Does the Medical Insurance System Play a Real Role in Reducing Catastrophic Economic Burden in Elderly Patients with Cardiovascular Disease in China? Implication for Accurately Targeting Vulnerable Characteristics.

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Abstract

Abstract Background:The vulnerability of cardiovascular disease (CVD) patients' health abilities, combined with the severity of the disease and the overlapping risk factors, can cause such people to bear the economic burden of the disease due to the use of medical services.We estimated the economic burden of patients with CVD and identified the weak link in the design of the medical insurance. Methods:Data from 5,610 middle-aged and elderly with CVD were drawn from the 2015 wave of China Health and Retirement Longitudinal Study (CHARLS). The recommended method of the World Health Organization (WHO) was adopted to calculate catastrophic health expenditure (CHE), impoverishment by medical expenses (IME), and applied the treatment-effect model to analyze the determinants of CHE. Results:The incidence of CHE was 19.9% of the CVD, compared to 7.6% of the sample households trapped in IME. The incidence of CHE in CVD participating in medical insurance was 2.6% higher than for uninsured families (16.3%).Family size, health satisfaction,combine with other chronic diseases, having hospitalization and disabled members, and participating in insurance were found to be significantly associated with the likelihood of CHE. Conclusions:Elderly with physical vulnerabilities were more prone to CHE. The medical insurance only reduced barriers to accessing health resources for elderly with CVD, but lacked policy inclination for high-utilization populations,and had poorly accurate identification of vulnerable characteristics of CVD,which in turn affects the economic protection ability of the medical insurance. The dispersion between the multiple medical security systems leads to the existence of blind spots in the economic risk protection of individuals and families.

Keywords:cardiovascular disease, catastrophic health expenditure, impoverishment by medical expense, medical insurance, elderly households

Background

Aging, rapid urbanization, and shifting disease patterns are causing cardiovascular disease (CVD) to become established as one of the primary diseases in the world.[1.2] Worldwide, roughly 17.9 million people die of CVD each year, and the absolute number of deaths from chronic CVD worldwide increased by 42.4% between 1990–2015 (2017).[3,4] The incidence and mortality of CVD are also serious in China. As of 2015, there were 290 million people suffering from CVD in China, including more than 9.5 million cases of heart disease.[5] In addition, between 1990–2013, the total number of CVD deaths increased by 46% in China, mainly due to population aging.[6] The increasing trend of CVD has brought a heavy economic burden to the world at the population and household levels.[7] It is estimated that as of 2015, the estimated annual global cost of CVD is expected to increase by 16%, from 906 billion to more than 104.4 million by 2030.[8] In India, 25% of families with a member with CVD experience catastrophic expenditure, and 10% are driven into poverty[9]

The particularity of the internal disease structure and the characteristics of the elderly have made China one of the countries with a high incidence of CVD. In China, the Disability Adjusted of Life Years(DALY) caused by cardiovascular disease has reached 582.255 million, accounting for roughly 20% of the world's

cardiovascular disease, which is nearly 9% higher than the international average.[10] Annual inpatient care cost has risen at a steady rate of 30% since 2004.[11]Compared to Western Europe, China suffers a 50% higher mortality rate from CVD and faces a larger economic burden.[12] Annual direct medical expenses for cardiovascular diseases in China are more than 130 billion yuan, accounting for more than 22% of the total medical expenses in China during the same period, which is 10% higher than Australia.[13] Some research indicates that during the 30 years from 2010–2040, the annual economic benefits of reducing cardiovascular mortality by 1% in China is equivalent to 68% of real GDP in 2010, exceeding US $10.7 trillion.[14]

China's basic medical insurance system consists of three types of medical insurance scheme urban employees' insurance medical(MIUE), urban resident insurance medical(MIUR), and the new rural cooperative medical system(NCMS).[15] The basic medical insurance for economic protection with two basic goals: first, to ensure that all people have access to high-quality care; and second, that everyone has the ability to pay for these services to maintain and improve their health.[16]

China has basically achieved 95% coverage of medical and health services. However, the inefficiency of the health care system and the uneven distribution of medical resources make the cost-effectiveness of continuous medical reforms lower, and the coverage and depth of the medical insurance system needs to be improved. Studies have demonstrated that the actual effect of this coverage has been offset by the rapid escalation of medical expenses,especially for the elderly group that combines age and disease.[17] Some scholars measured the disease burden of CVD patients aged 60 years and older in 2011–2013 and found that the direct and indirect medical costs of residents rose from 4,938 yuan to 5,717 yuan, and the OOP Out-of-pocket increased by roughly 12 percentage points (from 58.1% to 70%).[18] The resident's medical insurance reimbursement ratio is much lower than the European Union's (EU) major disease reimbursement ratio of not less than 60%.[19] The World Health Organization (WHO) reports that a reasonable OOP is 15–20%.[20] Once the literature exceeds the prescribed warning value, it will often cause vulnerable groups, such as rural residents and the elderly with low economic incomes, to fall into excessive cash health expenditures, resulting in " impoverishment by medical expenses" and "returning from poverty."

