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Study on the spatial and temporal differences and influencing factors of out-of-pocket payments as a share of total health expenditure in China

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Abstract

Background Globally, Out-of-pocket (OOP) payments as a share of Total Health Expenditure (THE) has always been a focus of attention in the field of health economics, which affects the economic burden of medical treatment for residents. At present, countries around the world have widely used spatial econometric models to conduct in-depth discussions and analyses of their own OOP, exploring the spatial distribution characteristics and influencing factors of OOP in different regions. However, in China, research in this area is relatively scarce, and few studies have been conducted from a macro perspective and space-time dimension.

Methods Based on the panel data of 31 provinces in China, the spatiotemporal distribution characteristics of the proportion of OOP payments in China from 2013 to 2022 were analyzed using spatial autocorrelation. The spatial Durbin model (SDM) was employed to explore the factors influencing OOP payments as a share of THE in China.

Results The results indicate that the proportion of OOP in China shows a decreasing trend, and there is a significant spatial positive correlation. The change in spatial agglomeration is relatively stable, and only some provinces have a slight change. SDM shows that the main factors affecting the inter-provincial differences in the OOP proportion in China include the elderly dependency ratio (direct effect − 0.181, indirect effect − 0.585), the child dependency ratio (direct effect 0.292, indirect effect 0.686), per capita GDP(direct effect 11.235), and the proportion of government health expenditure to fiscal expenditure (direct effect − 0.254, indirect effect − 0.994), the average number of medical visits per year (direct effect − 0.444), the expenditure of basic medical insurance (direct effect − 1.519, indirect effect − 3.940), and the average medical cost of outpatients (direct effect 3.142, indirect effect − 10.064). These factors collectively influence the spatial variation in OOP payments across provinces in China.

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Conclusion The spatial distribution difference of OOP proportion in China is obvious. Factors such as demographics, economics, policy, and health service utilization can all significantly influence OOP. The government should further implement differentiated medical security policies, optimize the allocation structure of health resources, enhance the capacity of primary medical services, promote cross-provincial medical cooperation, and ensure that local residents can enjoy equal access to high-quality medical services and reduce their medical burden.

Keywords Out-of-pocket payments, Spatial-temporal difference, Influencing factor, Spatial dubin model, China

Introduction

Out-of-pocket (OOP) payments are an important topic in global health economic research. Since the 1970s, OOP has gradually attracted extensive attention from scholars as a key indicator of the financial burden of medical care on residents [1, 2]. OOP refers to payment made directly by an individual to a healthcare provider in exchange for using healthcare services [3]. The World Health Organization (WHO) has indicated that when OOP payments account for more than 40% of total health expenditure (THE), it not only exacerbates the financial burden on individuals, potentially pushing families into poverty, but also may lead to underutilization of healthcare services by the population, which in turn negatively affects the overall health level and socio-economic development [4]. A level that is too low might result in a lack of rigidity in the cost of healthcare, thereby affecting the rational use of healthcare resources and increasing the burden on the healthcare system, which is not conducive to controlling the rapidly growing health costs [5]. Spatial differences in health expenditures are evident globally, particularly across the economic, social, and health security systems of various countries and regions. These disparities are especially pronounced in low-income and middle-income countries, where they reflect an unequal distribution of healthcare resources and insufficient policy protection [6]. Even in economically developed countries, the high cost of health care can still erode the financial situation of some families [4, 7]. This spatial variation exists not only between countries but within different regions of the same country. As the world's largest developing nation, China with its vast territory and large population, experiences unbalanced economic development. This leads to disparities in medical resources and health protection levels across various regions. Consequently, this inequitable distribution significantly increases the healthcare burden on the population [8].

Following China's Reform and Opening-up in 1978, the government dismantled the publicly-funded health protection system and permitted health institutions to recover costs through service charges. This led to health institutions generating income through over-diagnosis, over-treatment, and over-prescribing. Concurrently, the implementation of the household contract responsibility system dismantled the people's commune system and its cooperative medical insurance, leading to the collapse of grassroots health organizations in rural areas. Consequently, rural residents' health insurance coverage rate plummeted, causing the proportion of OOP relative to THE to soar from 20% in 1978 to 60% in 2001 [9]. Over 35% of urban families and 43% of rural households are shouldering an undue burden from medical expenses, which has led to poverty and a reduction in poverty due to illness. This phenomenon, known as "the difficulty and high cost of getting medical treatment," has sparked widespread public concern and drawn the Chinese government's attention [10]. The "Health Financing Strategy for the Asia Pacific Region (2006–2010)" states that when OOP payments as a share of THE reaches 30–50%, it significantly restricts residents' access to healthcare services and increases the financial burden on households [11]. In response to the high burden of OOP payments, the Chinese Government has implemented a series of policy measures to reduce the proportion of OOP relative to THE: In 2003, the New Rural Cooperative Medical Insurance (NCME) was established, followed by the launch of the pilot Urban Residents Medical Insurance (URMI) in 2007. Both programs involve substantial financial subsidies from central and local governments, along with moderate individual contributions. Additionally, the Urban Employees Medical Insurance (UEMI) scheme has been strengthened [12]. In 2009, the Chinese Government embarked on a comprehensive reform of its medical and health system, with a strong emphasis on accelerating the establishment and enhancement of a multi-tiered medical security system covering all the people [13]. In 2015, the Chinese government also proposed the establishment of a hierarchical diagnosis and treatment system, aimed at rationally allocating medical resources and promoting the equalization of basic medical and health services. With multiple initiatives, China's OOP share was below 30% for the first time in 2017 [9]. However, the Chinese government remains vigilant and has introduced several development plans aimed at further alleviating the relative burden of OOP expenses: The "'14th Five-Year' National Health Plan" proposes to reduce the proportion of OOP as a share of THE to 27% by 2025 [14]; the "Healthy China 2030" Outline explicitly stipulates that by 2030 the rate should be reduced to 25% [15]. China's health-care reform process presents a unique path, but it also mirrors strategies implemented in other middle-income countries. For example, in 1988,

