**Can Private Health Insurance Reduce the Incidence of** **Household Catastrophic Health Expenditure in China?**

**Long Shi1,2, Jun Chen1, Zangyi Liao1 and Xiao Li3\***

1School of Public Health and Management, Youjiang Medical University for Nationalities, Baise, China

2School of Public Policy & Management, Dongbei University of Finance & Economics, Dalian, China

3School of Political Science and Public Administration, China University of Political Science and Law, Beijing, China

4School of Economics and Management, Dalian Minzu University, Dalian, China

**\* Correspondence:**

Xiao Li

straw1226@163.com

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**Abstract**

Private health insurance is an important part of China's multilevel medical security system, which is conducive to improving the medical security level of insured households. Based on Chinese General Social Survey (CGSS) data, this study uses a logit model to estimate the impact of private health insurance on household catastrophic health expenditure. Our research results show that private health insurance can significantly reduce the incidence of catastrophic household health expenditure. Using the instrumental variable method to weaken the endogenous problem and the propensity score matching method to control the self-selection problem, the research conclusion is still valid. In terms of heterogeneity, private health insurance has a greater impact on reducing the incidence of catastrophic health expenditure in rural and non-elderly households. The mechanism test shows that health performance plays an intermediary role between private health insurance and catastrophic household health expenditure. This study suggests that the Chinese government should accelerate the development of private health insurance, expand its coverage of private health insurance, and reduce the incidence of catastrophic health expenditure in households.

**Highlights**

**What do we already know about this topic?**

The impact of various factors such as population aging, changes in the disease spectrum, and excessive medical care has stimulated a significant increase in medical consumption, leading to the risk of catastrophic medical expenditure for low-income households. The rapid development of private health insurance in China has provided new solutions to the problem of catastrophic health expenditure. However, there are few studies on the impact of private health insurance on catastrophic medical expenses, and relevant conclusions have not yet reached consensus, requiring further research.

**How does your research contribute to the field?**

We found that private health insurance has a greater impact on reducing the incidence of catastrophic health expenditure in registered rural residence registrations and non-elderly households. In addition, we provide evidence that health performance plays a partial intermediary role between private health insurance and catastrophic household health expenditures.

**What are your research’s implications toward theory, practice, or policy?**

The research results will guide the government or policy makers in implementing strategies, and provide a theoretical reference for further improving policies related to private health insurance and major disease insurance.

1. **Introduction**

With the aging of the population and the rapid development of the chronic disease spectrum, the combination of medical science and technology progress, excessive medical treatment, and other factors has stimulated substantial growth in medical consumption, which has brought severe challenges to the development of China's medical security industry. 1,2According to the data released by the National Bureau of Statistics of China, the per capita health expenditure will have reached 5112.34 yuan in 2020 while it was only 1490.06 yuan in 2010. In the past ten years, the per capita health expenditure in China has increased 3.43 times. At present, per capita health expenditure has exceeded the annual per capita disposable income of rural low-income families[[1]](#footnote-0), making low-income families face a heavy burden of medical expenses.

The Chinese government implemented a series of health policy reforms to reduce the burden of medical expenses on households. Among them, the medical insurance for urban employees was established for employees with fixed jobs and was implemented in 1988, the new rural cooperative medical system was mainly designed for rural residents and implemented in 2003, and the basic medical insurance for urban residents was designed specifically for urban unemployed residents and implemented in 2007. 3In addition, to ensure that urban and rural residents have more equitable access to basic medical services, the Chinese government began to combine the new rural cooperative medical system into the basic medical insurance for urban and rural residents in 2016. 4Through continuous institutional improvement, China has established a medical security system that covers all people. According to data from the Statistical Bulletin on the Development of National Medical Security in 2021, by the end of 2021, 1.36 billion people had participated in basic medical insurance in China, with a stable participation rate of more than 95%. Although the establishment of the basic medical insurance system has largely solved the problem that people cannot afford to see the disease, some patients’ families still face the risk of catastrophic health expenditure.5,6,7 Approximately 40% of the rural poor in China are poor due to illness[[2]](#footnote-1), and catastrophic health expenditure has become the main cause of household poverty. 8

On the basis of improving basic medical insurance, the Chinese government will promote the development of commercial medical insurance on the agenda and try to build a multilevel medical security system to avoid the impact of catastrophic health expenditure on households. At the policy level, in November 2021, the General Office of the State Council issued the Opinions on Improving the Medical Insurance and Relief System for Major and Extraordinary Diseases, which emphasized the need to "focus on reducing the burden of medical expenses for major and extraordinary diseases for people in need, establish and improve a long-term mechanism for preventing and resolving poverty caused by illness and returning to poverty." It made clear the need to promote the coordinated development and effective connection between basic medical insurance and private health insurance building a multi-level medical security system with extensive participation. At a practical level, local governments in China attach great importance to promoting the development of supplementary commercial medical insurance. For example, to narrow the gap between the rich and poor, Zhejiang Province actively explored the development of commercial supplementary medical insurance and promoted the construction of a demonstration area for common prosperity. In 2021, it promoted the development of commercial supplementary medical insurance to benefit people in 11 districts and cities across the province. Nearly half of the participants of basic medical insurance have been insured, with a total compensation of 2.7 billion yuan, and the number of beneficiaries will reach more than 450,000 people, with a loss ratio of 80.36% and a per capita compensation of 6153 yuan. This shows that private health insurance is playing an increasingly important role in multilevel medical security systems. At this stage, it is worth discussing whether commercial medical insurance can effectively reduce the risk of catastrophic household health expenditures. The answer is of great significance for solving the dual problems in China of poverty caused by illness and the return to poverty due to illness.

