BMJ Open

Medical expenditure and its influencing factors of patients with hypertension in Shanxi Province, China: a study based on 'System of Health Accounts 2011' and multiple-layer perceptron neural network

Guojie Liu,[1] Quan Fang,[2] Xinyu Ji,[3] Jing OuYang,[4] Yalan Zhu,[2] Leying Wang,[5] Xin Wang [2,6]

To cite: Liu G, Fang Q, Ji X, *et al*. Medical expenditure and its influencing factors of patients with hypertension in Shanxi Province, China: a study based on 'System of Health Accounts 2011' and multiple-layer perceptron neural network. *BMJ Open* 2022;**12**:e048396. doi:10.1136/bmjopen-2020-048396

► Prepublication history for this paper is available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2020-048396).

GL and QF contributed equally.

Received 27 December 2020
Accepted 31 January 2022

For numbered affiliations see end of article.

Correspondence to
Professor Xin Wang;
wxinsmile@qq.com

ABSTRACT

Objectives To study the medical expenditure and influencing factors of patients with hypertension in Shanxi Province, China.

Design A cross-sectional study.

Setting 1088 medical institutions, including general hospitals, traditional Chinese medicine hospitals, special hospitals, basic medical institutions and public health institutions.

Participants 180 441 hypertensive outpatients and 14 763 inpatients from 1 January to 31 December 2017.

Primary and secondary outcome measures Curative care expenditure for hypertension (CCE_{ht}) was measured based on System of Health Accounts 2011. Influenced factors were analysed by univariate analysis and multiple layer perceptron neural network.

Results In 2017, CCE_{ht} was US$307.71 million, accounting for 3.63% of total CCE and 0.14% of gross domestic product (GDP) in Shanxi Province of China. CCE of hypertensive outpatients ($CCE_{ht\text{-}out}$) and inpatients ($CCE_{ht\text{-}in}$) accounted for 44.49% and 55.51% of CCE_{ht}. Drug fee accounted for 81.55% of $CCE_{ht\text{-}out}$ and 22.50% of $CCE_{ht\text{-}in}$, respectively. The top three influencing factors were drug fee, surgical fee and hospitalisation days for inpatients, and drug fee, examination fee and test fee for outpatients.

Conclusions The medical expenditure of hypertension is still heavy for individuals and society. The diagnosis and treatment capacities of primary healthcare system has been enhanced. New rural cooperation medical insurance and urban employee basic medical insurance have a trend of overusing, and the burden of family healthcare expenditure is still heavy. To ease the economic burden of patients with hypertension and improve the efficiency of social resources utilisation, policymakers should pay more attention to key groups, further increase support for primary healthcare system, standardise the treatment and reimbursement of hypertension and incline the reimbursement policy to outpatient service.

Strengths and limitations of this study

- This is the first paper that uses the System of Health Accounts 2011 to analyse the expenditure of patients with hypertension in China.
- Due to the skewness and non-linearity of medical expense data, a multiple layer perceptron neural network is more suitable for analysing the influencing factors of curative care expenditure, which can model complex functions and ignore irrelevant inputs and noise.
- 1088 medical institutions and 195 204 patients with hypertension were included.
- This study did not measure the expenses of patients with hypertension in pharmacies, which may underestimate the true financial expenditure of patients with hypertension.
- Commercial insurance adopts the principle that patients pay in advance, and insurance companies reimburse later, which may lead to bias in allocation of curative care expenditure for hypertension in commercial insurance.

BACKGROUND

Hypertension is the leading risk factor for many non-communicable diseases such as stroke, ischaemic heart disease and chronic kidney disease. It is the leading cause of premature death, causing about 8.5 million deaths a year.[1 2] Because of the widespread use of antihypertensive drugs, global average blood pressure has not increased significantly in the past few decades and even decreased in some regions. However, due to demographic and lifestyle changes, and the low level of awareness, treatment and control of hypertension worldwide, the prevalence of hypertension continues to increase. The prevalence of hypertension among 30–79-year-olds doubled in 2019 compared with that in 1990. For low-income and middle-income countries, the situation was even worse.[3–5]

Along with the rapid development of society and economy, China has been undergoing tremendous demographic and epidemiological transitions. In the past decades,

non-communicable diseases have been a major threat to people's health,[6] increasing health expenditure. China has a high prevalence of hypertension, and it has risen from 18.8% in 2002[7] to 29.6% in 2014,[8] ranking first in the prevalence of major chronic diseases.

Hypertension requires long-term treatment and medication, which affects people's health and brings heavy economic burden to families and society.[6] In the USA, the average annual medical expenditure per person with high blood pressure was US$9089 per year. The total annual healthcare expenditure for people with high blood pressure was nearly US$200 billion higher than those without high blood pressure.[9] In China, total annual health expenditure of patients with hypertension was about US$34.5 billion per year, accounting for 6.6% of the total health expenditure.[10] Many countries have to take corresponding countermeasures because of the huge economic health expenditure. Still, despite efforts by health systems and policies to improve it, the progress in controlling hypertension as a modifiable risk factor has been slow globally.[1 4 11]

Current research on the economic burden of hypertension lacks an exploration of its cost financing and distribution, which are critical from a public health perspective because they are fundamental to understanding the financial challenges.[2 12] Therefore, we choose 'System of Health Accounts 2011' (SHA 2011) to analyse the curative care expenditure (CCE) of hypertension in China and multiple layer perceptron (MLP) for multivariate analysis, to provide more information for policymakers, analysts, and international comparisons.