However, the vulnerability of CVD patients' health abilities, combined with the severity and recurrence of the disease itself and the overlapping risk factors, can cause such people to bear the heavy economic burden of the disease due to the use of medical services. Therefore, in the effort to reduce the economic burden of patients with CVD, understanding the weak link in the design of the medical insurance system is particularly important for patients with CVD.

Methods

Data source and sampling method

The data used to calculate the rates of catastrophic health expenditure (CHE) and impoverishment by medical expenses (IME) were obtained from the 2015 China Health and Pension Tracking Survey (CHARLS) database, which is designed to collect microscopic information from >45-year-olds. CHARLS covers 450 communities in 150 counties from 28 of the 32 provinces in mainland China. Face-to-face household interviews were conducted by qualified investigators. Households were randomly selected from maps and listings within each rural or urban community by four-stage stratified cluster sampling to select eligible individuals. Data were collected through questionnaires, and quality control was implemented by supervisors and included GPS comparison, data verification, recording verification, and telephone verification. A total of 5,610 samples (2,507 households) were finally obtained after cleaning the incomplete data and missing values.

Statistical analysis

Calculation method for CHE and IME

We adopted the WHO's recommended method to calculate CHE and IME.[21] CHE was defined as an OOP payment for health care equaling or exceeding 40% of a household's capacity to pay. IME was defined as consumption expenditure equal to or higher than household subsistence expenditure but lower than the subsistence expenditure (SE) net of OOP health payments. The key expenditure indicators involved in the calculation process were as follows:

Equivalent family size: $eqsize_h = hhsize_h^{0.56}$

Equivalent food expenditure: total household food expenditure divided by equivalent family size

$$eqfood_h = \frac{food_h}{eqsize_h}$$

Poverty Line (pl): the weighted average food expenditure of a household, whose food expenditure as a share of household consumption expenditure fell between the 45th and 55th percentiles of the entire sample.

$$pl = \frac{\sum w_h * eqfood_h}{\sum w_h}$$

Household subsistence expenditure (SE): was calculated using food expenditure as a share of total household consumption expenditure.

$$se_h = pl * eqsize_h$$

A household's capacity to pay (CTP): was defined as non-subsistence spending of a household as a share of total household consumption expenditure.

if $ctp_h = \exp_h - se_h$ $se_h \leq food_h$

$ctp_h = \exp_h - food_h$ if $se_h > food_h$

Out-of-pocket health expenditure (OOP): the payments made by households for their health services without third-party compensation.

$$oopctp_h = \frac{oop_h}{ctp_h}$$

Household consumption expenditure (exp): comprises both monetary and in-kind payments on all goods and services and the money value of the consumption of home-made products.

The consumption quintile: ranked by equivalized per capital household consumption expenditure weighted with the standard household size rather than the actual household scale.

$eq\ exp_h = exp_h / eqsize_h$

Treatment effect model

The relationship between participating in the medical insurance system and CHE is characterized by a joint causal relationship. There are implicit selection biases in participating in the medical insurance system, such as the average community participation rate, self-assessment of health status, and other unobserved characteristics associated with initial selection. To address the bias caused by hidden selectivity bias and joint causality, we applied a instrumental variable (IV) method called the therapeutic effect model.[22,23]

Instrument indicators

We assume that indicators of medical insurance are endogenous. In order to address this endogeneity, we needed instrumental variables,which are related to endogenous predictors (medical insurance) but are not related to the error term of outcome variables（CHE).[24]The premise of using the instrumental variable method is that there are endogenous variables in the regression equation. So,it is necessary to identify endogenous variables(whether participation in medical insurance) in the regression equation.In our paper, we verify this problem by DWH test. In other words, the DWH test checks examines whether the endogenous predictor is truly endogenous.（The heterogeneity test result shows that, $P = 0.000 < 0.05$, so we use the DWH text）

By reviewing existing literature,we initially identified two possible instruments: self-assessment of health status and average community participation rate.Generally speaking self-reported poorly-healthy groups are more likely to choose to take insurance medical to maintain their health.[25] In addition, the average community participation rate of residents' basic medical insurance will have an impact on the willingness of families to participate in insurance.People living in the same community have certain common characteristics, such as family economic level and health management awareness, which will make them participate in medical insurance.Moreover, the basic medical insurance plan in China is a community or company-based unit. For example, the MIUE is driven by the company, and the NCMS is that the village cadres mobilize the villagers to participate in the medical insurance scheme, so that the community participation rate is highly correlated with the willingness to participate in the family.[26]

Good instrument should satisfy two main criteria known as relevance and validity criteria, that is to say, good instruments would be correlated with the endogenous variable (relevance criteria) but not to be correlated with the error terms in the model of the outcome variable (validity criteria).