Brazil established a unified universal free health care system, which reduced OOP by providing free health care, but regional differences remained significant [16]. In 1994, a family health plan was established to provide community residents with disease prevention, chronic disease management and other services through a team of family doctors. This further reduced the direct cash expenditure of residents for medical treatment due to illness [17]. In addition, Brazil encourages residents to purchase private insurance, and in 2000 established the National Agency for Supplemental Health to oversee the private insurance sector and ensure diversity and equity in medical services. Similarly, in 2018, the Indian government launched the Ayushman Bharat Program (ABP). The program, which includes Health and Wellness Coaching (HWC) and primary health care (PHC) services for all, aims to improve comprehensive health care for the poor and vulnerable and to reduce OOP during patient visits. Despite some progress in reducing OOP, India still faces challenges in terms of supply and demand for healthcare services and government spending on health [18, 19]. Like these countries, although China has gradually solved the problem of high OOP in recent years and the burden of people's medical treatment has been eased, the problem of spatial difference and equity still cannot be ignored. These issues continue to be critical indicators of interest for both government officials and scholars across various fields, historically, presently, and into the future.

Currently, research has increasingly focused on the spatial variability of OOP payments across different countries. A study conducted in Malawi revealed the presence of geographic spillovers of OOP expenditures, with factors such as education being the main factors influencing the spatial dependence of OOP payments [20]. Educated people seek quality health care, and they have a high income level that allows them to pay for it. As education levels rise, if local health care supplies do not meet al.l their needs, residents will move to neighboring areas, resulting in higher local and neighboring areas' OOP spending. Similarly, South Korea discovered regional disparities in outpatient OOP expenses through spatial autocorrelation analysis and further explored the spatial relationship between OOP and socioeconomic status using a geographically weighted regression (GWR) [21]. Research shows that areas with lower economic status often face higher OOP payments burden, and this imbalance between regions not only affects the medical burden of local residents, but also may affect neighboring areas through spillover effects. It is recommended that regional disparities be addressed and that the fairness of overall health services be enhanced through inter-regional resource sharing and the balanced distribution of medical services. Zhang et al. analyzed spatial differences in OOP payments using the spatial Durbin model (SDM) and found that demand, supply, and socioeconomic factors are key factors in reducing OOP payment risk and ensuring the sustainability of health financing [22]. Among the supply factors, the proportion of primary health care beds and the proportion of health technicians in hospitals and primary health institutions have a significant negative indirect impact on OOP payments. Additionally, the direct impact of bed share on OOP payments is also significantly negative. This suggests that the provision of health resources not only has an impact locally, but also has an indirect impact on the surrounding area through spatial interactions. Hou and Wang analyzed the distribution of healthcare expenditures in different provinces using the entropy weight method, σ convergence, and β convergence, revealing a large disparity in government investment in public health across provinces [23]. Governments in economically developed regions have more financial power to invest in health, while those in economically weaker regions often struggle to provide effective health care. This widens regional health disparities and affects OOP payment levels in surrounding areas via spatial spillovers. These studies show that spatial differences in OOP payments are not only affected by local factors, but also by the spillover effects from neighboring policies, resource allocation, and social economy.

Although the aforementioned studies have delved into the spatial distribution differences and influencing factors of OOP, research in this area in China remains scarce. Based on the new era of socialism with Chinese characteristics, this study explores whether the spatial differences in the share of OOP payments as a share of THE and the fairness issue have been improved accordingly in this development context. Simultaneously, it reveals the impacts of various factors, such as demography, economy, policy, and the supply and utilization of healthcare resources, on the proportion of OOP payments to THE in the spatial dimension. This provides a more comprehensive understanding of the spatial variations in OOP payments as a share of THE in China. Furthermore, it offers a theoretical basis and policy suggestions for optimizing China's healthcare reform policies and promoting a balanced distribution of healthcare resources among regions.

Data and methods

Data sources and variables

The spatial basic unit for this study is the 31 provinces, autonomous regions, and municipalities directly under the central government in China (Due to different statistical standards, Hong Kong, Macao, and Taiwan are not included in this study). All the data are obtained from China Health and Family Planning Statistical Yearbook (2013–2017), China Health and Health Statistics

Table 1 Description of variables

Types	Variables	Code	Definitions	Expected sign
Dependent variable		OOP/THE	OOP payments as a share of THE	
Independent variables	Demographic factors	ODR	Old dependency ratio	+
		CDR	Children dependency ratio	+
	Economic factors	PGDP	Per capita GDP	+
		UR	Per capita disposable income of urban and rural residents	+
	Policy factor	GE	Proportion of government expenditure on health to fiscal expenditure	-
	Supply of medical resources factor	MTP	The number of medical technicians in healthcare facilities per 1000 persons	-
	Health care utilization factors	ANMV	Average number of medical visits per year	+
		AHR	Annual hospitalization rate of residents	+
	Medical insurance factor	BMIE	Basic medical insurance expenditures	-
	Medical expense factors	ACMTO	Average cost of medical treatment for outpatients	+
		AMEI	Average medical expenses of inpatients	+

Table 2 Descriptive statistics of variables

Variables	Mean	S.D.	Min	Max
OOP/THE	27.985	6.403	5.160	44.990
ODR	16.062	4.568	7.010	28.770
CDR	23.675	6.475	11.710	38.380
PGDP	10.935	0.432	10.003	12.156
UR	2.560	0.513	1.827	7.108
GE	8.123	1.586	3.970	13.930
MTP	6.881	1.623	3.640	15.460
ANMV	5.589	1.879	2.670	11.650
AHR	16.302	6.302	6.200	107.000
BMIE	5.816	1.014	2.477	7.747
ACMTO	5.535	0.271	4.690	6.525
AMEI	9.125	0.320	8.526	10.198

Yearbook (2018–2022), China Statistics Yearbook (2013–2022), and China National Health Accounts Report in 2023. To address the problem of missing data for certain years or regions, we have taken the approach of looking up the statistical yearbooks of each province and the statistical bulletin of national economic and social development to fill in the blanks or used the linear interpolation method to deal with the missing data [24].