METHODS

Study design and data sources

It was a cross-sectional study. The data consisted of two parts. The total data were collected from Shanxi Health Financial Yearbook 2017, Shanxi Health Statistical Yearbook 2017, China National Health Accounts Report 2017, Shanxi Health Accounts Report 2017, and so on. The sample data were obtained by multistage stratified cluster random sampling. First, we chose four sample cities (Taiyuan, Changzhi, Yuncheng and Xinzhou) from Shanxi Province based on the sufficient consideration of the level of health information management system and economic development. Next, we chose one county and one district in every city and selected six township hospitals and community health service organisations in every county or district. At last, we chose medical institutions and public health institutions based on the type and administrative structure of institution. The two parts of data were used to calculate the CCE of hypertension under the framework of SHA 2011, and the influencing factors were analysed by MLP neural network.

Study samples

We screened patients with hypertension by International Classification of Diseases Tenth Revision (ICD-10) coding. Patients with hypertension were often accompanied by other chronic diseases, such as stroke, myocardial infarction, and so on. These multiple chronic diseases were not excluded in this study, although this may increase the economic burden of hypertension. Because we believe that, as the most common risk factor for cardiovascular disease, good control of blood pressure can help to reduce the incidence and economic burden of other diseases. Another reason was that it was difficult to calculate the expenditure of hypertension in these patients with multiple chronic diseases separately from the expenditure of other diseases.

The final valid sample included 180 441 outpatients with hypertension and 14 763 inpatients from 1088 medical institutions. The basic information of the sample included gender, age, disease coded by ICD-10 and Global Burden of Disease (GBD), total expense, drug fee, examination fee, level of health institutions, financing schemes, and so on.

Patient and public involvement

Patients or the public were not involved in the design, conduct, or dissemination plans of this research.

Calculation of CCE in the frame of SHA 2011

SHA 2011 is an internationally recognised health policy analysis and evaluation tool for systematically describing the financial flows related to healthcare. According to the situation of China, researchers from the China National Health Development Research Center proposed a complex system for the systematic description of the financial flows in 2014.[13 14] In SHA 2011, CCE contains curative care, rehabilitative care and long-term healthcare, not including preventive care.

$E_{\text{t-exp}}$is total expenditure in different health institutions of Shanxi Province, including curative and partial preventive expenditure, can be queried from the 2017 Shanxi Health Statistical Yearbook. e_{exp}, e_{pre} and e are curative expenditure per patient, total preventive expenditure and total expenditure in the sample. Through formula (1), we can remove preventive expenditure and get curative expenditure $E_{\text{c-exp}}$ of outpatient or inpatient in deferent health institutions of Shanxi Province. E_{exp} represents curative expenditure in various dimensions, such as age, gender, region, and so on. $\frac{e_{exp}}{\text{e-e}_{\text{pre}}}$ is a sharing coefficient of per patient. Through formula (2), we can work out the curative expenditure of patients in various dimensions, such as gender, age, health institutions and financing schemes.

$$E_{\text{c-exp}} = E_{\text{t-exp}}\left(1 - \frac{e_{\text{pre}}}{e}\right) \quad (1)$$

$$E_{\text{exp}} = \sum_{\text{k}=1}^{n}\left(E_{\text{c-exp}} \times \frac{e_{exp}}{\text{e-e}_{\text{pre}}}\right)_k \quad (2)$$

$E_{\text{t-subsidy}}$represents total government subsidy in deferent health institutions of Shanxi Province, including curative and partial preventive expenditure in outpatient and inpatient, can be queried from the 2017 Shanxi Health Financial Yearbook. $E_{\text{p-subsidy}}$ is government subsidy in preventive service, collected from the yearbook as well.

We can get curative government subsidy from formula (3). $N_{\text{b-subsidy}}$ is the number of hospital's bed, $N_{\text{o-subsidy}}$ is the number of curative outpatients and $\frac{N_{\text{b-subsidy}}}{N_{\text{b-subsidy}}-N_{\text{o-subsidy}}\times 0.1}$ is a sharing coefficient of inpatients. We can calculate government subsidy of inpatient ($E_{\text{i-subsidy}}$) and outpatient ($E_{\text{o-subsidy}}$) through formulas (4) and (5) separately. Then times the sharing coefficient of per patient, we can get the government subsidy of patient (E_{subsidy}) in various dimensions through formula (6). In formula (7), CCE (E_{CCE}) is the sum of E_{income} and E_{subsidy} in various dimensions.