We use the Over-identification Test and GMM regression to check the validity and relevance.[27,28] In addition, in order to further investigate the weak instrumental variable problem, we also perform redundancy-test. The results show that community participation rate becomes our ultimate effective instrumental variable. The results regarding the validity and relevance are **presented in Table1.**

Table 1. Validity test and correlation test

The treatment effect model includes a two-stage regression. In the first phase, we regression the outcome variables of the covariates (the heterogeneity test results show that P = 0.000 <0.05, so we use GMM as our regression equation); based on the results of the first phase, we add instrument variables and the outcome variable performs a quadratic regression.

Outcome variable

We created a binary indicator for CHE as the outcome variable (1=occurrence, 0=no occurrence).

Covariates

In our study, we used three sets of information as covariates for this paper: **Social demographic characteristics**, specifically age, gender, marital status, education level of household head, family size, and having a member over 65 years old.**The health status of family members**, including whether the household has at least one member with a chronic disease, who has been admitted to the hospital, or has a disability.**The demand and utilization of health services for household heads**, mainly including hospitalization rate, outpatient rate, and non-admission rate (defined as the percentage of patients who need to be hospitalized but are not hospitalized).

Results

Sample characteristics

Table 2. Patients' demographic characteristics

Table 2 summarizes the characteristics of cardiovascular disease patients with CVD in 2015. The total sample comprised 2,507 households and 5,610 individuals, of which 50.2% of household heads with CVD were male, and around 65.7% of the elderly were aged <64. Over 59.4% had an elementary to junior high education level. Only 23.3% of the CVD patients had a health satisfaction status of "good," with >60.4% having one or more other chronic diseases. There were more rural than urban patients included (75.1% vs 24.9%); and patients with CVD living in the middle part of China were slightly over-represented compared to residents of the west and east. Furthermore, 97.1% of the CVD patients had medical insurance.

Health-care needs and service utilization

Table 3. Health care demand, service utilization, and reimbursement of household head

Regarding health service utilization for the high-risk group of elderly CVD patients, in 2015, the rate of monthly prevalence was 11.4% overall. A higher proportion of patients with CVD used inpatient services (14.8%), and more than 19.8% of respondents reported the utilization of outpatient services over the past month. The hospitalization reimbursement ratio of the CVD patients was only 44.5%, and the non-

admission rate was 6.2%. The above indicators demonstrate different trends for different populations with cardiovascular diseases as follows:

Cardiovascular patients with a high level of health service demand but low utilization of health services and low reimbursement rate. For example, families with cardiovascular disease patients and >3 other chronic diseases had a high demand for health services. Its prevalence rate and hospitalization rate were 13.8% and 23.5%, respectively. However, the health service utilization (non-admission rate 9.8%) and the reimbursement level (48.5%) were lower than cardiovascular disease patients without other chronic diseases.

In terms of family economic level and type of medical insurance, cardiovascular patients with a high level of health service demand and high health utilization but low reimbursement. Household heads of cardiovascular diseases with NCMS had a higher prevalence (14.3%) and outpatient rate (20.5%), but the hospitalization reimbursement ratio (39.7%) was lower by nearly 30% than MIUE (69.8%). Patients who participated in MIUR of cardiovascular diseases demonstrated a similar pattern. It is worth noting that among the wealthiest households with cardiovascular diseases, the hospitalization rate and visit rate were 16.4% and 20.9%, respectively, but the hospitalization reimbursement ratio was only 49.2%, less than 50%.

CHE, and IME in different households

Table 4.CHE, and IME in different households

We further measured the incidence of CHE and IME in elderly with CVD, and 19.9% of all interviewed CVD patients encountered CHE, and the IME occurred in 7.6% of the overall population. The proportion of OOP to household payment capacity was 17.2%.

We also found that as the family size and combination with other chronic diseases increased for CVD patients, the risk of households being trapped in CHE and IME also increased. For example, the incidence of CHE among the household of cardiovascular patients with more than three other diseases (31.8%) was twice that of having no other diseases (14.7%). Furthermore, families with inpatients and disability members of CVD increased the risk of CHE and had a greater financial burden. The incidence of CHE were 29.3% and 31.1%, which is more than 10% higher than that of those without inpatients and disability members of CVD 18.6% and 19.5%).