In this study, OOP as a share of THE is utilized as the dependent variable. With reference to previous literature, we have chosen the old dependency ratio and the children dependency ratio as representative factors of the demographic structure dimension to reflect the influence of different age structures on OOP [25]. Similarly, in terms of economic factors, per capita GDP and the per capita disposable income of urban and rural residents are selected to reflect the level of regional economic development and the degree of economic imbalance between urban and rural areas [26]. In terms of policy, the proportion of government health expenditure in fiscal expenditure is selected to reflect the government's emphasis on and investment in the medical and health field [23]. Additionally, to assess the impact of healthcare resource supply on OOP spending, we select the number of medical technicians per 1,000 persons in healthcare facilities. We also select factors related to medical service utilization, insurance coverage, and healthcare expenses to explore their impact on OOP spending [27].

Finally, the Variance Inflation Factor (VIF) was applied to these factors to check for multicollinearity in variable selection. Non-proportional variables are transformed using their natural logarithm to address potential heteroscedasticity. Table 1 shows the specific meanings of the indicators. Table 2 shows the descriptive statistics for each variable.

Methods

Spatial weight matrix

The construction of a spatial weight matrix is the premise of spatial autocorrelation analysis and reflects the spatial dependence relationship among various elements in the region, which mainly includes Bishop adjacency matrix, Rook adjacency matrix, Queen adjacency matrix, inverse distance matrix and economic characteristic matrix [28]. The Queen adjacency is when two regions share a common boundary or vertex. A review of the literature on adjacency matrices showed that 75% of the included literature used the Queen adjacency matrix [29]. In view of the wide application of the Queen adjacency matrix in existing studies, the Queen adjacency matrix is also used in this study to ensure consistency with mainstream methods and to facilitate comparison with other studies. Since Hainan Province has no neighboring province, it is treated as a neighboring province to Guangdong Province, based on previous studies [30]. The spatial adjacency matrix is defined such that a value of 1 indicates that the regions are adjacent, while a value of 0 indicates

that the regions are not adjacent. Its basic form is as follows:

$$w_{ij} = \begin{cases} 1 \; if \; provinces \; i \; and \; j \; share \; border \; or \; vertex \\ 0 \; otherwise \end{cases} \quad (1)$$

Spatial autocorrelation tests

Global spatial autocorrelation can test the overall spatial distribution of a region, and the Global Moran's I is the most widely used statistic for spatial autocorrelation [31]. It is calculated as follows:

$$Global \; Moran's \; I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n}W_{ij}\left(x_i-\bar{x}\right)\left(x_j-\bar{x}\right)}{\sum_{i=1}^{n}\sum_{i=1}^{n}W_{ij}\sum_{i=1}^{n}\left(x_i-\bar{x}\right)^2} \quad (2)$$

In Eq. (2), $x_i$and x_j denote the OOP as a share of THE in regions i and j, respectively, n is the total number of provinces, $\bar{x}$ is the mean value of OOP share, and W_{ij} denotes the spatial weight matrix. The value range of Moran's Index is generally between −1 and 1. When Moran's Index > 0, it indicates a positive spatial correlation. When Moran's Index < 0, it indicates a negative spatial correlation. When Moran's Index = 0, the space presents randomness.

The local Indicator of Spatial Association (LISA), developed by Anselin as a localized adaptation of the global Moran's index statistic, is also known as the Local Moran's Index. It is utilized to investigate the spatial relationships between a specific area and its immediate neighbors [32]. The formula is calculated as follows:

$$Local \; Moran's \; I = \frac{n\left(x_i-\bar{x}\right)\sum_{j=1}^{n}W_{ij}\left(x_j-\bar{x}\right)}{\sum_{j=1}^{n}\left(x_i-\bar{x}\right)^2} \quad (3)$$

x_i、x_j、n、$\bar{x}$、W_{ij} are the same statistics used to calculate the global Moran's index. When the local Moran's index > 0, it indicates a positive correlation between the observed value and its neighboring regions, meaning that the high (low) value of this region is surrounded by high (low) value of the neighboring regions. When the local Moran's index < 0, it indicates that the high (low) value of this region is surrounded by low (high) values of neighboring regions, indicating a negative spatial correlation. Figure 1 illustrates the trend changes in OOP/THE, while Fig. 2 displays the LISA maps for the years 2013, 2016, 2019, and 2022, both generated using ArcGIS Pro.

Spatial econometric mode

There are three traditional spatial econometric models: Spatial Error Model (SEM), Spatial Auto-Regression model (SAR), and Spatial Dubin Model (SDM) [33]. SEM is primarily used to address spatial error dependence, while the SAR mainly focuses on the spatial lag effect of the dependent variable. SDM is a combination of SAR and SEM that takes into account both the spatial lag of the dependent variable and the effect of the error term on the model. Therefore, we use SDM to spatially analyze the factors affecting individual cash health expenditures. The formula is as follows:

$$Y_{it} = \rho\sum_{j=1}^{n}W_{ij}y_{it} + \alpha x_{it} + \beta\sum_{j=1}^{n}W_{ij}x_{it} + \mu_{it} \quad (4)$$

Among them, Y is the dependent variable, representing the OOP payments as a share of THE; x is the independent variable, representing ODR, CDR, PGDP, UR, GE, MTP, ANMV, AHR, BMIE, ACMTO, and AMEI; i denotes the province; t represents the year; ρ is the spatial autocorrelation coefficient; α is the autoregressive coefficient; β represents the coefficient of the spatial lag term of the independent variable; and μ is the random disturbance term. The direct effect represents the influence of each factor on a specific region, while the indirect effect, or spatial spillover effect, reflects the impact of the factors from neighboring regions on that region. The total effect is the sum of the direct and indirect effects. Spatial econometric analysis is conducted using STATA 16SE.