$$E_{\text{c-subsidy}} = E_{\text{t-subsidy}} - E_{\text{p-subsidy}} \quad (3)$$

$$E_{\text{i-subsidy}} = E_{\text{c-subsidy}} \times \frac{N_{\text{b-subsidy}}}{N_{\text{b-subsidy}}-N_{\text{o-subsidy}}\times 0.1} \quad (4)$$

$$E_{\text{o-subsidy}} = E_{\text{c-subsidy}} \times \left(1 - \frac{N_{\text{b-subsidy}}}{N_{\text{b-subsidy}}-N_{\text{o-subsidy}}\times 0.1}\right) \quad (5)$$

$$E_{\text{subsidy}} = \sum_{k=1}^{n}\left[E_{\text{i-subsidy}}\left(\text{or } E_{\text{o-subsidy}}\right) \times \frac{e_i}{e\text{-}e_{\text{pre}}}\right]_k \quad (6)$$

$$E_{\text{CCE}} = E_{\text{exp}} + E_{\text{subsidy}} \quad (7)$$

MLP neural network

Due to the skewness and non-linearity of medical expense data, MLP neural network is more suitable for analysing the influencing factors of CCE, which can model complex functions and ignore irrelevant inputs and noise.[15] MLP neural network consists of an input layer, multiple hidden layers and an output layer. According to the principles of input layer variables, we chose gender, age, surgical fee, drug fee, test fee, treatment fee, bed fee, consultation fee, examination fee, nursing fee, diagnosis fee, hospitalisation days, type of health financing schemes, type of medical institutions and level of medical institutions as input layer variables for inpatients. We chose gender, age, drug fee, test fee, treatment fee, consultation fee, examination fee, registration fee, type of health financing schemes, type of medical institutions and level of medical institutions as input layer variables for outpatients. We chose one hidden layer and curative expenditure from patients with hypertension as a neuron in the output layer.

Statistical analysis

The CCE of patients with hypertension was described in terms of financing and allocation. All the calculations were performed by the software STATA V.12.0 (StataCorp, College Station, Texas, USA). In the analysis of influencing factors, the samples were divided into training and testing set randomly. According to the relative error, we can get cost model and variable's importance rank. MLP neural network was established by IBM SPSS Statistics V.20 (IBM, Armonk, New York, USA).

RESULTS

Basic result of CCE for patients with hypertension (CCE_{ht})

As shown in table 1, in 2017, the CCE_{ht} was US$307.71 million (RMB 2061.64 million yuan, average US$1=RMB¥6.7, in 2017), accounting for 3.63% of the gross CCE for Shanxi Province, and 0.14% of gross domestic product (GDP). CCE_{ht} accounted for 15.98% of CCE for circulatory system diseases, with the highest CCE in the ICD-10 disease classification. CCE_{ht} accounted for 4.93% of CCE for non-communicable diseases in the GBD classification. CCE of hypertensive outpatients ($CCE_{ht\text{-}out}$) and inpatients ($CCE_{ht\text{-}in}$) accounted for 44.49% and 55.51% of CCE_{ht}. Drug fee accounted for 81.55% of $CCE_{ht\text{-}out}$ and 22.50% of $CCE_{ht\text{-}in}$, respectively.

Table 1 CCE_{ht} of Shanxi Province in 2017

	Outpatient	Inpatient	Total
CCE_{ht} US$ million	136.89	170.82	307.71
Ratio (CCE_{ht}/CCE_{sx})	5.68%	2.81%	3.63%
Ratio (drug fee/CCE_{ht})	81.55%	22.50%	55.54%
Ratio (CCE_{ht}/CCE_{cd})	36.71%	11.00%	15.98%
Ratio (CCE_{ht}/CCE_{ncd})	8.74%	3.66%	4.93%
Ratio (CCE_{ht}/total CCE_{ht})	44.49%	55.51%	100%

CCE, curative care expenditure; CCE_{cd}, CCE for circulatory system diseases; CCE_{ht}, CCE for patients with hypertension; CCE_{ncd}, CCE for non-communicable diseases; CCE_{sx}, CCE for Shanxi Province.

Allocation of CCE_{ht} in terms of age and gender

The samples were divided into 10-year age groups: 0–9, 10–19, and so on, 80–89 and 90+. The allocation in figure 1 shows that CCE_{ht} increased with age from 30, and the highest occurred in the age group of 60–69. The patients aged from 40 to 79 accounted for 86.49% of total CCE_{ht}. The difference between outpatient and inpatient expenditure varied with age group. The total outpatient expenditure was 2.80 times the inpatient expenses for patients under 50 years old, and the inpatient expenditure was 1.64 times the outpatient expenditure for patients over 50 years old.