It is worth noting that income level is not the main reason for the high incidence of CHE in patients with cardiovascular disease. Among them, sub-poor families with CVD had the highest incidence rate of CHE and health expenditure burden, which were 22.5% and 22.1%, respectively, higher than the richest households with CVD with the lowest incidence rate (17.5%) 5% and 4.6%,respectively. As far as the type of insurance is concerned, among the three basic medical insurances, cardiovascular families with NCMS had the greatest economic burden of disease, and the risk of CHE was also the highest (21.6%), nearly 8.3% higher than that of NIUE (13.3%).

The treatment-effect model for patients with CVD

Table 5. Results of treatment-effect model for patients with CVD

Community participation rate was added as an effective instrumental variable to the treatment-effect model. The results were as follows: family size, health satisfaction, combination with other chronic diseases, having hospitalization members, having disabled members, and participating in insurance were all found to be significantly associated with the odds of encountering CHE with CVD ($P<0.05$).

Social demographic perspective: The incidence of CHE and family size with CVD have developed in reverse—that is,as the cardiovascular family grows in size, the risk of CHE is reduced by 4.99 percentage points.

Health needs and utilization perspective: Combination with other chronic diseases, health satisfaction**,**having hospitalization members, and having disabled members had a positive correlation with the risk of CHE in cardiovascular patients, and with an increase of combining other chronic diseases or hospitalization members increased,the risk of a family's CHE increased by 4.68 percentage points and 10.01percentage points, respectively.

Medical insurance perspective: It is worth noting that cardiovascular patients participating in medical insurance increased ,the risk of CHE and increased the risk of being trapped in CHE by 28.9 percentage points.

Medical insurance level

As shown in the above figure, among patients with cardiovascular disease, rural population accounts for 75.1% of the sample size, and the CHE of NCMS was the riskiest, at 21.6%. In addition, the treatment-effect model shows that the probability of CHE participating in health insurance families with cardiovascular disease has increased by 29.8 percentage points. Therefore, to identify the NCMS of key bottlenecks, we conducted a specific influencing factor analysis and found that families with cardiovascular disease combined with >3 other chronic diseases (38.88%) were the primary cause of high CHE in NCMS. Next, in turn, being more than 75 years old (33.33%), having disabled members (33.33%), having hospitalization members (32.41%), and combining two chronic diseases (30.74%) were the top five factors influencing high CHE of families with cardiovascular disease in NCMS.The results are **presented in Fig.1.**

Discussion

The proportion of households associated with CHE and IME in elderly patients with CVD were 19.9% and 7.6%, respectively. These rates were higher than those of developed countries,but were lower than those of low-income countries.[29,30] The incidences of CHE participating in medical insurance were 3.6% higher than those of uninsured households (16.3%). In addition, families with cardiovascular disease have a

much higher risk of IME than families without cardiovascular disease (7.0%) and the overall population (7.2%).It can be seen that cardiovascular disease patients' risk tolerance for health care payments is actually lower than the average in China. At the same time, our study also found that cardiovascular families with chronic patients, inpatients, and disabled members, are at a higher risk of falling into poverty because of the cost of health care, and they are becoming a stubborn group with a high burden of CVD disease under the medical insurance system.

As a kind of vulnerable group, patients with cardiovascular disease are mainly characterized as a high-risk group integrating physiological, social, and health factors. We need to identify risk factors for patients with CVD and identify vulnerable groups and then better play the economic protection role of the medical insurance system. As mentioned earlier, despite these governmental efforts, many disadvantaged groups are not considered target populations for benefit enhancement. Through comprehensive analysis, we found that the disadvantaged elderly population with mental health has the following characteristics:

Older groups with physical vulnerability are more prone to CHE.

In the first place, age growth, loss of healthy capital, and decline in physiology are inevitable for the elderly. However, elderly people are at a disadvantage in accessing resources and fail to enjoy social welfare policies fairly.[31,32] For example, the incidence of CHE in elderly people over 75 years old in the NCMS was 33.33%, second only to the merger of three chronic diseases (33.88%).The WHO reported that 23% of the world's disease burden is on older people, and chronic non-communicable diseases have a major impact on this burden.[33] Furthermore, the morbidity and concurrency of elderly patients with CVD may eventually lead to premature death and disability, while long-term health care costs, drug costs, and rehabilitation costs greatly increase the risk of CHE.[34] Our results show that the hospitalization rate (23.5%), rate of visits (24.5%), and incidence of CHE (31.8%) of patients with more than three chronic diseases are far higher than those without chronic diseases (13.3%, 17.7%, 14.7%, respectively), and the treatment-effect model shows that the combination with other chronic diseases increases the risk of 4.68 percentage points of CHE. Past evidence has demonstrated that the likelihood of using health care (e.g, hospitalization) increases in the presence of chronic or multiple conditions.[35] It can be seen that with the increase of the number of chronic diseases, the addition of other chronic diseases will prolong the hospitalization time on the basis of the original single disease, which will cause CVD patients to superimpose the cost of other diseases when they bear the economic pressure from their cardiovascular disease burden. Studies have found that one-third of adults have multiple chronic diseases, equivalent to 3/4 of the elderly in developed countries.[36] Therefore, suffering from a variety of chronic diseases has become a major health problem for the elderly in the future, greatly increasing the risk of CHE.