Health insurance is seen as an important mechanism to protect people from the financial consequences of poor health and healthcare financing. Scholars have extensively discussed the relationship between private health insurance and catastrophic health expenditure. There are three main views. The first is that private health insurance can effectively reduce the incidence of catastrophic health expenditure.9,10,11 This type of literature provides two reasons: (1) compared with public medical insurance, private health insurance has a relatively higher level of protection, which is more conducive to reducing household medical expenses; and (2) it is believed that private health insurance provides reimbursement for certain medical services or expenses not covered by public medical insurance, which further improves the level of household medical security. The second view is that private health insurance has no significant effect on reducing the incidence of catastrophic health expenditure.12,13,14Scholars with this viewpoint are mostly from developing countries. Private health insurance provided by private insurance companies has no significant impact on protecting families from catastrophic health expenditure because this type of insurance covers limited outpatient and inpatient services and generally only covers a small part of the population. The third view is that the combination of public medical insurance and private health insurance can protect individuals from catastrophic out-of-pocket expenses, and that a single insurance plan cannot solve this problem.15,16 This is because the scope of medical and drug service guarantees of public health insurance is limited, and the reimbursement amount is generally set as a ceiling. Only a supplementary guarantee of private health insurance can effectively reduce the incidence of catastrophic medical payments in households.

In recent years, with the rapid development of private health insurance in China, scholars have begun to pay attention to the impact of private health insurance on catastrophic health expenditure. Gao et al. 17 conducted an empirical analysis using data from the China Labor-force Dynamics Survey (CLDS) and found that participating in commercial medical insurance can effectively reduce the catastrophic health expenditure of urban and rural residents. However, Chen et al.18compared the utilization rate, cost, and various types of health insurance in catastrophic health expenditure for middle-aged and elderly people in China. Taking the basic medical insurance for urban workers as a reference, private health insurance could not reduce the risk of catastrophic health expenditure for households.In general, Chinese scholars’ research on the impact of private health insurance on catastrophic health expenditure is still in its infancy, and the relevant conclusions have not yet reached a consensus, which requires further discussion.

This study will conduct further research from the following aspects: First, the data of the Chinese General Social Survey (CGSS) in 2015, 2017, and 2018 will be used to assess the impact of private health insurance on household catastrophic health expenditure. The tool variable method and propensity score matching method (PSM) will be used to overcome the endogenous and selective bias problems that may exist in sample estimation to correctly identify the causal relationship between private health insurance and household catastrophic health expenditure. Second, the heterogeneity of the impact of private health insurance on household catastrophic health expenditure in terms of registered residence and age will be examined and provide more accurate data to support the improvement of relevant policies. Finally, this study will use the intermediary effect model to test the impact mechanism of private health insurance on household catastrophic health expenditure through the intermediary effect of health performance.

**2.Data, variables, and model construction**

**2.1 Data**

The data used in this study were obtained from the CGSS released by Renmin University of China, which is the earliest nationwide, comprehensive, and continuous academic survey project in China. Since 2003, a continuous cross-sectional survey has been conducted annually on more than 10,000 households in provinces, cities, and autonomous regions of the Chinese Mainland, and data from multiple levels of society, community, family, and individuals have been collected systematically and comprehensively. As a result, it is widely representative. In 2015, 2017, and 2018, there were 10,968, 12,582, and 12,787 valid samples obtained, respectively.

We combined data from the CGSS in 2015, 2017, and 2018 into mixed-sectional data. After screening and removing some samples due to missing data or incorrect logical answers, under the control of all variables, the remaining valid samples in 2015, 2017, and 2018 were 2560, 3186 and 3471, respectively. We combined the data of the three phases vertically, and the final sample size was 9217.

**2.2 Variables**

**2.2.1 Dependent Variable**

The dependent variable of this study is catastrophic health expenditure (*CHE*). The criteria for defining catastrophic health expenditure are generally measured by the threshold at which the household's own medical expenditure reaches the household's affordability. Most studies have defined this threshold as 40%.19,20 As household non-food expenditure is used to measure a household's affordability, the measurement bias often ignored by poor households can be partly avoided. This study used the respondent's household medical self-expenditure as the numerator and household non-food expenditure as the denominator to calculate the occurrence of catastrophic health expenditure. When household medical self-expenditure is equal to or higher than 40% of the household non-food expenditure, it is considered that catastrophic health expenditure occurs, and we assign 1 to *CHE* if the respondent's family has catastrophic medical expenditure, otherwise 0.

**2.2.2 Independent Variable**

The independent variable in this study was private health insurance (*PHI*). We assign 1 to *PHI* if respondents have private health insurance, otherwise 0.