CCE_{ht} of male patients was generally higher than that of females, accounting for 51.27% and 48.73% of CCE_{ht}, respectively. There was a significant difference between

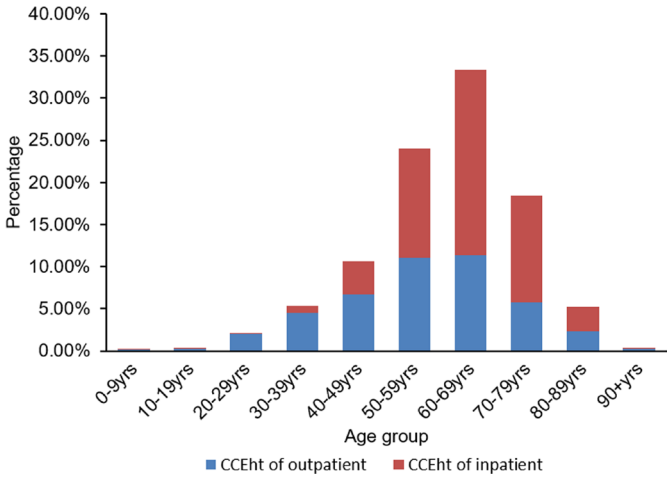

Figure 1 Allocation of CCE_{ht} of outpatient and inpatient in terms of age. CCE_{ht}, curative care expenditure for hypertension

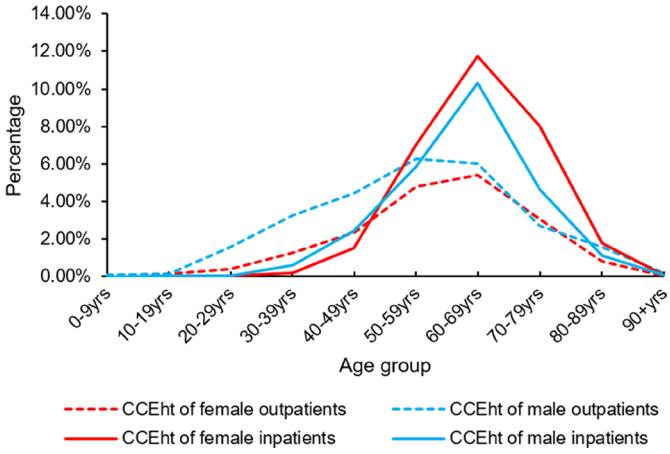

Figure 2 Allocation of CCE_{ht} in terms of age and gender. CCE_{ht}, curative care expenditure for hypertension.

CCE_{ht} for males and females in terms of age. As shown in figure 2, the CCE_{ht} for male outpatients was significantly higher than that of females, especially in the group of 20–49. The CCE_{ht} for male outpatients was about 1.76 times that of females. From the age of 50, CCE_{ht} in females was higher than that of males, and for hospitalised patients aged 50–89, CCE_{ht} in females was about 1.31 times higher than that of males.

Allocation of CCE_{ht} in medical institutions and institution levels

Medical institutions in this study included hospitals (general hospitals, traditional Chinese medicine hospitals and special hospitals), basic medical institutions and public health institutions. As data in table 2 show, 34.41% and 65.51% of outpatients chose general hospitals and basic medical institutions, accounting for 76.56% and 23.43% of total $CCE_{ht\text{-}out}$, respectively. About 45.99% and 53.98% of inpatients chose general hospitals and basic medical institutions, accounting for 36.19% and 63.80% of total $CCE_{ht\text{-}in}$, respectively.

Medical institution levels included provincial, municipal, district and county levels. Data show that 71.07% of outpatients and 74.75% of inpatients chose county-level medical institutions, accounting for 45.33% of $CCE_{ht\text{-}out}$ and 71.96% of $CCE_{ht\text{-}in}$, respectively.

Allocation of CCE_{ht} in health financing schemes

Financing schemes involved government subsidy, social medical insurance, voluntary medical insurance (commercial insurance, CI), other insurances (civil servant insurance, employment injury insurance, assistance, and so on) and family healthcare expenditure (out-of-pocket, OOP). Social medical insurance involved urban employee basic medical insurance (UEBMI), urban resident basic medical insurance (URBMI) and new rural cooperation medical insurance (NRCMI). As data show in table 3, 72.44% of outpatients and 88.78% of inpatients had social medical insurance, of which 64.13% of outpatients and 71.48% of inpatients had NRCMI, respectively. The patients with UEBMI had the highest per capita reimbursement ratio. OOP accounted for 47.85% of total $CCE_{ht\text{-}out}$ and 14.48% of total $CCE_{ht\text{-}in}$, respectively.

Analysis of influencing factors of CCE_{ht} by MLP neural network

In the MLP neural network, 9 and 8 hidden neurons were found from hyperbolic tangent function for inpatients and outpatients, respectively. The neural network structure and results are shown in table 4. After continuous learning, testing relative error of the MLP model was 6.3% for inpatients and 3.1% for outpatients. The top three influencing factors for inpatients were drug fee, surgical fee and hospitalisation days. The top three

Table 2 Allocation of CCE_{ht} in medical institutions and institution levels

		$N_{ht\text{-}out}$/Total $N_{ht\text{-}out}$	$CCE_{ht\text{-}out}$/Total $CCE_{ht\text{-}out}$	$N_{ht\text{-}in}$/Total $N_{ht\text{-}in}$	$CCE_{ht\text{-}in}$/Total $CCE_{ht\text{-}in}$
Medical Institutions	Hospital	34.41%	76.56%	45.99%	36.19%
	General hospital	20.84%	60.18%	20.08%	16.83%
	Traditional Chinese medicine hospital	6.52%	4.94%	13.55%	8.23%
	Special hospital	7.05%	11.44%	12.36%	11.13%
	Basic medical institution	65.51%	23.43%	53.98%	63.80%
	Public health institution	0.08%	0.01%	0.03%	0.01%
	Total	100.00%	100.00%	100.00%	100.00%
Institutions levels	Provincial level	10.05%	34.06%	13.13%	3.57%
	Municipal level	15.78%	14.49%	8.71%	7.08%
	District level	3.10%	6.12%	3.41%	17.39%
	County level	71.07%	45.33%	74.75%	71.96%
	Total	100.00%	100.00%	100.00%	100.00%

