some provinces with small populations have high percent, such as Tibet, Qinghai and Ningxia, not because of region economy and population but because of policies. The central and local Chinese governments medical health investment presented a thirty-seventy ratio, had achieved the local Chinese governments should assume primary responsibilities for medical health investment [18]. So, per capita government health inputs were severely uneven in 31 Chinese regions, we needed to develop policies to narrow the disparities among regions.

Spatial and temporal changes in per capita government health inputs are significant. Abundance heatmap suggests that per capita government health inputs were low in 2011–2014. Besides, there has been a significant increase from 2015, with the greatest increases in Central Plains, northeastern provinces and eastern regions in China (e.g., Tianjin, Shandong, Hebei, Heilongjiang, Jilin, as well as Zhejiang), as well as with the decreases in Central and Western regions in China (e.g., Guizhou, Yunnan, Xinjiang, Anhui, Chongqing, as well as Hubei), which is closely associated with region economy [3]. The consistency of regional government health-input is difficult to ensure among 31 regions for regional economic differences, which is recognized as the first reason for differences of abundance heatmap. Second, the stress of governments' fiscal spending in different fields also accounts for differences of abundance heatmap. Local government spending distributes on distinct domains (e.g., education, economy, and health) [19]. 31 regions' government are considerably more divergent. Indeed, there were no need to keep the per capita government health inputs as consistent as possible, whereas persistent low-level indicators in some regions indicated low-health-investment by the government. Accordingly, the government is required to pay sufficient attention to health system inputs.

Conclusions

Interpretation of sustainable increases in total health care costs take on a critical significance in adequate health financing in the past three decades. Health financing structure tended to be consistent with international standards over the past three decades, and the Chinese government has been committed to achieving health financing. Equity in health financing has been not sufficient in China, spatial and temporal differences in China's health financing structure are significant. Sustainable increases in the quantity, equity, and strengthening local government-oriented measures are of great significance to us. This research to low- middle-income countries were enlightening and helpful.

This study has some limitations, which could be the subject of future lines of research. First, we met the challenges related to the reliability and completeness of population data. Most of Chinese regions are input-province or output-province of migratory population, such that the actual population were not consistent with history data. We acknowledge that the input data had

some weaknesses, though it was not significantly different. Second, the per capita government health inputs from 2011 onward were counted, and only the regions data of health financing structure from 2011 onward are presented in China Public Health Statistics Yearbook. We could explain more issues if we had the supplementary data of prior to 2011. Third, significant regional differences appeared with such data are arguably relevant for national policy, and an in-depth analysis was conducted on national policy for its' complexity.

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Availability of data and materials
The data that support the findings of this study are open on 2010-2012 China Health Statistics Yearbook, 2013-2017China Health and Family Planning Statistics Yearbook, 2018-2021 China Health Statistics yearbook. All research data are accessible at.

Data Availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Ethics approval was not required for this study.

Competing interests
The authors declare no competing interests.

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