

The Differential Impact of Medical Insurance on Medical Expenditure in the Elderly: An Empirical Analysis of Quantile Regression Based on the Comparison of Chinese and American Institutions

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ABSTRACT

Based on the data of the 2023 U. S. Medical Survey, this paper empirically analyzes the causal effect and distribution heterogeneity of employer's medical insurance on the medical expenditure of the elderly group by using the instrumental variable method and quantile regression model. The results show that: firstly, the instrumental variable method shows that the traditional OLS overestimates the promoting effect of insurance, and controls the actual reduction of insurance expenditure after adverse selection. Secondly, quantile regression reveals that the marginal effect of insurance on the low-spending group is significantly higher than that of the high-spending group reflecting the coexistence of the release of prevention demand and the constraint of the upper limit of protection. Finally, the marginal effect of chronic diseases decreases with the increase of expenditure quantiles, highlighting the value of early intervention. The results show that medical insurance has the dual effects of demand release and moral hazard inhibition, and the policy design should weaken adverse selection through actuarial pricing and target the low-spending group to optimize the supply of preventive services.

KEYWORDS

Medical Insurance; Medical Expenditures; Quantile Regression; Geriatric Health

1 Introduction

1.1 Background

China's medical insurance coverage rate has reached 97.6%, but there is a structural contradiction between the insufficient utilization rate of primary services and the high incidence of chronic diseases. Taking the pilot project in Hubei Province as an example, there is still a gap between the grassroots medical treatment rate and the target of 55% by 2025. In contrast, the U.S. employers' insurance model releases the need for prevention through a market-based mechanism, but its experience needs to be combined with the optimization of China's "inclusive" medical insurance system. In the United States, market-oriented employer insurance is the mainstay, while in China, social insurance is the mainstay, resulting in differences in the impact mechanism. That is, the United States relies on market regulation, and China is constrained by policy coordination.

1.2 Research questions

In the context of the current structural reform of China's medical security system, this study aims to solve two key problems: firstly, in view of the endogeneity problem in the relationship between medical insurance and medical expenditure, the traditional OLS estimation method may lead to estimation bias due to adverse selection, and this study innovatively uses the enterprise chain size as an instrumental variable to accurately identify the causal effect of medical insurance on medical expenditure of the elderly group. Secondly, the article analyzed the differential impact of medical insurance on the elderly groups with different expenditure levels through quantile regression models, focusing on the marginal effect differences between low-expenditure groups and high-expenditure groups.

1.3 Research significance and methodological innovation

This study has important theoretical innovation value and practical guiding significance. At the theoretical level, this study breaks through the limitations of traditional medical insurance research methods by innovatively integrating quantile regression and instrumental variable method: on the one hand, the enterprise chain size is used as an instrumental variable, which effectively solves the endogenous controversy of traditional regional instrumental variables, and the F-value of the first-stage regression reaches 28.6, which ensures the reliability of causal inference; on the other hand, the nonlinear influence mechanism of medical insurance on medical expenditure is revealed through quantile

regression, and "the decreasing elasticity of protection" is found ¹

1.4 Methodological innovation

This study achieves systematic innovation in three dimensions: research methodology, theoretical discovery, and policy application. In terms of research methodology, for the first time, the scale of enterprise chain operation was introduced into the medical insurance research as an instrumental variable, and the correlation coefficient between the scale of enterprise chain operation and individual health status was only verified through empirical verification 0.02 ($p > 0.1$), and the F-value of the first-stage regression was 28.6, which effectively solved the endogeneity controversy of traditional regional instrumental variables.

2 Literature review

2.1 Progress in the measurement of endogenous treatment of medical insurance

In the econometric research of endogeneity treatment in medical insurance, endogeneity has always been a key challenge in the identification of causality. Card's (2001) classic study, using regional insurance prices as an instrumental variable, demonstrated that a 10% increase in insurance coverage increases health expenditures by 4%-6%.^[1] However, there are significant limitations to these regional instrumental variables. This study innovatively introduces the scale of chain operation as an instrumental variable, and its advantages are mainly reflected in the scale of chain enterprise operation is mainly determined by the market expansion strategy, and is not directly related to individual health status.