CCE_{ht}, curative care expenditure for hypertension; $CCE_{ht\text{-}in}$, CCE of inpatients with hypertension; $CCE_{ht\text{-}out}$, CCE of outpatients with hypertension; $N_{ht\text{-}in}$, inpatients with hypertension; $N_{ht\text{-}out}$, outpatients with hypertension.

Table 3 Allocation of CCE_{ht} in health financing schemes

Financing schemes	$N_{ht\text{-}out}$ /Total $N_{ht\text{-}out}$	$CCE_{ht\text{-}out}$ /Total $CCE_{ht\text{-}out}$	$N_{ht\text{-}in}$ /Total $N_{ht\text{-}in}$	$CCE_{ht\text{-}in}$ /Total $CCE_{ht\text{-}in}$
Government subsidy	/	2.39%	/	55.37%
Social medical insurance	72.44%	47.33%	88.78%	28.62%
UEBMI	5.03%	24.92%	8.68%	4.79%
URBMI	3.28%	2.58%	8.62%	1.82%
NRCMI	64.13%	19.83%	71.48%	22.01%
Voluntary medical insurance (CI)	0.46%	0.00%	0.05%	0.01%
Other insurances	6.74%	2.43%	5.84%	1.61%
OOP	20.36%	47.85%	5.33%	14.48%
Total	100.00%	100.00%	100.00%	100.00%

CCE_{ht}, curative care expenditure for hypertension; $CCE_{ht\text{-}in}$, CCE of inpatients with hypertension; $CCE_{ht\text{-}out}$, CCE of outpatients with hypertension; CI, commercial insurance; $N_{ht\text{-}in}$, inpatients with hypertension; $N_{ht\text{-}out}$, outpatients with hypertension; NRCMI, new rural cooperation medical insurance; OOP, out-of-pocket; UEBMI, urban employee basic medical insurance; URBMI, urban resident basic medical insurance.

influencing factors for outpatients were drug fee, examination fee and test fee.

DISCUSSION

In China, the high prevalence of hypertension mainly concentrates in the northeast and north China.[16] Shanxi Province is located in Northern China with a resident population of 37 million,[17] and its prevalence of hypertension is about 33.2%.[18] That is, approximately 12.3 million residents of Shanxi Province suffer from hypertension. The study shows CCE_{ht} of Shanxi Province in 2017 accounted for 0.14% of GDP.[16] Compared with 0.03% of GDP in the Latin American region in 2015,[19] patients with hypertension consumed a large number of health resources, which implies the prevention and control system of hypertension should be strengthened.

The study shows that CCE_{ht} increases with age, and the patients aged 40–79 account for the majority of total CCE_{ht}. Population ageing is an essential factor that increases the CCE_{ht}. As we know, China has entered the 'ageing society',[20] which means that the economic burden caused by hypertension diseases will become heavier and heavier.

This study also shows that the CCE_{ht} increases significantly since the age of 30 in both sexes. More and more young people suffer from hypertension. It has been a

Table 4 Neural network structure and result

$Parameter_{(1)}$	$Parameter_{(2)}$	Inpatient	Outpatient
Input layer	Independent variables	X_1–X_{15}	X_1–X_{12}
	Number of neurons	15	12
	Rescaling methods for independent variables	Standardised	Standardised
Hidden layer(s)	Number of hidden layers	1	1
	Number of neurons in hidden layer	9	8
	Activation function	Hyperbolic tangent	Hyperbolic tangent
Output layer	Dependent variable(s)	1	1
	Number of neurons	1	1
	Activation function	Identity function	Identity function
	Error function	Sum of squares	Sum of squares
Result	Sample size	14 763	180 441
	Training set/testing set	70.5:29.5	70:30
	Training relative error	12.7%	7.1%
	Testing relative error	6.3%	3.1%
	Standardised importance of variables (top 3)	Drug fee (100.0%), surgical fee (85.2%), hospitalisation days (59.2%)	Drug fee (100.0%), examination fee (33.8%), test fee (22.2%)

significant public health problem in developing countries, mainly attributable to the unhealthy lifestyles of young people, such as insufficient exercise, long-term use of smartphones and computers, lack of sleep, and so on.[21 22] Once established, hypertension will systematically promote abnormal development and progression of the heart, blood vessel and kidney.[23] Therefore, in our study, outpatient spending accounts for the majority of CCE_{ht} before age 40, while the inpatient spending replaces it after age 50.