**2.2.3 Control Variables**

Referring to existing studies,11,16,21 the control variables in this study mainly included personal and family characteristics. Among them, personal characteristics included gender (*Gender*), age (*Age*), body mass index (*BMI*), residence location (*Location*), education level (*Education*), marriage (*Marriage*), employment status (*Employment*), and family characteristics including household size (*Size*), economic status (*ln\_income*), and housing conditions (*Housing*). All control variables and their definitions are listed in **Table 1**.

**2.2.4 Mediating Variable**

This study further explored the intermediary role of health performance between private health insurance and catastrophic health expenditures. Referring to previous literature,22 we can measure health performance (*Health*) through the question of health status. If respondents answered "very unhealthy," "relatively unhealthy," "average," "relatively healthy," and "very healthy," the values were assigned to 1-5, respectively. The larger the value, the better the health performance.

The variables and their definitions are presented in **Table 1**, and their descriptive statistics are presented in **Table 2**.

(Insert Table 1 here.)

(Insert Table 2 here.)

**3.3 Empirical Model**

The dependent variable in this study is the nature of the dichotomy. First, we use a logit model to test the impact of private health insurance on catastrophic household health expenditures. The following regression model was established:

（1）

Where is the dependent variable of the household catastrophic health expenditure of the respondents; is the independent variable of private health insurance;represents the control variables, including *Gender, Age, BMI, Location, Education, Marriage, Employment, Size, ln\_income, Housing;*  denotes the intercepted item; is the coefficient of interest;denotes the coefficients of the control variables; *i* represents the respondents; and is a normally distributed random error vector.

**3.Empirical results and analysis**

**3.1Benchmark Regression Results**

We conducted an empirical analysis using model (1) and the results are reported in **Table 3**. Column (1) shows that the coefficient of *PHI* is negative and significant at the 1% level without adding any control variable. On this basis, after adding individual and family characteristic variables, columns (2) and (3) show that the coefficient of *PHI* is still negative and significant at the 5% level. The above results show that private health insurance has a significant negative effect on catastrophic household health expenditure in China and supports H1. In other words, having private health insurance can significantly reduce the incidence of catastrophic household health expenditure.

Some of the control variables in Table 3 deserve attention. First, at the personal characteristics level, age is positively related to catastrophic health expenditure. The BMI index shows that body weight tends to be in the normal range, which is conducive to reducing the incidence of catastrophic health expenditure. Compared with urban areas, catastrophic health expenditures are more likely to occur in rural areas. In addition, improvement in education level is conducive to reducing the incidence of catastrophic health expenditure. Second, at the level of family characteristics, there is a negative correlation between family size and the incidence of catastrophic health expenditure, and an increase in family income is conducive to reducing the incidence of catastrophic health care.

(Insert Table 3 here.)

**3.2Endogeneity Test**

Estimation under the condition of missing variables or causal relationship between private health insurance and catastrophic medical expenditure can easily cause endogenous problems, and the direct use of logit for regression may not make the results sufficiently robust. To further weaken endogeneity, this study uses the instrumental variable method for estimation. Referring to Fisman and Svensson’s practice of using the average of groups as an instrumental variable,23 this study used the provincial-level private health insurance participation rate of the respondents as an instrumental variable of private health insurance in the current year, which meets two conditions of the tool variable. The first condition is the correlation. The higher the provincial-level private health insurance participation rate in the current year, the more likely respondents are to participate in private health insurance. The second condition is exogenous. The provincial-level data does not directly affect personal behavior in the micro data and has little impact on the household catastrophic health expenditure of the interviewees, meeting the requirements of being exogenous. When using the instrumental variable for estimation, this study used the IV-probit model.

**Table 4** reports the regression results using the IV-probit model. On the basis of controlling other variables, Wald test results of the exogenous hypothesis of private health insurance show that the P value is less than 0.001, so *PHI* can be considered as an endogenous variable at the level of 1%. In addition, the results of the first step regression show that the coefficient of the instrumental variable is significantly positive at the level of 1%, indicating that the instrumental variable has a strong explanatory power to the endogenous variable. The results of the second step regression show that after controlling the endogeneity, the coefficient of private health insurance is still significantly negative at the level of 1%, which further indicates that participation in private health insurance has an inhibitory effect on household catastrophic health expenditure, which is consistent with the result of the benchmark regression.

(Insert Table 4 here.)

**3.3Robust Test**

A resident’s purchase of commercial medical insurance is the result of voluntary selection based on economic conditions and other factors. Therefore, whether they own private health insurance is affected by self-selection factors, which is not a random decision. If they directly use the logit model for estimation, there may be a selective bias. Therefore, this study used the propensity score matching method (PSM) for a robustness test.24

**Figure 1** displays the changes in the standardized bias of all covariates before and after propensity score matching. **Figure 2** displays the distribution range of the tendency scores between the treatment and control groups. **Table 5** reports the detailed results of the propensity score-matching balance test. After matching, the standard deviation of each variable is significantly reduced, and the standard deviation is less than 10%. In addition, the results of t-tests for each variable do not reject the original assumption that there is no systematic difference between the treatment and control groups, which indicates that the selective bias of the samples has been eliminated to a large extent.