Results

A descriptive statistical analysis of OOP payments as a share of THE in China

Table 3; Fig. 1 show that China's OOP payments ratio has been on an overall decreasing trend from 2013 to 2022. The minimum value increased from 7.47% in 2013 to 8.52% in 2022, while the maximum value decreased from 44.99 to 29.13%. The interquartile range fluctuated between 9.50 and 5.03, suggesting a trend toward the equalization of the OOP payments share among provinces. Although the gap among provinces is gradually narrowing, disparities in expenditure remain. In 2022, the share of the OOP payments in Henan (29.13%), Shanxi (28.92%), and Heilongjiang (28.88%) were higher than that in provinces with relatively lower OOP payments, such as Tibet (8.52%), Beijing (13.56%) and Shanghai (13.91%).

Spatial correlation analysis of OOP payments as a share of THE in China

The findings from the global spatial autocorrelation analysis in Table 4 reveal that the global Moran's I for OOP/THE across China's 31 provinces over the past decade is positively significant at the 5% level. This signifies a pronounced spatial autocorrelation in the distribution of OOP/THE. Analyzing the temporal trend, there is a discernible downward trajectory in the global Moran's I for

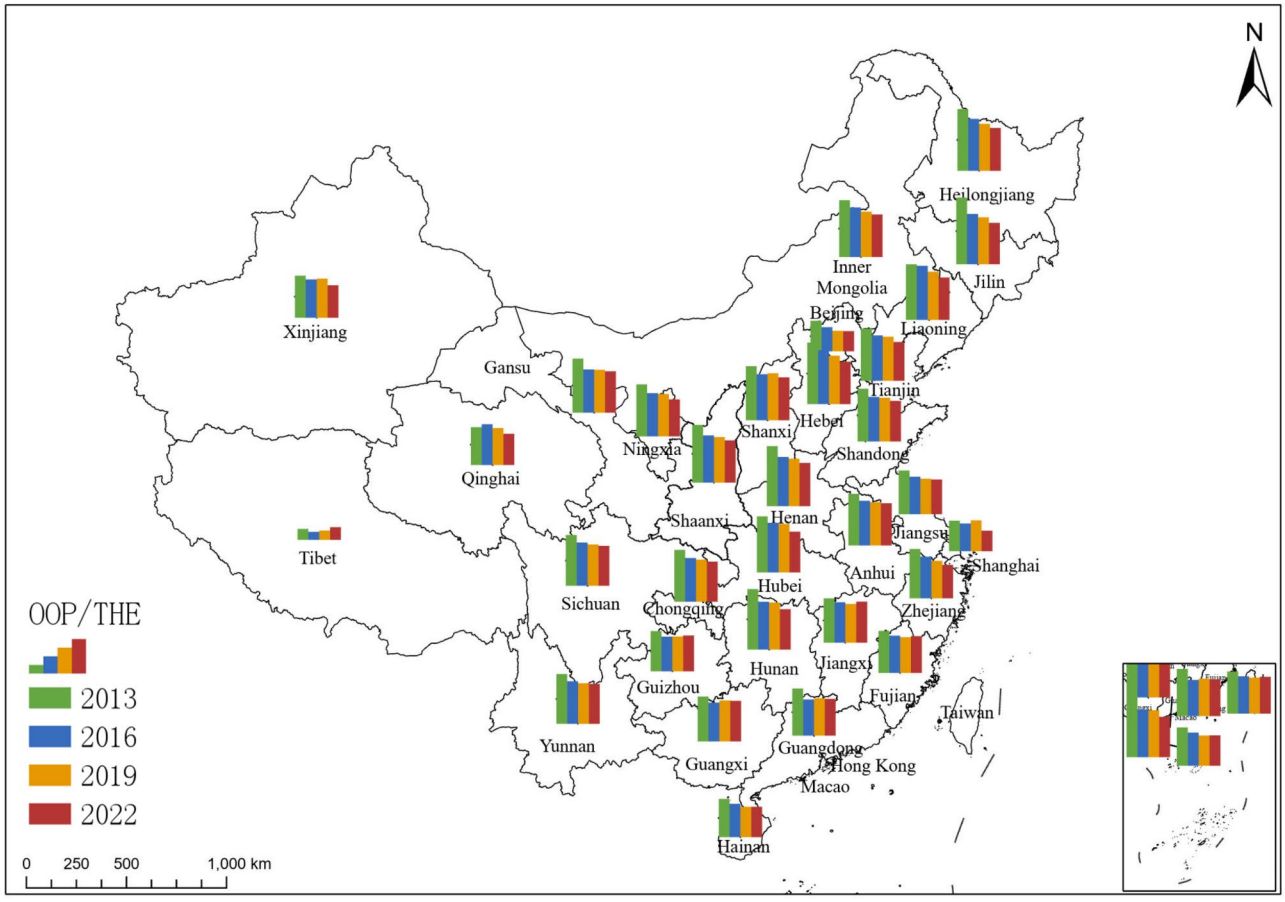

Fig. 1 Temporal and spatial changes of OOP payments as a share of THE in China

OOP/THE from 2013 to 2022, suggesting a progressive attenuation in spatial correlation.

To more intuitively reflect the local spatial correlation of OOP as a share of THE, this study maps the LISA of OOP payments as a share of THE at the time points of 2013, 2016, 2019, and 2022. In 2013, Beijing was identified as a low-high clustering region, while Inner Mongolia, Liaoning, Jilin, Heilongjiang, Henan, and Shaanxi constituted a high-high clustering area. Concurrently, Tibet, Qinghai, and Xinjiang were recognized as low-low clustering areas. By 2016, the low-high clustering area had remained stable, yet there was a notable shift in the high-high clustering region, with Shaanxi being replaced by Hebei. In 2019, the high-high clustering area further evolved to encompass Inner Mongolia, Liaoning, Jilin, Shanxi, Shaanxi, Henan, and Hubei. By 2022, the high-high clustering area contracted to include only Inner Mongolia, Shanxi, Shaanxi, and Henan. Meanwhile, Shanghai, Qinghai, and Xinjiang exhibited low-low clustering patterns; Beijing continued to be classified as a low-high clustering area. For further details, please refer to Fig. 2.