Previous studies show that hypertension was higher in men than women at younger ages, but higher in women in older generations.[24] Although there is no correlation between prevalence and the economic burden of disease, higher prevalence often means more expenditure. This study shows that with the increase of age, the rise of CCE_{ht} is gradually higher in women than in men. For outpatients, the CCE_{ht} is gradually higher in women than in men after age 70, and for inpatients, it is after age 50. Multiple studies have shown that adverse lifestyle habits such as smoking and alcohol consumption, age, stress, body mass index, weight, family history and biological factors are all risk factors for hypertension.[25–28] For young men, higher smoking and alcohol use rates mean men have a higher risk of high blood pressure.[25 26] For women with postamenorrhoea, who are more prone to central obesity, dramatic oestrogen levels can influence their vascular system and they are more prone to systolic hypertension.[27 28] Therefore, we advocate more targeted measures based on comprehensive intervention. For the young, we should pay more attention to the men. While for the old, it is the women who should be paid more attention to.

For a long time, Chinese patients tended to go to provincial and municipal general hospitals rather than primary healthcare systems, mainly due to insufficient medical resources, imperfect medical system, limited level of general practitioners in the primary healthcare system and patients' distrust of community doctors.[29] Studies show that basic medical institution is an effective way to control hypertension.[30 31] As a result, the standardised prevention and treatment of hypertension were included in the national basic public health service programme in 2009.[32] Basic medical institutions offer free regular physical examinations and standardised management for patients with hypertension. Basic medical institutions should give full play in the role of prevention and treatment of hypertension. Our study shows (table 2) that 65.51% of outpatients and 53.98% of inpatients chose basic medical institutions, effectively reducing CCE_{ht}, especially $CCE_{ht\text{-}out}$. Although 34.41% of outpatients and 45.99% of inpatients still chose general hospitals, more than 70% of patients with hypertension chose county-level medical institutions instead of provincial (or municipal) hospital. It suggests that the diagnosis and treatment capacities of primary healthcare system has been enhanced. To better prevent and control hypertension, the government should continue to increase the support to the primary healthcare system, strengthen the standardised construction of the primary healthcare system, enhance the training of community doctors, encourage the exploration of a new model of cooperation between primary healthcare system and provincial (or municipal) hospital, guide more chronic patients to the primary healthcare system and reasonably divert patients with mild hypertension. It will effectively reduce the family economic burden and improve the utilisation efficiency of social resources.

Different types of medical insurance will greatly impact patients' medical behaviour and expenses.[33] This study shows the majority of outpatients and inpatients with hypertension use social medical insurance. According to the population characteristics report of the Shanxi provincial government in 2017,[17] rural and urban populations accounted for 42.66% and 57.34% of total population, respectively. However, in this study, the number of rural outpatients with hypertension was nearly eight times that of urban patients. The number of hospitalised rural patients with hypertension was four times that of urban patients. It implies that NRCMI has been widely used in rural areas and has a trend of overusing. Consistent with the literatures,[34] in this study, UEBMI has the highest per capita reimbursement ratio. Due to the higher reimbursement ratio, UEBMI patients tend to pursue high consumption of medical services, driven by the interests of medical institutions. It implies that patients with UEBMI are more likely to over-pursue certain unnecessary high-tech materials, technologies and high-cost treatment programmes. This suggests that the government should strengthen the standardisation of disease treatment and restrict unnecessary medical behaviour. At the same time, the research also shows that the government subsidy in inpatient is 23 times that of outpatient, and nearly half of $CCE_{ht\text{-}out}$ is paid by OOP. It indicates that the burden of family health expenditure is still very heavy in the outpatient treatment of hypertension. For patients with stable control of hypertension, the services provided by grassroots clinics can meet the needs of patients. Compared with large general hospitals, the cost of medical services provided by grassroots clinics is lower. Therefore, the government should improve the priority of primary medical institutions in the process of hypertension treatment, incline the policy to outpatient service and increase the reimbursement limit of outpatient expenses in basic medical insurance, which is conducive to reducing the total direct medical expenses of patients with hypertension.

Analysis of influencing factors by MLP neural network shows that drug fee is the most important influencing factor of CCE_{ht}. This is mainly because most hospitals in China could sell retail drugs at a price plus a 15% profit margin as a source of financing for healthcare providers. This distorted incentive aggravates the unreasonable behaviour of hospitals supporting doctors with drugs. Long-term medication, irrational use of medicines by medical staff, blind and excessive consumption of new specialty drugs and imported drugs emerge one after

another.[35 36] In addition, in outpatient treatment, the impact of examination fee and test fee on $CCE_{ht\text{-}out}$ follows drug fee, which implies that the phenomenon of 'relying on medicine, examination and test to support doctors' still exists. Therefore, the government should further strengthen the standardisation and supervision of drugs and inspection items, improve the usage of generic medication and inspection efficiency. In inpatients, the impact of surgical fee and hospitalisation days on $CCE_{ht\text{-}out}$ follows drug fee. The included samples may have other medical conditions caused by high blood pressure, which means surgery costs may be incurred. The expensive imported medical materials mainly cause the high surgical fee. Research[37] shows some high-value consumable medical equipments made by domestic manufacturers are fully complying with international standards and partially or completely replacing imported products. It is suggested that medical personnel use domestic supplies as much as possible, which is feasible for social and economic benefits. Hospitalisation days can also significantly increase $CCE_{ht\text{-}in}$. Study shows that 18.10% of the hospitalisation days are unnecessary, which increases the economic burden of patients and reduces the reasonable allocation of medical resources.[38] The hospital should shorten hospitalisation time to reduce $CCE_{ht\text{-}in}$ on the premise of ensuring medical quality.