**Table 6** reports the estimation results based on the propensity score matching method. The nearest-neighbor matching results show that the ATT value is -0.0304, which is significant at the 5% statistical level, indicating that participating in private health insurance can reduce the incidence of household catastrophic health expenditure by 3.04%. The radius matching method and kernel matching method are further used for estimation, and the results show that the estimated ATT of matched is -0.0256 and -0.0299, and they are significant at the statistical level of 5%. It shows that participation in private health insurance can indeed reduce the incidence of household catastrophic health expenditure, and it also shows that direct estimation using the logit model may underestimate the negative inhibitory effect of private health insurance on catastrophic health expenditure.

(Insert Figure 1 here.)

(Insert Figure 2 here.)

(Insert Table 5 here.)

(Insert Table 6 here.)

**3.4Heterogeneity Analysis**

The above findings verify the overall effect of private health insurance on catastrophic household health expenditure. This section discusses the heterogeneous impact of private health insurance on catastrophic household medical expenditure based on differences in registered residence and age.

The results in columns (1) and (2) of **Table 7** show that the coefficient of the impact of private health insurance on rural households' catastrophic health expenditure is significantly negative at the 5% level, while the impact on urban residents is not significant. In other words, private health insurance can significantly reduce the incidence of catastrophic health expenditure in rural households but has little impact on the incidence of catastrophic health expenditure in urban households. Therefore, these findings confirm H2a. Due to the difference in the level of medical security between urban and rural areas, rural households face higher medical out-of-pocket expenditures and a higher risk of catastrophic health expenditure. According to the theory of increasing marginal utility, private health insurance has a greater marginal effect on reducing the incidence of catastrophic health expenditures in rural households.

The results in columns (3) and (4) of **Table 7** show that the negative effect of private health insurance on household catastrophic health expenditure mainly affects non-elderly people aged 18–59, while the impact on elderly people aged over 60 is not statistically significant. The physical functions of elderly people are in a stage of rapid decline, their disease risks are rising rapidly, and their demand for private health insurance is increasing. However, the elderly health insurance market has a "supply and demand mismatch" dilemma. To avoid adverse selection risks, insurance companies do not support elderly people to buy most health insurance products, which further dispels the possibility of the significant impact of private health insurance on the catastrophic health expenditure of elderly people.

(Insert Table 7 here.)

**3.5Mediating Effect of Health Performance**

Private health insurance can directly reduce the incidence of catastrophic expenditure by improving the level of household medical security benefits. It may also reduce household medical expenditure through indirect channels to improve the health performance of residents, thus avoiding the occurrence of catastrophic health expenditure. To further explore the mechanism of private health insurance on household catastrophic health expenditure, we selected health performance as the intermediary variable and referred to the way to identify the intermediary effect in the existing literature to verify the channel of catastrophic health expenditure.25,26 The model was constructed as follows:

(3)

(4)

In Formulas (3) – (4), is the intermediary variable and is the random error term. The steps of the intermediary effect test are as follows: Step 1: In the benchmark model equation (1), estimate the influence of the independent variable on the dependent variable, and verify whether passes the significance test. Step 2: In equation (3), the intermediate variable is used as the explained variable for regression analysis. If the intermediate variable is selected reasonably, will be significant. Step 3: In equation (4), the intermediary variables and core explanatory variables are included in the model for regression analysis. If both and pass the significance test, the intermediary effect was considered valid.

**Table 8** reports the test results of intermediate variables. Among them, column (1) is the total effect of private health insurance on catastrophic health expenditure, and its coefficient is significantly negative at the level of 5%. Column (2) shows the impact of private health insurance on health performance. Its coefficient is significantly positive at the level of 1%, indicating that commercial medical insurance can improve the health level of the insured population. Column (3) shows the impact of private health insurance and health performance on household catastrophic health expenditure. After adding intermediary variables, the coefficient value of private health insurance is -0.2107, which is less than the coefficient value of total effect -0.2503, indicating that health performance weakens the impact of private health insurance on household catastrophic health expenditure and plays a part of intermediary role and confirms H3. A possible reason is that the health management services of insurance companies have improved the health level of the insured, which has promoted the insured to get sick less often and have fewer serious diseases, thus reducing the catastrophic medical expenditure of families. In addition, the medical expense compensation of private health insurance encourages insured people to seek medical treatment in a timely manner when they are ill to restore their health quickly, avoid further deterioration of their health resulting from the disease, and thus reduce the catastrophic medical expenditure of families.

(Insert Table 8 here.)

**4. DISCUSSION**

Insurance is an important measure to reduce the financial burden on patients' families.27 In order to prevent catastrophic medical expenses for households, the Chinese government attaches great importance to the development of private health insurance. Based on the mixed cross-sectional data of the CGSS in 2015, 2017, and 2018, this study explored the impact of private health insurance on household catastrophic health expenditure, the heterogeneity of registered residence and age differences, and the intermediary role of health performance.