The medical insurance system only guarantees the basic health utilization threshold for elderly patients with CVD and lacks policy inclination for high-utilization populations.

The existing medical insurance system reduces the threshold of health service utilization for vulnerable groups. such as those with cardiovascular diseases, but only achieves the first goal of medical insurance —that is, to ensure that all people have access to high-quality care. Our results show that the incidence of CHE for high-demand people with inpatients and disabled patients is much higher than that of the normal population. In our paper, families with disabled patients had higher prevalence (21.7%) and outpatient rates (21.8%) than those without disabilities (13.4% and 19.6%, respectively). However, the hospitalization reimbursement ratio was only 40.6%, far below the overall level (44.5%), and OOP accounted for 35.6% of total household health expenses, which is much higher than that of OECD countries.[37] A study in South Korea showed that families with disabilities face higher CHE than those without people with disabilities, and annual living expenses for OOP medical expenses are roughly 1.2 to 1.4 times greater.[38] This may be due to physical or mental disability in disabled patients leading to job loss or reduced earnings, while higher medical care needs due to disability increase the burden of high medical costs.[39] Even relatively small expenditures are catastrophic for poor families, and excessive out-of-pocket health care spending can lead to poverty.[40]

The medical insurance system has poorly accurate identification of vulnerable characteristics, which in turn affects the economic protection ability of the medical insurance system for patients with cardiovascular diseases.

China's medical insurance policy aims to solve the problem of “people falling into poverty due to illnesses” and to ensure that most people are not reduced to poverty because of health-related issues. However, our results indicate that the risk of CHE for CVD patients participating in medical insurance schemes has increased by 28.9%, which had the highest incidence of CHE for NCMS. It can be seen that the medical insurance system has the disadvantages of insufficient protection of policies in reducing the economic burden of residents’ medical care and maintaining residents’ health rights and health. China’s health sector reform has achieved unprecedented progress, but protecting vulnerable groups from health care-related impoverishment remains a challenge. Specifically, we need to reconsider benefit packages and redesign social health care insurance programs in order to further protect the elderly population with cardiovascular disease.

Inequality between types of health insurance systems: binary urban and rural structure divided by place of residence.The household registration system in China directly affects the ability to obtain various medical benefits.[41] In our paper, the hospitalized reimbursement ratio of MIUE with cardiovascular disease patients was 69.8%, while that of the NCMS was only 39.7%, accounting for only half of the MIUE. Urban residents are expected to have a greater awareness about their health and better access to health insurance (especially private health insurance) and hence are more likely to obtain health insurance. The health needs of people in rural areas are not able to be converted into effective medical needs in time due to lower income levels, high medical prices, and inadequate medical care, thus bearing the risk of greater CHE. A Chinese study shows that NCMS cannot prevent CHE from happening in poor families but only reduces the incidence of CHE in wealthy families.[42] This differentiated design of health

care benefits can sometimes lead to social inequalities, often with the same disease, at different costs, and patients with higher socioeconomic status usually enjoy better health insurance and higher service utilization. In rural areas, this should further increase the reimbursement ratio of outpatient and inpatient expenditures to the elderly with cardiovascular diseases who receive treatment at every kind of hospital.[43]

Inequality of different income groups under the same medical insurance system.Our research indicated that the incidence of CHE in sub-poor households with CVD (22.5%) was higher than 5% of households with the highest income. Its OOP accounts for 22.1% of CTP, and the economic burden of disease was higher than that of high-income families by nearly 10%. A similar phenomenon occurred in India. According to the data, India's medical expenditure accounts for only 0.9% of the GDP, which is lower than the 2.8% of the GDP of less developed countries. However, with only government spending, among the five economic subgroups, the poorest households with less income receive only 10% of medical care, while 20% of the wealthiest households receive up to 33% of social subsidies, three times as much as the poorest households.[44] The heavy burden of disease can lead to a difficult family life in low-income groups, which thus fall into the evil cycle of “poor illness due to illness and illness due to poverty.” Therefore, the internal system design of medical insurance should strengthen the economic support and protection for poor families and achieve certain policy inclinations.

The inconsistencies between multiple health care systems lead to blind spots in the economic risk protection of individuals and families.