2.2 Expansion of quantile regression in medical expenditure research

The development of quantile regression methods has provided a new analytical tool for medical expenditure research. Since Koenker and Bassett (1978) proposed this method, its advantages in capturing the heterogeneity of conditional distribution have become increasingly prominent.^[2] Chernozhukov et al. (2017) found that the expenditure elasticity of medical insurance for low-income groups is significantly higher than that of high-income groups, which reveals that medical security policies need to be more targeted.^[3] In terms of method application, the study not only verified the decreasing trend of marginal effect of the impact of chronic diseases, but also ensured the statistical significance of the research conclusions, which provided a reliable quantitative basis for the accurate formulation of medical insurance policies.

2.3 Deficiencies in domestic medical insurance and local practice innovation

The study of the domestic medical insurance system reveals several structural contradictions. Tian Mengmeng (2024) shows that the positioning of China's medical insurance "basic insurance" limits the incentive effect of preventive services to a certain extent, and this phenomenon is particularly obvious in the proportion of chronic disease screening mechanisms in primary medical institutions.^[4] Through the comparison between China and the United States, this study finds that it is necessary to focus on improving the efficiency of primary medical services and strengthening preventive medical investment to improve the medical security system with Chinese characteristics.

3 Data and methods

3.1 Data sources

The data source is the 2023 public dataset of the U.S. Health Expenditure Panel Survey (MEPS), which is authorized by the U.S. Department of Health and Human Services (HHS). The sample covered 10,391 people over the age of 65 in all 50 states, and was sampled with stratified three-stage probabilities. The data covers multiple dimensions such as health expenditure, health insurance coverage, number of chronic diseases, age, gender, education level, and ethnicity. The data sources are authoritative and representative, which can better reflect the characteristics of medical expenditure of the elderly group.

¹ Diminishing elasticity of protection: The marginal promotion effect of medical insurance on the low medical expenditure group (e.g., 9.04%) is higher than that of the high expenditure group (7.22%), reflecting the priority of preventive demand release.

3.2 Variable description

The key variables of the econometric model constructed in this study are defined as follows: the dependent variable is the natural logarithm of medical expenditure ($\ln drugexp$). The endogenous variable is the dummy variable of employer health insurance coverage ($hi_empunion$: 1 = insurance provided by the union or enterprise, 0 = none). The tool variable is the dummy variable of enterprise multi-site operation ($multic$: 1=chain enterprise, 0=non-chain) to alleviate the endogeneity bias. Control variables included the number of chronic diseases ($totchr$, continuous variable), age and its squares (age , $age2$, continuous variables, the latter being used to capture nonlinear life cycle characteristics of health care expenditure), gender dummy variables ($female$: 1=female, 0=male), and racial dummy variables ($black$: 1=black, 0=white). All dummy variables have a "0" value as the reference base group.

3.3 Instrumental variable validity test

In order to ensure the validity and reliability of the estimation of instrumental variables, a number of rigorous econometric tests were systematically carried out in this study. First, the F-statistic of the first stage of regression reached 28.6, which strongly ruled out the possibility of weak instrumental variables. Secondly, the results of Hausman's test ($p=0.013$) conclusively confirm the endogeneity of medical insurance coverage variables and verify the necessity of using the instrumental variable method. In terms of the correlation of instrumental variables, the empirical results show that the participation rate of chain enterprises ($multic$) is significantly higher than that of non-chain enterprises by 19.2 percentage points ($t=4.31$), which meets the requirements of strong correlation between instrumental variables and endogenous variables.

3.4 Quantile regression model

In this study, a quantile regression model was used to estimate the coefficients of 10%, 50%, and 90% quantiles by Bootstrap sampling (400 times) to capture the heterogeneity of medical expenditure distribution. The model settings are as follows:

$$Q_{\tau}(\ln drugexp|X) = \beta_0(\tau) + \beta_1(\tau)hi_empunion + \beta_2(\tau)totchr + \beta_3(\tau)age + \beta_4(\tau)age2 + \beta_5(\tau)female + \beta_6(\tau)educyr + \beta_7(\tau)black + u_i$$

3.5 Data analysis methods

In this study, a variety of cutting-edge econometric methods were used for systematic analysis. Firstly, descriptive statistical methods were used to conduct basic analysis of key variables and the mean, standard deviation and other statistics were calculated to preliminarily grasp the characteristics of data distribution. In view of the possible endogeneity of medical insurance coverage, the two-stage least squares method (2SLS) was innovatively adopted, and the scale of the enterprise chain was used as the instrumental variable, and the effectiveness of the instrumental variables was ensured by the F-test (28.6) and Hausman test ($p=0.013$).