Spatial econometric model selection results

In this study, a series of testing methods were used to determine the optimal spatial econometric model. First of all, the Lagrange multipliers (LM) test was significant. Secondly, the Likelihood ratio (LR) test and Wald test rejected the null hypothesis that the SDM can degenerate into a SEM or SAR. Finally, the Hausman test showed that the fixed effect model was more suitable. Consequently, we have selected the fixed effect SDM as our econometric model for this study. The relevant results are presented in Table 5.

Regression results and spatial effect decomposition

The regression analysis in Table 6 reveals that the spatial autocorrelation coefficient of OOP/THE is significantly positive at the 1% level, indicating that the proportion of OOP payments has a positive spatial spillover effect. Specifically, for every 1% increase in OOP/THE in neighboring provinces, there is an accompanying increase of 0.415% in the OOP payments ratio within this province. In addition, the parameter estimates of ODR, CDR, PGDP, ANMV, BMIE, and ACMTO, as well as those of ODR, CDR, GE, BMIE, and ACMTO of the neighboring provinces in the SDM are significant, which indicates

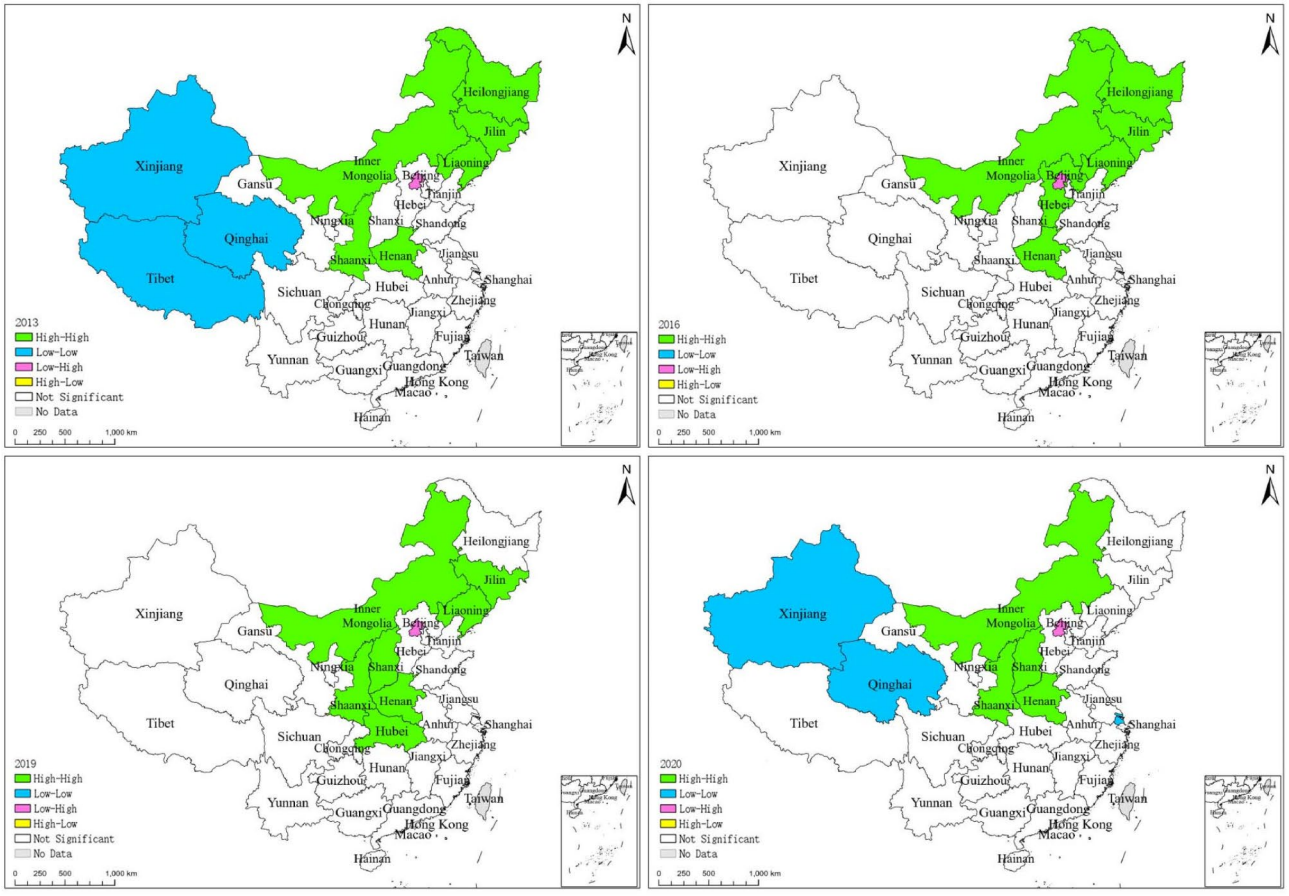

Fig. 2 LISA of OOP payments as a share of THE in China from 2013 to 2022

Table 3 Statistical characteristics and changing trends of China's OOP payments as a share of THE indicators from 2013 to 2022

Year	Min	Q1	Median	Q3	Max	IQR
2013	7.47	28.32	34.75	37.82	44.99	9.50
2014	6.47	27.57	31.91	36.04	40.90	8.47
2015	5.71	26.04	29.82	33.52	36.89	7.48
2016	5.46	25.34	29.11	32.26	36.46	6.92
2017	5.16	24.79	27.96	32.09	35.18	7.30
2018	5.62	25.40	28.31	31.31	33.96	5.91
2019	6.28	24.90	28.28	31.62	32.72	6.72
2020	7.16	24.35	27.51	29.38	30.93	5.03
2021	8.85	24.25	27.86	29.84	31.16	5.59
2022	8.52	23.43	26.98	28.46	29.13	5.03

that these factors have a certain degree of influence on the changes in the local OOP/THE.

In terms of population factors, the ODR has significantly negative direct, indirect, and total effects. Conversely, the CDR exhibits significantly positive direct and indirect effects. Regarding economic factors, PGDP shows significantly positive direct and total effects. For policy factors, the GE has significantly negative direct, indirect, and total effects. In terms of the utilization and cost of medical services, the ANMV and BMIE have significantly negative direct effects, while the ACMTO is significantly positive. Additionally, the indirect effects of BMIE and ACMTO are significantly negative. See Table 7.