China has established multiple medical security systems, including basic medical insurance, major illness insurance, commercial medical insurance, social medical assistance, and charity assistance. However, the complexity of cardiovascular disease and the difference in the income of the population mean that various systems have not woven a standard, unified safety net to prevent impoverishment by medical expense, which is mainly reflected in the following two points.

Firstly, the particularity of cardiovascular disease can lead to the loss of labor, the indirect cost of nursing expenses, and transportation expenses, and long-term drug maintenance will also increase the economic burden of patients. These neglected indirect costs and drug costs have become blind spots in the economic protection of basic health care systems. In our study, elderly cardiovascular patients still have to pay more than half (55.5%) of their medical expenses after reimbursement by basic medical insurance schemes. Moreover, there is no effective mechanism to connect basic insurance schemes, major disease schemes, and medical assistance insurance systems, resulting in this group of patients falling into poverty after paying for the high medical expense.

Secondly, our result also shows that sub-poor households have the highest incidence of CHE at 22.5%, and the OOP accounts for 22.1% of CTP, much higher than the poorest households. The medical security system has implemented certain health expense reduction policies for these “extremely poor families” without economic sources or micro-income, including lowering the deductible line, increasing the proportion of reimbursement, and improving or eliminating top-up measures. The high-risk marginalized

population with an economic income slightly higher than that of the poorest households, which is prone to CHE, has not reached the standard of assistance for supplementary medical assistance and has failed to be covered by a multilevel medical security system.

It can be seen that exploring the integration of multilevel medical insurance systems, promoting the complementary functions and overlapping effects of multilevel medical insurance systems, and jointly solving the poverty problems caused by cardiovascular patients have become the target task of the current prevention and treatment process of chronic diseases.

Conclusions

The findings revealed that the incidence of CHE and IME were relatively high among elderly households with CVD patients. The elderly who had poor health satisfaction, combination with other chronic diseases, inpatients, and disabled people were the high-risk groups of CVD. Medical insurance programs have not reduced the risk of CHE or relieved the financial burden of CVD patients in China, especially the elderly who participate in the NCMS. Therefore, there is an urgent need for Chinese policymakers to improve the accuracy of medical health insurance schemes to target the vulnerable characteristics of elderly cardiovascular patients. While improving the accessibility of health services for cardiovascular patients, the next step should be to focus on achieving another function of the medial health insurance system, which is to maximize the economic protection for the vulnerable en-rollers and reducing their risk of being trapped in the poverty, rather than increasing the risk. It is worth noting that our research has its limitations. First, the data were self-reported surveys that may be affected by measurement errors. Second, the study used cross-sectional samples rather than panel data, making it difficult to test the long-term effects of health insurance and other control variables on CHE in cardiovascular patients.

Abbreviations

Cardiovascular Disease :CVD; Disability Adjusted of Life Years:DALY; Calculate Catastrophic Health Expenditure CHE; Impoverishment by Medical Expenses :IME; Urban employees' Insurance Medical:MIUE; Urban resident Insurance Medical:MIUR ; New rural Cooperative Medical System:NCMS; Poverty Line :pl

Household subsistence expenditure :SE; A household's capacity to pay :CTP

Out-of-pocket health expenditure :OOP Household consumption expenditure:EXP

Instrumental Variable :IV

Declarations

Ethics approval and consent to participate Not applicable

Consent for publication Not applicable

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Authors' contributions：MYM conducted literature search, planned the study, carried out data collection, performed data analysis and interpretation and drafted the manuscript.YL and QHW conducted frame design, easibility analysis and helped conceptualize the project .NSW,MLJ and LHS reviewed literature search and data analysis.TS,HL,and HG revised the manuscript and gave critical feedback.XLF, WXT, QX and YHH conducted quality control and review of manuscripts.All authors have read and approved the manuscript.

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Tables

Table 1. Validity test and correlation test

Instrumental variable	DWH test	Over-identification test	F test	Redundancy test
Community participation rate	chi2(1) =4.5588 (p=0.0327<0.05) *	chi2(1) =1.6578 **(p=0.1979>0.05)** *	**F=24.3034>10**	Chi-sq. (1)=**0.0000***
Self-assessed health				Chi-sq.(1) =0.3873

Table 2. Patients' demographic characteristics

Variables	Variable value	Percentage（%）
CHE	No	80.1
	Yes	19.9
Participate in medical insurance scheme	No	2.9
	Yes	97.1
Gender of household head	Female	49.8
	Male	50.2
Marital status of household head	Others	15.0
	Married	85.0
Education level of household head	Illiteracy	21.5
	Elementary to junior high	59.4
	High school and above	15.4
Family size	1	62.6
	2-3	31.9
	More than 3 people	5.5
Age of household head	45-54	32.5
	55-64	33.2
	65-74	23.5
	More than75years old	8.7
Having members over 65 years old	No	44.2
	Yes	54.0
Combined with other chronic diseases	No	39.6
	1	35.5
	2	21.3
	3	3.6
Having hospitalized members	No	87.1
	Yes	12.2
Having disabled members	No	3.1
	Yes	92.3
Health satisfaction	Very good	4.2
	Good	19.1
	Fair	48.8
	Poor	20.5
	Very poor	6.8
Household consumption per capital quintile	Lowest	20.7
	2	21.3
	3	19.9
	4	20.2
	Highest	17.9
Region	Eastern	33.7
	Middle	46.3