Our study has some limitations. First, this study samples reflect the economic burdens of hypertension from medical institutions. As we all know, patients with hypertension need long-term medication, and some patients may go directly to buy medicine in drugstores instead of medical institutions. Therefore, the true financial expenditure of patients with hypertension may be underestimated. Second, in CI, the patient's medical expenses are generally paid in advance and then reimbursed by the insurance company after treatment. So, it may be biased in allocation of CCE_{ht} in CI. Third, sample cities were selected based on the level of health information management system and economic development. More cities will improve the extension of this study, which is also the goal of our future research.

CONCLUSION

From the calculation of CCE_{ht} in the frame of SHA 2011, we find that the medical expenditure of hypertension is still heavy for individuals and society, the diagnosis and treatment capacities of primary healthcare system has been enhanced, new rural cooperation medical insurance and urban employee basic medical insurance have a trend of overusing, and the burden of family healthcare expenditure is still heavy. To ease the economic burden of patients with hypertension and improve the utilisation efficiency of social resources, the policymakers should pay more attention to key groups, further increase support for primary healthcare system, standardise the treatment and reimbursement of hypertension, and incline the reimbursement policy to outpatient service.

Author affiliations
[1]School of Forensic Medicine, China Medical University, Shenyang, China
[2]College of Health Management, China Medical University, Shenyang, China
[3]First Hospital of China Medical University, Shenyang, China
[4]Humanity and Management College, Shaanxi University of Chinese Medicine, Xianyang, China
[5]First Clinical Department, China Medical University, Shenyang, China
[6]School of Public Health, Xin Jiang Medical University, Urumqi, China

Acknowledgements The authors express thanks to China National Health Development Research Center for their help with SHA 2011 analysis. We also gratefully acknowledge the support of the Health Commission of Shanxi Province in providing data.

Contributors GL and XW designed the whole process and did the preresearch. GL, XJ, JO and YZ did the preresearch and statistical analysis. GL was the main drafter of the manuscript. QF was the major contributor to the revision. YZ and LW contributed to the coordination and manuscript editing. XW was the director for the fund and designed ideas for research. XW is responsible for the overall content as the guarantor. All authors reviewed and contributed to the subsequent drafts and approved the final version for publication.

Funding The research was supported by the National Natural Science Foundation of China (71673299) and Natural Science Foundation of Liaoning Province (20170541031).

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study does not involve human participants.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. Data are available upon reasonable request (wxinsmile@qq.com).

ORCID iD
Xin Wang http://orcid.org/0000-0001-7591-0103

REFERENCES

1 Nguyen TN, Chow CK. Global and national high blood pressure burden and control. *The Lancet* 2021;398:932–3.
2 Zhou B, Perel P, Mensah GA, *et al*. Global epidemiology, health burden and effective interventions for elevated blood pressure and hypertension. *Nat Rev Cardiol* 2021;18:785–802.
3 NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in hypertension prevalence and progress in treatment and control from 1990 to 2019: a pooled analysis of 1201 population-representative studies with 104 million participants. *Lancet* 2021;398:957–80.
4 Mills KT, Stefanescu A, He J. The global epidemiology of hypertension. *Nat Rev Nephrol* 2020;16:223–37.
5 Mills KT, Stefanescu A, He J. The global epidemiology of hypertension. *Nat Rev Nephrol* 2020;16:223–37.
6 Wang J, Zhang L, Wang F, *et al*. Prevalence, awareness, treatment, and control of hypertension in China: results from a national survey. *Am J Hypertens* 2014;27:1355–61.
7 Si Y, Zhou Z, Su M, *et al*. Catastrophic healthcare expenditure and its inequality for households with hypertension: evidence from the rural areas of Shaanxi Province in China. *Int J Equity Health* 2017;16:27.
8 World Health Organization. Updated revised draft global action plan for the prevention and control of non-communicable diseases 2013-2020.Geneva, 2013. Available: https://www.who.int/publications/i/item/9789241506236
9 Kirkland EB, Heincelman M, Bishu KG, *et al*. Trends in healthcare expenditures among US adults with hypertension: national estimates, 2003-2014. *J Am Heart Assoc* 2018;7:e008731.