Our empirical results show that private health insurance has a significant negative effect on catastrophic household health expenditure; that is, participation in private health insurance can significantly reduce the incidence of catastrophic health expenditure. Furthermore, the instrumental variable method was used to overcome the endogeneity problem, and the propensity score matching method was used to eliminate the influence of self-selection on the estimation results. The research conclusions remain valid. As is known to all, China's basic medical insurance has achieved universal coverage, and it has played a positive role in reducing the incidence of catastrophic health expenditure. 28,29,30However, the effect of separate basic medical insurance on reducing the incidence of catastrophic health expenditures is still limited. First, owing to the positioning of basic medical insurance in China, the setting of the top line of security benefits, the low level of overall planning, and the imbalance between groups with security benefits, some patients receive relatively little compensation and higher medical expenses need to be paid by their families.31,32, 33Second, with the continuous innovation and development of medical technology and products, an increasing number of new technologies and drugs are being used for clinical treatment. Some new technologies and new drugs are not covered by social medical insurance and are expensive, requiring patients to pay high medical expenses.34 Third, China currently has about 20 million patients with rare diseases. However, the annual treatment cost of some rare disease drugs that are not included in the national medical insurance catalogue has reached millions of yuan, far higher than the standard of catastrophic health expenditure.35,36 As a supplementary form of basic medical insurance, commercial medical insurance mainly refers to the high medical expenses that remain after the reimbursement of basic medical insurance compensation by patients. The reimbursement scope includes, but is not limited to, basic medical insurance coverage.37,38Therefore, private health insurance can significantly reduce expenditure on patients' family medical expenses and avoid the impact of catastrophic high out-of-pocket expenses.

We also found that the impact of private health insurance on catastrophic household health expenditure varies with registered residence registration and age. Specifically, private health insurance has a greater impact on reducing the incidence of catastrophic health expenditure in registered rural residence registrations and non-elderly households. Influenced by the long-term development of dual economic and social structures, there is a substantial difference in household income between rural and urban areas in China, and the income level of rural residents is generally lower than that of urban areas.39,40As the financial risk of disease is related to household income, the risk of catastrophic health expenditure of households in rural and urban areas is different.41In addition, the new rural cooperative medical insurance, which is affected by the dual-track development of China's basic medical insurance, has a large gap in the level of security benefits compared to the basic medical insurance for urban workers, which will also lead to a difference in the risk of catastrophic health expenditure between urban and rural households.42,43 Therefore, the impact of private health insurance on catastrophic health expenditures may also differ between urban and rural areas.

From the perspective of age difference, in order to avoid adverse selection risk, most commercial medical insurance products exclude elderly people, which makes many of them lose the qualification to purchase commercial medical insurance, resulting in the coverage of private health insurance for elderly people that is far less than for non-elderly people.44 Life cycle theory explains the objective fact that the incidence rate of diseases increases significantly with age. Elderly families are more likely to have catastrophic health expenditures, but they lack supplementary protection from private health insurance, which makes the supply and demand of commercial medical insurance for elderly people to be a mismatch. Therefore, there may be differences in the impact of commercial medical insurance on catastrophic health expenditures of elderly and non-elderly families.

Finally, we provide additional evidence that health performance plays a partial intermediary role between private health insurance and catastrophic household health expenditures. In terms of theoretical analysis, in addition to directly reducing the incidence of catastrophic health expenditure by compensating patients for medical expenses, private health insurance may reduce the incidence of catastrophic health expenditure by improving the health level of residents. According to existing research, private health insurance has a positive effect on residents' health performance.28,45 On the one hand, private health insurance companies have improved their health awareness by providing health management services to insured people, actively changing their bad lifestyles in the past, so that they can reduce the occurrence of diseases or avoid the deterioration of diseases as much as possible.46,47 On the other hand, private health insurance not only encourages insured people to seek medical treatment in time when they are ill, but also encourages them to make more active use of high-quality medical services, which is conducive to preventing minor diseases from becoming serious diseases, thus reducing the incidence rate of major diseases among the insured population.48,49,50Therefore, private health insurance can also reduce the incidence of catastrophic household health expenditure through health performance.

Obviously, this study has several limitations. Firstly, when calculating medical expenses, indirect expenses (such as transportation costs, food, accommodation, and work delays caused by disease treatment) are not included in self-paid medical expenses, resulting in an underestimation of the incidence of catastrophic medical expenses to some extent. Secondly, due to data limitations, this study mainly examines the mediating role of health performance between private medical insurance and catastrophic household medical expenses, ignoring the testing of other mediating roles. Again, although this study used mixed cross-sectional data from three periods for empirical testing, the causal relationship judgment was not as accurate as the tracking data. In the future, we can try to use tracking data for research in order to obtain more objective evaluation results.

**5.Conclusion and implications**

Due to the limited amount of compensation for patients' medical expenses under China's basic medical insurance, there are still some families of patients with major diseases that may face catastrophic medical expenses. So, how should we reduce the incidence of catastrophic health expenditures among Chinese households? This is an urgent practical problem that needs to be solved. Our research results show that private health insurance can significantly reduce the incidence of catastrophic household health expenditure. In terms of heterogeneity, private health insurance has a greater impact on reducing the incidence of catastrophic health expenditure in rural and non-elderly households. The mechanism test shows that health performance plays an intermediary role between private health insurance and catastrophic household health expenditure. Therefore，Chinese government should accelerate the development of private health insurance.