Discussion

The results show that the spatial agglomeration of OOP/THE in China has been gradually weakening, suggesting an improvement in the equilibrium of OOP payments in the spatial distribution. This trend aligns with the findings of other scholars [8]. The Chinese government has exerted considerable efforts in reforming the healthcare

Table 4 Global Moran index 2013–2022

Year	Moran's index	Z
2013	0.256***	2.805
2014	0.301***	3.265
2015	0.287***	3.186
2016	0.208***	2.400
2017	0.214***	2.535
2018	0.193**	2.286
2019	0.190**	2.244
2020	0.149**	1.864
2021	0.216***	2.483
2022	0.211***	2.401

**$p<0.05$, ***$p<0.01$

Table 5 Statistical indicators of the spatial econometric model

Test	Statistic
Moran's I	16.711***
LM-error	207.886***
Robust LM-error	200.979***
LM-lag	25.323***
Robust LM-lag	18.417***
LR error	54.47***
LR lag	51.15***
Wald error	30.98***
Wald lag	31.26***
Hausman	35.09***

***$p<0.01$

Table 6 Spatial Durbin model regression results

Variables	Coefficient	Variables	Coefficient
ODR	−0.141*	W*ODR	−0.314***
	(0.079)		(0.118)
CDR	0.245***	W*CDR	0.339**
	(0.072)		(0.142)
PGDP	10.637***	W*PGDP	−1.139
	(2.209)		(3.596)
UR	0.103	W*UR	−0.220
	(0.228)		(0.383)
GE	−0.178	W*GE	−0.532**
	(0.135)		(0.236)
MTP	−0.023	W*MTP	0.044
	(0.178)		(0.324)
ANMV	−0.458*	W*ANMV	0.449
	(0.249)		(0.443)
AHR	−0.010	W*AHR	0.080
	(0.015)		(0.052)
BMIE	−1.198**	W*BMIE	−1.996**
	(0.553)		(0.935)
ACMTO	3.754**	W*ACMTO	−7.917***
	(1.641)		(2.963)
AMEI	0.584	W*AMEI	−0.813
	(1.831)		(2.961)
Rho	0.415***		
	(0.058)		
Sigma2_e	1.765***		
	(0.151)		

OOP/THE OOP payments as a share of THE, *ODR* Old dependency ratio, *CDR* Children dependency ratio, *PGDP* Per capita GDP, *UR* Per capita disposable income of urban and rural residents, *GE* Proportion of government expenditure on health to fiscal expenditure, *MTP* The number of medical technicians in healthcare facilities per 1000 persons, *ANMV* Average number of medical visits per year, *AHR* Annual hospitalization rate of residents, *BMIE* Basic medical insurance expenditures, *ACMTO* Average cost of medical treatment for outpatients, *AMEI* Average medical expenses of inpatients

Standard errors in parentheses. *$p<0.1$, **$p<0.05$, ***$p<0.01$

system. Since the initiation of research into OOP payments, the proportion of such payments has been progressively reduced alongside economic growth, increased government health investment, and the ongoing refinement of the health security system. These efforts have resulted in a decreased financial burden on residents for medical care. Although the minimum value of OOP/THE saw a slight rebound in 2021 and 2022 due to the impact of epidemics, this temporary increase did not undermine the substantial progress achieved in reducing regional disparities concerning the share of OOP payments [34]. The LISA map provides further insights into the dynamic changes in regional disparities. It shows that the high-high clustering has diminished from an initial focus in six northern provinces to a more concentrated presence in four: Inner Mongolia, Shaanxi, Shanxi, and Henan. Concurrently, Beijing has consistently exhibited a low-high clustering pattern. Traditional industrial bases such as Liaoning, Jilin, and Heilongjiang, along with economically active central regions like Shaanxi and Henan, are not as advanced in terms of economic development and government health expenditures when compared to Beijing. Beijing, benefiting from the "siphon effect," has attracted a large number of high-quality healthcare resources, resulting in relatively low OOP/THE. In contrast, the surrounding provinces face a higher OOP payment burden. The low-low clustering area is primarily concentrated in Tibet, Qinghai, and Xinjiang, regions that are economically underdeveloped. These provinces face relatively low levels of economic development, a shortage of medical resources, and limited healthcare options for their residents, leading to lower overall medical expenditures. However, due to their unique geographic and ethnic contexts, both national and local governments have made significant investments in healthcare to alleviate the medical burden on residents. As a result, these regions experience a relatively low proportion of OOP payments [23]. Overall, while the spatial balance of OOP payments has improved, inter-regional inequities persist. Therefore, it is necessary to encourage the government to optimize health expenditure intervention measures based on local conditions. On the one hand, in areas with high OOP payment levels, the government should continuously augment investment. This involves procuring advanced medical equipment to enhance the medical diagnostic capabilities of hospitals. On the other hand, it is essential to optimize the internal structure of government health expenditures. This can be achieved by carrying out

Table 7 Spatial effect decomposition results

Variables	Direct	Indirect	Total
ODR	−0.181**	−0.585***	−0.766***
	(0.076)	(0.165)	(0.160)
CDR	0.292***	0.686***	0.978***
	(0.071)	(0.211)	(0.234)
PGDP	11.235***	5.139	16.374***
	(2.028)	(5.019)	(5.148)
UR	0.086	−0.267	−0.181
	(0.240)	(0.665)	(0.808)
GE	−0.254**	−0.994***	−1.247***
	(0.128)	(0.350)	(0.376)
MTP	−0.009	0.061	0.052
	(0.174)	(0.480)	(0.511)
ANMV	−0.444*	0.366	−0.078
	(0.255)	(0.087)	(0.773)
AHR	−0.001	0.124	0.123
	(0.016)	(0.087)	(0.097)
BMIE	−1.519***	−3.940***	−5.459***
	(0.534)	(1.360)	(1.490)
ACMTO	3.142*	−10.064**	−6.922
	(1.657)	(4.742)	(5.365)
AMEI	0.502	−1.322	−0.820
	(1.879)	(4.711)	(5.289)