10 Chinese Journal of cardiovascular health and disease 2020 summary. *Chinese Journal of Circulation* 2021;36:521–45.
11 Dzau VJ, Balatbat CA. Future of hypertension the need for transformation. *HYPERTENSION* 2019;74:450–7.
12 Christensen MC, Previgliano I, Capparelli FJ, *et al*. Acute treatment costs of intracerebral hemorrhage and ischemic stroke in Argentina. *Acta Neurol Scand* 2009;119:246–53.
13 Zhai TM, Zhang YH, Wan Q. Methodological research on China health expenditure estimation based on SHA 2011. *Chinese Health Economics* 2015;34:9–11.
14 Chai PP, Zhang YH, Wan Q. Estimation results of China curative care expenditure based on SHA 2011. *Chinese Health Economics* 2015;34:17–19.
15 Zhao SY, Zhang XY, YL L. Study on Diagnosic model of syndrome of deficiency of both Yin and Yang in hypertension based on decision tree and neural network. *Chin. Arch. Tradit. Chin. Med* 2019;37:1120–3.
16 Li Y, Wang L, Feng X, *et al*. Geographical variations in hypertension prevalence, awareness, treatment and control in China: findings from a nationwide and provincially representative survey. *J Hypertens* 2018;36:178–87.
17 Shanxi Municipal Bureau Statistics. Shanxi statistical yearbook, 2018. Available: http://tjj.shanxi.gov.cn/tjsj/tjnj/nj2018/indexch.htm [Accessed 10 Agu 2019].
18 Li Y, Feng X, Zhang M, *et al*. Clustering of cardiovascular behavioral risk factors and blood pressure among people diagnosed with hypertension: a nationally representative survey in China. *Sci Rep* 2016;6:27627.
19 Stevens B, Verdian L, Pezzullo L. The economic burden of hypertension in LatinAmerica. *Value in Health* 2016;19:A647–8 https://www.valueinhealthjournal.com/article/S1098-3015(16)33099-6/pdf
20 JL H, Yin Z, Duan WJ. Factors of hospitalization expenditure of the genitourinary system diseases in the aged based on "System of Health Account 2011" and neural network model. *Journal of Global Health* 2018;8:34–6.
21 Perk J, De Backer G, Gohlke H, *et al*. European guidelines on cardiovascular disease prevention in clinical practice (version 2012). The fifth joint Task force of the European Society of cardiology and other societies on cardiovascular disease prevention in clinical practice (constituted by representatives of nine societies and by invited experts). *Eur Heart J* 2012;33:1635–701.
22 Nguyen QC, Tabor JW, Entzel PP, *et al*. Discordance in national estimates of hypertension among young adults. *Epidemiology* 2011;22:532–41.
23 Volpe M, Camm J, Coca A, *et al*. The cardiovascular continuum refined: a hypothesis. *Blood Press* 2010;19:273–7.
24 Armas Rojas N, Dobell E, Lacey B, *et al*. Burden of hypertension and associated risks for cardiovascular mortality in Cuba: a prospective cohort study. *Lancet Public Health* 2019;4:e107–15.
25 Zhao L, Sun W, Wang J, *et al*. Differences in the treatment and control of hypertension in urban and rural residents of the northeastern region of the People's Republic of China: a cross-sectional study. *Clin Exp Hypertens* 2019;41:366–72.
26 Yang L, Yan J, Tang X, *et al*. Prevalence, awareness, treatment, control and risk factors associated with hypertension among adults in southern China, 2013. *PLoS One* 2016;11:e0146281.
27 Di Giosia P, Giorgini P, Stamerra CA, *et al*. Gender differences in epidemiology, pathophysiology, and treatment of hypertension. *Curr Atheroscler Rep* 2018;20:13.
28 Mozaffarian D, Benjamin EJ, Go AS, *et al*. Heart disease and stroke statistics--2015 update: a report from the American Heart Association. *Circulation* 2015;131:e29–39.
29 Xiao R. Health education nursing of community hypertension. *Chin Heal Standard Management* 2016;7:206–7.
30 Zhang Q, ZH X, Zhou SS. Health management of community hypertension based on regional medical association: an empirical study. *Chin. Rem. Clin* 2018;18:1888–90.
31 Chen XY, Li R. Application of chain management in education among hypertensive patients of the community. *Chinese Journal of Practical Nursing* 2017;33:91–4.
32 Liu L-S, Writing Group of 2010 Chinese Guidelines for the Management of Hypertension. [2010 Chinese guidelines for the management of hypertension]. *Zhonghua Xin Xue Guan Bing Za Zhi* 2011;39:579–616.
33 Zhang JY, XR L, Gao H. Influencing factors for hospitalization expenses in patients with hypertension. *Chin J Hyperten* 2020;28:271–5.
34 Bo L, Xie QJ. Analysis on the hospitalization expenses of hypertension patients. *Hosp Admin J Chin PLA* 2018;25:887–90.
35 Fang Q, Shang D, Zhang Y, *et al*. Will the zero-margin drug policy reduce the economic burden of stroke patients in China? *J Glob Health* 2021;11:08007.
36 Sun Q, Santoro MA, Meng Q, *et al*. Pharmaceutical policy in China. *Health Aff* 2008;27:1042–50.
37 Li Y, YQ D, Guan ML. Factors analysis of hospitalization costs of cardiovascular and cerebrovascular diseases in a tertiary specialized hospital in Ningxia. *Ningxia Medical Journal* 2016;38:1264–6.
38 Hu Q, Luo ML. Analysis on factors influencing hospitalization length of hepatitis B patients. *Disease Surveillance* 2017;32:674–7.