	Western	20.0
location	Rural	75.1
	Urban	24.9

Table 3. Health care demand, service utilization, and reimbursement of household head

		Prevalence (%)	Hospitalization rate (%)	Outpatient rate (%)	Non-admission rate (%)	Hospitalization reimbursement ratio (%)
Family size	1	14.1	15.6	19.8	6.3	41.1
	2-3	13.6	13.5	19.3	5.7	52.8
	More than 3 people	13.8	14.7	24.0	8.3	49.1
Hospitalization members	Yes	24.7	/	34.2	13.1	44.6
	No	12.3	/	17.3	5.0	/
Having disabled members	Yes	21.7	17.2	21.8	9.9	40.3
	No	13.4	14.6	19.6	5.8	46.0
Combined with other chronic diseases	No	12.0	13.3	17.7	5.3	45.3
	1	14.0	15.3	20.8	6.0	46.8
	2	16.6	14.6	20.0	7.4	49.1
	≧3	13.8	23.5	24.5	9.8	48.5
Medical insurance schemes	MIUE	8.6%	20.4	20.0	3.3	69.8
	MIUR	15.5	18.4	19.1	8.5	52.0
	NCMS	14.3	13.7	20.5	6.6	39.7
	Integrated insurance	14.7	16.3	23.3	4.7	54.2
	Others and not having insurance	13.0	13.5	14.3	7.2	59.2
Economic quintile	Lowest	13.1	14.9	19.9	6.3	41.8
	2	12.4	14.8	19.5	6.2	42.5
	3	14.2	13.4	19.6	5.2	38.3
	4	15.8	14.8	19.6	6.8	42.7
	Highest	14.0	16.4	20.9	6.5	49.2
Overall		11.4	14.8	19.8	6.2	44.5

Table 4.CHE, and IME in different households

		Incidence of CHE (%)	Incidence of IME (%)	OOP/CTP (%)
Family size	1	22.6	8.6	21.1
	2-3	15.6	6.2	13.7
	More than 3 people	14.4	3.6	12.8
Hospitalization members	Yes	29.3	8.7	28.4
	No	18.6	7.5	15.6
Having disability members	Yes	31.1	10.3	35.6
	No	19.5	7.4	16.7
Health satisfaction	Very good	17.1	4.1	17.0
	Good	17.3	5.8	17.5
	Fair	17.5	7.7	14.1
	Poor	24.4	8.5	21.7
	Very poor	30.5	10.0	25.3
Combine other chronic diseases	No	14.7	6.1	14.6
	1	20.2	6.8	18.8
	2	27.0	10.5	19.2
	≧3	31.8	14.2	22.8
Medical insurance	MIUE	13.3	3.1	13.0
	MIUR	15.1	4.5	13.8
	NCMS	21.6	9.0	19.7
	Integrated insurance	20.5	5.1	6.1
	Others and not having insurance	16.3	3.8	15.3
Household consumption per capital quintile	Lowest	19.3	8.3	17.9
	2	22.5	10.1	22.1
	3	20.4	7.8	18.4
	4	19.5	5.9	16.2
	Highest	17.5	5.5	13.6
Overall	/	19.9	7.6	17.2

Table 5. Results of treatment-effect model for patients with CVD

	Coef.	Std. Err.	z	P>|z|	95% C.I.	
CHE						
Marital status of household head	0.0129	0.0233	0.53	0.599	-0.0335	0.0581
Region	-0.0209	0.0116	-1.79	0.073	-0.0438	0.0019
Gender of household head	0.0081	0.0174	-0.47	0.640	-0.0424	0..0261
Education level of household head	0.0016	0.0151	0.11	0.915	-0.0281	0.0313
Household consumption per capital quintile	-0.0069	0.0061	-1.12	0.262	-0.0190	0.0052
Family size	**-0.0499**	**0.0138**	**-3.61**	**0.000**	**-0.0770**	**-0.0227**
Urban and rural	-0.0379	0.0203	-1.86	0.063	-0.0779	0.0019
Health satisfaction	**0.0246**	**0.0093**	**2.64**	**0.008**	**0.0063**	**0.0429**
Having disabled members	**0.0961**	**0.0473**	**2.03**	**0.042**	**0.0033**	**0. 1889**
Having members over 65 years old	0.0129	0.0171	0.76	0.450	-0.0206	0.0465
Combined with other chronic diseases	**0.0468**	**0.0088**	**5.32**	**0.000**	**0.0296**	**0.0641**
Having hospitalized members	**0.1001**	**0.0252**	**3.97**	**0.000**	**0.0506**	**0.1495**
Having insurance	**0.2895**	**0.1454**	**1.99**	**0.047**	**0.0044**	**0.5745**
Having insurance						
Community participation rate	**0.0571**	**0.0056**	**10.08**	**0.000**	**0.0460**	**0.0682**