OOP/THE OOP payments as a share of THE, *ODR* Old dependency ratio, *CDR* Children dependency ratio, *PGDP* Per capita GDP, *UR* Per capita disposable income of urban and rural residents, *GE* Proportion of government expenditure on health to fiscal expenditure, *MTP* The number of medical technicians in healthcare facilities per 1000 persons, *ANMV* Average number of medical visits per year, *AHR* Annual hospitalization rate of residents, *BMIE* Basic medical insurance expenditures, *ACMTO* Average cost of medical treatment for outpatients, *AMEI* Average medical expenses of inpatients

Standard errors in parentheses. *$p<0.1$, **$p<0.05$, ***$p<0.01$

refined management of such expenditures, establishing a fund-usage supervision mechanism, and ensuring that funds are channeled to areas where they are truly needed. The government should also broaden social financing channels, introduce preferential tax policies, and encourage enterprises and social organizations to contribute to the medical and health sector. Additionally, efforts should be made to collaborate with commercial health insurers to develop supplementary medical insurance products tailored to the needs of residents in areas with high OOP payment burdens. In regions with low OOP payment levels, overutilization of healthcare services may result in the waste of limited resources. It is advisable to improve the hierarchical medical care system, clarify the diagnostic and treatment scopes of medical institutions at all levels, and balance the interests among medical institutions. This includes managing common, frequent, and chronic diseases in grassroots medical institutions, guiding high-quality medical resources to these areas, and establishing a counterpart assistance mechanism between large urban hospitals and grassroots medical institutions. At the same time, attracting excellent medical personnel to work in grassroots areas can be achieved by improving salaries and optimizing career prospects. The ultimate objective is to transform the traditional "inverted-pyramid" model into a "right-side-up pyramid" model, ensuring that limited medical resources are allocated and utilized more efficiently [8, 35].

The results show that an increase in ODR in both local and neighboring provinces leads to a decrease in the share of local OOP/THE, while an increase in CDR in these regions raises the share of local OOP payments. Among them, the result of the ODR is contrary to other scholars' research [36, 37]. We consider that with the acceleration of the aging process, China has introduced a series of medical security policies for the elderly. These include increasing the reimbursement ratio of inpatient and outpatient chronic disease insurance for the elderly, expanding the coverage of long-term care insurance, further expanding long-term care insurance coverage, and guiding social forces to participate in the supply of health services for the elderly. These policies have significantly reduced the OOP payments burden on the elderly [38, 39]. However, due to the uneven distribution of medical resources and the large mobility of the population in China, the phenomenon of cross-provincial medical treatment is increasing [40, 41]. Especially for the elderly group, because they have difficulty rationally choosing medical institutions according to their own conditions. Some patients prefer large or out-of-province hospitals to pursue higher medical technology and better services [42]. This demand for high-quality medical services drives them to seek medical treatment across provinces. This phenomenon not only encourages provinces to increase investment in geriatric medical services to meet local needs but also prompts neighboring provinces to establish cross-provincial medical cooperation networks [43]. Through remote diagnosis and treatment, sharing of medical equipment, and expert resources, these measures can reduce the frequency of cross-provincial medical treatment among the elderly while improving the overall efficiency and accessibility of regional medical services [44]. Compared with the government and society's support for the elderly, children receive relatively little support in the medical security system. While children's health needs are equally important, children have a relatively high share of out-of-pocket payments in policy design and resource allocation, which can affect their access to health services. As family concepts evolve, parents' investment in children's preventive healthcare has gradually increased. According to the data, family OOP payments account for 57.9% of children's health expenditures, and these high OOP costs impose a significant financial burden on families [45]. In addition, due to the restrictions of the household registration system, migrant children often cannot access the same health insurance benefits as local children in the areas they move to. This is especially true when there are significant disparities in

health insurance policies between provinces, resulting in higher OOP payments when they seek medical treatment [46]. Therefore, the establishment of a medical insurance system specifically for children, particularly migrant children, should be accelerated. This should include enhanced health insurance support as well as policies that prioritize children in terms of medical services, drug lists, and reimbursement levels. The aim is to reduce the proportion of OOP expenses for children, thereby alleviating the financial burden on families [47]. The location of medical treatment and the place of insurance participation should incorporate the data of patients who seek medical treatment in different locations into the supervision of the health insurance fund, based on their respective rule bases and knowledge bases. Active exploration of collaborative supervision between the place of insurance participation and the place of medical treatment should be pursued to optimize the efficiency of medical insurance fund utilization and jointly ensure the safe and sustainable operation of the fund [48].

The results show that an increase in PGDP has a significant impact on the growth of OOP/THE. The research results of many scholars have confirmed the correlation between this variable and OOP [22, 49]. As the economy develops and the overall income level of the population rises, household purchasing power for health and medical care strengthens, which boosts their willingness to pay for high-quality healthcare services, further driving the increase in personal health expenditures. GE in local and neighboring provinces exerts a dampening effect on the growth of OOP payments at the local level. This result indicates that increasing government investment in healthcare by means of financial subsidies, policy intervention, and drug price control can effectively improve the accessibility and quality of healthcare services, thereby reducing the financial burden on residents [47]. In addition, Yang Y points out that policy interventions may have a demonstration effect; when a region increases its government health expenditures, neighboring regions may be inspired to follow suit [49]. The increase in health expenditure can attract more medical resources to the region, improving its healthcare services and indirectly attracting residents from neighboring provinces to seek treatment or access services. This, in turn, further promotes the flow of regional medical resources. Meanwhile, medical institutions within the province, in an effort to retain patients, may take measures to reduce costs and improve service quality. Such competitive mechanisms can ultimately reduce the burden of OOP payments on residents [50]. Therefore, the spillover effect can be used to strengthen cross-provincial medical cooperation, establish regional medical consortia or specialist alliances, and to hold joint meetings regularly to discuss issues such as medical resource sharing and talent exchange. Telemedicine and expert consultation can also be used to improve the accessibility and equity of medical services and to reduce patient demand for cross-provincial medical treatment [49].It should also clarify government responsibilities in key areas of healthcare, encourage healthy competition, avoid harmful strategic interactions, and foster coordinated and orderly competition between regions [24]. The government should also prioritize public health, fully leverage the capabilities of basic medical and healthcare institutions, and strengthen the guidance and intervention provided by family doctors for common and chronic diseases. This approach will help control the occurrence and spread of diseases, ultimately reducing residents' OOP payments related to medical treatment [8].