First, on the basis of continuous improvement of basic medical insurance, we should accelerate the development of private health insurance, give full play to the complementary role of private health insurance in the multi-level medical security system, form multiple protection effects through the coordination of the government and the market mechanisms, and effectively resolve the disease risks of the people. In particular, we should defuse the risk of major and serious diseases, reduce the risk of catastrophic health expenditure of patients' families, prevent the occurrence of "poverty caused by illness" and “poverty returned due to illness,” and lay a solid foundation for promoting common prosperity.

Second, insurance companies should be encouraged to strengthen their supply of inclusive private health insurance products. Through the "inclusive" price design, rural residents with low incomes have the opportunity to buy private health insurance at a relatively low price. At the same time, through the "low threshold" designed by the insurance conditions, elderly people have the opportunity to reduce their own disease risk through private health insurance and solve the dilemma of the "supply and demand mismatch" in the elderly health insurance market. In addition, relevant government departments should be encouraged to participate in the design of inclusive private health insurance products of insurance companies to ensure that private health insurance is linked with basic medical insurance, serious illness insurance, and medical assistance in terms of security function. In addition, it should reflect the preference for compensation for major and serious diseases to effectively resolve the risk of catastrophic health expenditure.

Third, we should encourage insurance companies to provide medical expense compensation for patients while strengthening the health management of the insured population for several reasons. Among these are that the insured population will be able to develop a healthier lifestyle and improve their health level, reducing the occurrence of diseases among the insured population as much as possible or avoiding the deterioration of the condition of the insured people who have already suffered from diseases. Other benefits would be the reduction of the incidence rate of major diseases among the insured population, thus effectively reducing the incidence of catastrophic health expenditure of residents' families, thereby solving the problem of fear of seeking medical attention because of its related expense at its source.

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**Authors’ contributions**

Long Shi: writing—original draft, data collection, and literature search.

Jun Chen: validation, writing, reviewing, and editing.

Zangyi Liao: conceptualization, methodology, validation, and formal analysis.

Xiao Li: writing, reviewing, editing, and supervision.

All authors have contributed to the manuscript and approved the submitted version.

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**Competing interests**

The authors declare that they have no competing interests.

**Author details**

1School of Public Health and Management, Youjiang Medical University for Nationalities, Baise, China.2School of Public Policy & Management, Dongbei University of Finance & Economics, Dalian, China.3School of Political Science and Public Administration, China University of Political Science and Law, Beijing, China

4School of Economics and Management, Dalian Minzu University, Dalian, China

**Data Availability Statement**

Publicly available datasets were analyzed in this study. These data are available at <http://cgss.ruc.edu.cn/>

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**Tables**

**TABLE 1** | The definitions of all variables.

|  |  |  |
| --- | --- | --- |
| **Variables** | **Symbols** | **Definitions** |
| **Dependent variable** |  |  |
| Catastrophic health expenditure | CHE | the respondents have catastrophic medical expenditure; Yes=1; No=0 |
| **Independent variable** |  |  |
| Private health insurance | PHI | the respondents have private health insurance; Yes=1; No=0 |
| **Instrumental variable** |  |  |
| Coverage rate of provinces | Coverage | Provincial coverage rate of private health insurance |
| **Mediating variable** |  |  |
| Health performance | Health | Health is equal to 1-5, representing very unhealthy, relatively unhealthy, average, relatively healthy, very healthy, respectively, respectively. |
| **Control variables** |  |  |
| Gender | Gender | Male = 1; Female = 0. |
| Age | Age | Age of respondents (years) |
| Body mass index | BMI | BMI is equal to 1-5, representing BMI≥32，28≤BMI<32，24≤BMI<28，BMI<18.5, 18.5≤BMI<24, respectively. |
| Residency location | Location | Urban = 1; Rural = 0. |
|  |  |  |
| Education level | Education | Education is equal to 1-4, representing Primary school and below, middle school, high school, College degree or above, respectively. |
| Marriage | Marriage | Married = 1; Unmarried = 0. |
| Employment status | Employment | Employed =1; Unemployed and others=0 |
| Household size | Size | Number of family members living together |
| Economic status | ln\_income | The logarithm of annual household income |
| Housing conditions | Housing | The housing conditions of families |