Coef:Coefficient;Std. Err:standard error of the mean;95% C.I:Confidence Interval

Figures

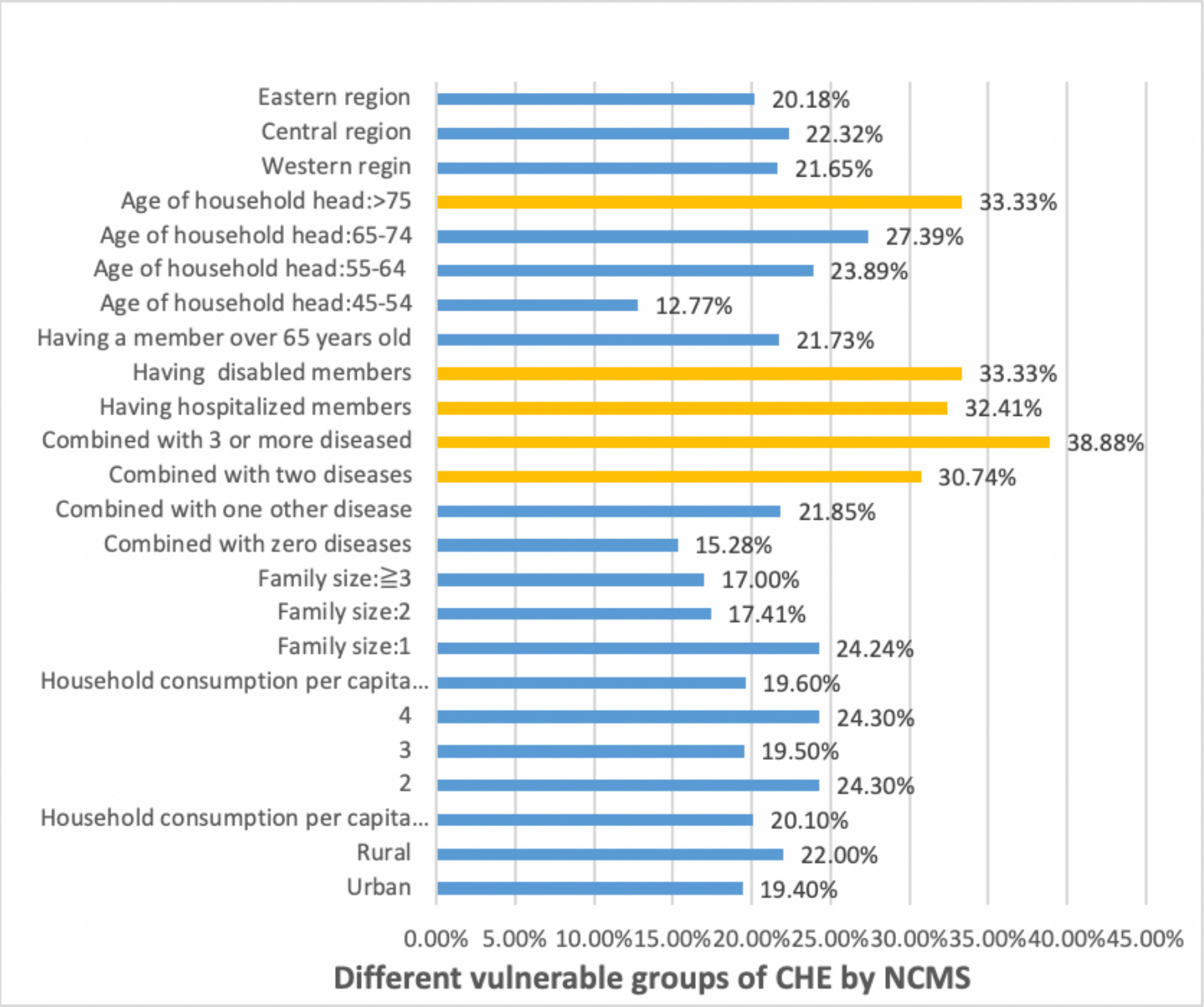

Figure 1

Different vulnerable groups of CHE by NCMS