The results show that an increase in local ANMV, as well as in the BMIE of both the local and neighboring provinces, helps reduce the local OOP payments ratio. In contrast, an increase in local ACMTO leads to a high local OOP payments burden, while an increase in other places ACMTO has the opposite effect. With the increase in basic medical insurance expenditure, improvements in reimbursement rates, and expanded coverage, the treatment costs borne by patients have gradually decreased. Studies have shown that raising outpatient reimbursement rates not only significantly increases the number of outpatient visits but also encourages patients to seek medical care proactively, preventing minor illnesses from developing into more serious conditions and thus reducing overall healthcare costs [51]. Many scholars have found that in the treatment of chronic diseases such as hypertension and diabetes, where expanding the coverage for outpatient chronic diseases care has effectively reduced the medical burden on residents [52]. At the same time, the establishment of employee outpatient accounts has provided employees with a more flexible and quicker way to access health insurance funds. This not only promotes the utilization of grassroots outpatient services, alleviates pressure on large hospitals, and fosters an orderly system of hierarchical diagnosis and treatment, but also greatly facilitates the reasonable sharing of costs for medicines, examinations, and other medical services, further enhancing the practicability and universality of medical insurance. Despite the continuous expansion of health insurance coverage, some problems still affect its effectiveness. The essence of the Diagnosis Related Groups (DRG) and Diagnosis-Intervention Packet (DIP) payment method implemented in China is to purchase medical services using the "packaged payment" model. However, there is a situation of transferring inpatient expenses to outpatient services, resulting in an increase in the average medical costs of outpatient services. Although the reimbursement ratio is constantly increasing, reaching the minimum deductible

line is difficult due to the low average outpatient cost, thereby increasing the actual medical burden of residents [53]. The increase in the average medical cost per outpatient visit will become a key factor hindering the utilization of health services by residents. Especially for economically disadvantaged groups, they may be forced to give up some necessary medical services, leading to a reduced utilization rate of health services, compromised timely diagnosis and treatment, increased risk of disease delay and aggravation, and significant damage to residents' health status. Moreover, this situation also poses a challenge to the sustainable development of the overall health system [51]. Therefore, controlling the average cost of outpatient consultations and exploring a supervision model for outpatient coordinated funds remain key issues that the government needs to address to prevent the problem from expanding. An increase in health insurance expenditure in a neighboring province indicates a stronger investment and protective capacity in the field of health insurance. Since cross-location settlement follows the reimbursement catalog of the place of consultation and the reimbursement policies of the insured place, patients seeking medical care across regions tend to choose provinces and cities with broader health insurance coverage, with the aim of taking advantage of better reimbursement strategies to reduce their financial burden [54]. Therefore, the government should actively promote the optimization of medical insurance policy. On the one hand, the government should strive to optimize the medical insurance catalog and treatment design, accelerate the unification of the national medical insurance reimbursement catalog, further include outpatient expenses in the off-site settlement scope of remote settlement, and reduce the uneven use of medical services caused by regional policy differences. On the other hand, the government should actively explore the establishment of an inter-regional medical insurance fund adjustment mechanism. When there is a gap in the medical insurance fund in a certain region, the surrounding regions can make appropriate adjustments through consultation so as to ensure that the medical treatment of residents is not affected. These measures can not only effectively restrain the unreasonable profit-seeking behavior caused by policy differences but also reduce the operational risks associated with medical insurance funds and promote the healthy and stable development of the medical insurance system. At the same time, the increase in outpatient expenses in the neighboring regions has led to a spillover effect on cross-regional medical costs. This spillover effect has prompted local governments to adjust policies by enhancing medical insurance coverage to alleviate residents' medical expenditure pressure [55].

Future research and limitation

This study has several limitations. First, it is limited to analyzing data at the provincial level, which may lead to ecological fallacies or mask spatial differences within provinces. Second, the study relies solely on statistical yearbook data for macro-level analysis, lacking further insights from fieldwork and micro-level research. Therefore, follow-up studies can include data at the prefecture-level city level to reveal differences and spatial associations between different regions in the province. In addition, favorable evidence can be sought at the micro level to provide a reference basis for provinces to reduce the economic burden of personal health care for their residents.

Conclusion

Our study shows that OOP/THE decreases from year by year, with spatial spillover effects. Population factors, economic factors, policy factors, etc. will all have an impact on OOP in each province. Currently in China, the reimbursement policy of medical insurance, hierarchical medical system, DRG/DIP payments and other policies have significantly contributed to the reduction in OOP expenses for patients. Although there are still some inadequacies in the implementation of these measures, generally speaking, the continuous strengthening and improvement of these strategies are crucial to achieving reasonable control of medical costs, improving the quality of medical services and thus reducing the overall personal payment costs of patients. Thus the findings of this study may provide valuable evidence for the adjustment and allocation of health resources in China and have important implications for developing countries facing high health burdens.

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Authors' contributions
All authors contributed to this study design. Xiaoyu Dong: Data curation, Methodology, Writing – Original draft. Huaizhi Cheng: Data curation, Writing-Original draft, Visualization, Supervision. Ruotong Tian, Lingxiao Gao, Wenpei Lyu, Jiaqi Zhang: Data curation, Software, Writing – review & editing. Doudou Huang, Bin Guo: Funding acquisition, Writing – review & editing.

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Data availability
This was a secondary analysis. All data can be obtained from https://data.stats.gov.cn/easyquery.htm?cn=C01 and http://www.nhc.gov.cn/mohwsbwstjxxzx/tjzxtjsj/tjsj_list.shtml. To obtain the detailed data, please contact the corresponding author.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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