**TABLE 2 |** Descriptive statistics.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Variables** | **Obs** | **Mean** | **S.D.** | **Min** | **Max** |
| CHE | 9217 | 0.2105 | 0.4077 | 0 | 1 |
| PHI | 9217 | 0.1112 | 0.3144 | 0 | 1 |
| Gender | 9217 | 0.4703 | 0.4991 | 0 | 1 |
| Age | 9217 | 50.6745 | 16.3462 | 18 | 96 |
| BMI | 9217 | 4.0646 | 1.1962 | 1 | 5 |
| Location | 9217 | 0.6261 | 0.4839 | 0 | 1 |
| Education(Ref:Primary school and below) |  |  |  |  |  |
| Education\_2 | 9217 | 0.2866 | 0.4522 | 0 | 1 |
| Education\_3 | 9217 | 0.1846 | 0.3880 | 0 | 1 |
| Education\_4 | 9217 | 0.1815 | 0.3855 | 0 | 1 |
| Marriage | 9217 | 0.7941 | 0.4044 | 0 | 1 |
| Employment | 9217 | 0.1461 | 0.3533 | 0 | 1 |
| Size | 9217 | 2.8726 | 2.6211 | 1 | 99 |
| ln\_income | 9217 | 10.5095 | 2.4195 | 0 | 16.1181 |
| Housing | 9217 | 109.0970 | 72.1019 | 5 | 500 |
| Health | 9217 | 3.9124 | 1.1102 | 1 | 5 |

**TABLE 3** | The benchmark regression result.

|  |  |  |  |
| --- | --- | --- | --- |
| **Variables** | （1） | （2） | （3） |
| PHI | -1.0706 \*\*\*  （0.1119） | -0.3157\*\*\*  （0.1190） | -0.2503\*\*  （0.1207） |
| Gender |  | 0.0529  （0.0568） | 0.0457  （0.0572） |
| Age |  | 0.0553\*\*\*  （0.0023） | 0.0514\*\*\*  （0.0023） |
| BMI |  | -0.0509\*\*  （0.0232） | -0.0521\*\*  （0.0235） |
| Location |  | 0.3715\*\*\*  （0.069） | 0.3265\*\*\*  （0.0713） |
| Education(Ref:Primary school and below) |  |  |  |
| Education\_2 |  | -0.2166\*\*\*  （0.0692） | -0.1933\*\*\*  （0.0700） |
| Education\_3 |  | -0.5311\*\*\*  （0.0918） | -0.4964\*\*\*  （0.0935） |
| Education\_4 |  | -0.8168\*\*\*  （0.1229） | -0.7444\*\*\*  （0.1241） |
| Marriage |  | -0.0288  （0.0778） | 0.1099  （0.0809） |
| Employment |  | -0.1540  （0.0956） | -0.1397  （0.0965） |
| Size |  |  | -.1485\*\*\*  （0.0247） |
| ln\_income |  |  | -0.1066\*\*\*  （0.0116） |
| Housing |  |  | -0.0006  （0.0004） |
| Constant | -1.2341 \*\*\*  （0.0264） | -4.1236\*\*\*  （0.2109） | -2.4556\*\*\*  （0.2508） |
| Pseudo r-squared | 0.0124 | 0.1493 | 0.1660 |
| Number of obs | 9217 | 9217 | 9217 |

\*\*\*p ≤ 0.01, \*\*p ≤ 0.05; robust standard errors are in parentheses.

**TABLE 4 |** Endogeneity test.

|  |  |  |
| --- | --- | --- |
|  | Step 1 Regression  （1） | Step 2 Regression  （2） |
| Coverage | 0.5980 \*\*\*  （0.0527） |  |
| PHI |  | -2.7276\*\*\*  （0.5464） |
| Control variables | Yes | Yes |
| Constant | 0.0194  （0.0265） | -1.1649\*\*\*  （0.1581 ） |
| Wald test | 28.06\*\*\* |  |
| Observations | 9217 | 9217 |

\*\*\*p ≤ 0.01;robust standard errors are in parentheses.

**TABLE 5 |** Balance test for the quality of propensity score matching.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Variables | Mean |  | Bias (%) | Bias Reduction  (%) | t-test | p |
| Treated group | Control group | t-value | P>|t| |
| Gender Unmatched | 0.4810 | 0.4690 | 2.4 |  | 0.7200 | 0.4690 |
| Matched | 0.4814 | 0.4766 | 1 | 59.2 | 0.2200 | 0.8250 |
| Age Unmatched | 42.9970 | 51.6350 | -56.7 |  | -16.1700 | 0.0000 |
| Matched | 43.0050 | 42.3220 | 4.5 | 92.1 | 1.0400 | 0.3000 |
| BMI Unmatched | 4.0107 | 4.0714 | -5 |  | -1.5300 | 0.1260 |
| Matched | 4.0137 | 4.0703 | -4.6 | 6.7 | -1.0500 | 0.2940 |
| Location Unmatched | 0.4019 | 0.6542 | -52.2 |  | -15.9500 | 0.0000 |
| Matched | 0.4023 | 0.4165 | -2.9 | 94.4 | -0.6500 | 0.5150 |
| Education\_2 Unmatched | 0.2019 | 0.2972 | -22.1 |  | -6.3700 | 0.0000 |
| Matched | 0.2021 | 0.1987 | 0.8 | 96.4 | 0.1900 | 0.8470 |
| Education\_3 Unmatched | 0.2507 | 0.1763 | 18.2 |  | 5.8000 | 0.0000 |
| Matched | 0.2510 | 0.2363 | 3.6 | 80.3 | 0.7700 | 0.4400 |
| Education\_4 Unmatched | 0.4478 | 0.1482 | 69.3 |  | 24.1900 | 0.0000 |
| Matched | 0.4473 | 0.4595 | -2.8 | 95.9 | -0.5500 | 0.5790 |
| Marriage Unmatched | 0.7668 | 0.7975 | -7.4 |  | -2.2900 | 0.0220 |
| Matched | 0.7666 | 0.7490 | 4.3 | 42.7 | 0.9300 | 0.3530 |
| Employment Unmatched | 0.2654 | 0.1312 | 34.1 |  | 11.5400 | 0.0000 |
| Matched | 0.2646 | 0.2583 | 1.6 | 95.3 | 0.3300 | 0.7440 |
| Size Unmatched | 2.9161 | 2.8672 | 1.7 |  | 0.5600 | 0.5730 |
| Matched | 2.9160 | 2.8452 | 2.4 | -44.8 | 0.6500 | 0.5180 |
| ln\_income Unmatched | 11.5580 | 10.3780 | 53 |  | 14.8900 | 0.0000 |
| Matched | 11.5540 | 11.5670 | -0.6 | 98.8 | -0.1600 | 0.8730 |
| Housing Unmatched | 99.5270 | 110.2900 | -15.9 |  | -4.5100 | 0.0000 |
| Matched | 99.5360 | 99.5900 | -0.1 | 99.5 | -0.0200 | 0.9850 |

**TABLE 6 |** Estimation results of propensity score matching method.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | Treated group | Control group | ATT | S.E. | T-value |
| Nearest-Neighbor matching | Unmatched | 0.0907 | 0.2255 | -0.1347\*\*\* | 0.0134 | -10.03 |
| Matched | 0.0908 | 0.1213 | -0.0304\*\* | 0.0136 | -2.24 |
| Radius matching | Unmatched | 0.0907 | 0.2255 | -0.1347\*\*\* | 0.0134 | -10.03 |
| Matched | 0.0908 | 0.1164 | -0.0256\*\* | 0.0113 | -2.26 |
| Kernel matching | Unmatched | 0.0907 | 0.2255 | -0.1347\*\*\* | 0.0134 | -10.03 |
| Matched | 0.0908 | 0.1208 | -0.0299\*\* | 0.0113 | -2.66 |

The Nearest-Neighbor matching adopts 1-to-2 matching; the radius value of the radius matching is 0.03, and the kernel matching is the default value.

**TABLE 7 |** Results of heterogeneity analysis.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variables** | Region difference | | Age difference | |
| Rural  (1) | Urban  (2) | 18~59 years old  （3） | 60 years old  and above  （4） |
| PHI | -0.3403\*\*  （0.1765） | -0.1575  （0.1681） | -0.3386\*\*  （0.1630） | 0.0018  （0.1963） |
| Control variables | Yes | Yes | Yes | Yes |
| Constant | -2.2885\*\*\*  （0.2802） | -2.1202\*\*\*  （0.4365） | -2.2179\*\*\*  （0.1921） | -1.4918\*\*\*  （0.4853） |
| Pseudo R2 | 0.1587 | 0.1626 | 0.1143 | 0.0611 |
| Observations | 5771 | 3446 | 6186 | 3031 |

\*\*\*p ≤ 0.01, \*\*p ≤ 0.05; robust standard errors are in parentheses.

**TABLE 8 |** Results of mediating effect.

|  |  |  |  |
| --- | --- | --- | --- |
| **Variables** | CHE | Health | CHE |
| （1） | （2） | （3） |
| PHI | -0.2503\*\*  （0.1207） | 0.0763\*\*\*  (0.0306) | -0.2107\*  (0.1249) |
| Health |  |  | -0.5361 \*\*\*  (0.0266) |
| Control variables | Yes | Yes | Yes |
| Constant | -2.4556\*\*\*  （0.2508） | 3.9950\*\*\*  (0.0906) | -0.4121\*\*\*  （0.2769） |
| Pseudo R2 | 0.1660 | 0.1655 | 0.2131 |
| Observations | 9217 | 9217 | 9217 |

\*\*\*p ≤ 0.01, \*\*p ≤ 0.05, \*p ≤ 0.1; robust standard errors are in parentheses.

**Figures**



**Fig. 1** Standardized difference scatter plot of all covariates before and after propensity score matching (%).



**Fig. 2** Distribution range of propensity score for the treatment group and control group.

1. According to the data released by the China National Bureau of Statistics, the per capita disposable income of rural households with the lowest income of 20% will be 4856 yuan in 2021, according to the five equal income groups. Available online at: [https://data.stats.gov.cn/easyquery.htm?cn=C01](https://data.stats.gov.cn/easyquery.htm?cn=C01(accessde) [(](https://data.stats.gov.cn/easyquery.htm?cn=C01(accessde)accessed November 5, 2022) [↑](#footnote-ref-0)
2. Available online at: [http://www.gov.cn/xinwen/2017-01/23/content\_5162653.htm](http://www.gov.cn/xinwen/2017-01/23/content_5162653.htm%20(accessed) [(accessed](http://www.gov.cn/xinwen/2017-01/23/content_5162653.htm%20(accessed) November 5, 2022) [↑](#footnote-ref-1)