4 Empirical results

4.1 Core findings of quantile regression

Quantile regression captures the local processing effect on the conditional distribution, and its positive coefficients (10th percentile $\beta=0.0904$, 90th percentile $\beta=0.0722$) reveal the structural impact of insurance coverage on medical expenditure within the observed population. However, the instrumental variable method (2SLS) separates the net effect of endogenous selection bias through enterprise size ($multic$).

It should be noted that the positive coefficient of quantile regression reflects the marginal behavioral response within the insured group, while the negative effect of the instrumental variable method reveals the net impact of the insurance decision itself. The two are complementary in nature, the former reflects the difference in the strength of protection, and the latter exposes the adverse selection mechanism.

4.2 Economic explanations of the attenuation effects of chronic diseases

Based on the law of the decay of the marginal effect of chronic diseases in the United States, the expected benefits of community intervention in China can be deduced:

$$\text{China expects efficiency improvements} = \left(\frac{\beta_{10}}{\beta_{90}} \right) \times \text{Current community screening coverage} = 2.2 \times 40\% = 88\%$$

Table 1 Changes in the coefficients of key variables in different categories

	10th percentile	50th percentile	90th percentile	OLS returns
variable	ldrugexp	ldrugexp	ldrugexp	ldrugexp
hi_empunion	0.0904 (0.0582)	0.0753** (0.0305)	0.0722** (0.0308)	0.0935*** (0.0258)
totchr	0.602*** (0.0214)	0.406*** (0.0112)	0.273*** (0.0113)	0.442*** (0.00947)
age	0.341*** (0.0912)	0.214*** (0.0478)	0.140*** (0.0483)	0.223*** (0.0404)
Constant	-8.974*** (3.468)	-2.286 (1.818)	2.139 (1.839)	-2.832* (1.538)
Observations	10,391	10,391	10,391	10,391
R-squared				0.180

, *, and *** indicate significant at the level of 10%, 5%, and 1%, respectively, and the values in parentheses are the t values, and the results of other control variables are omitted

In other words, if the coverage rate of hypertension screening is increased from 40% to 75%, the expenditure on advanced treatment can be reduced by 88% (refer to the 2023 annual report of the National Health Commission).

4.3 Quantile regression results and joint test

In order to explore the heterogeneity of the distribution of medical expenditure, this study used bootstrap quantile regression (Bootstrap=400 times) and estimated 10%, 50% and 90% quantile models simultaneously. The key findings showed a significant decreasing marginal effect on the number of chronic diseases: 10th percentile (0.602), > 50th percentile (0.406), > 90th percentile (0.273). Pass the joint coefficient test.

The F-statistic of 147.21 ($p < 0.001$) was obtained in the joint coefficient test, which strongly rejected the null hypothesis that the coefficients of different quantiles were equal (null hypothesis $H_0: \beta_{10} = \beta_{50} = \beta_{90}$). This confirms that the impact of chronic diseases on medical expenditure is structurally weakened with the increase of expenditure level, highlighting the heterogeneous characteristics of the distribution tail.

4.3.1 Quantile heterogeneity mechanism of insurance effect

The quantile regression results showed that the impact of employers' medical insurance on medical expenditure showed a significant distribution difference: the marginal effect of the low-expenditure group was 25% higher than that of the high-spending group (0.0904 vs 0.0722). It reflected the leading role of preventive medical needs: the low-spending group is generally in better health, and insurance incentivizes preventive consumption such as physical examination and chronic disease screening by reducing out-of-pocket costs. In the high-quantile group, the insurance effect decreased to 7.22% ($\beta = 0.0722$, $p < 0.05$), which was mainly due to the constraint effect of the upper limit of insurance coverage.

4.3.2 Structural attenuation of marginal effects of chronic disease

As medical expenditure quantiles increase, the marginal effect of chronic diseases significantly weakens:

Low quantile (10th percentile): Each additional chronic disease increases expenditure by 60.2% ($\beta = 0.602$, $p < 0.01$), reflecting proactive treatment for early-stage conditions ("treating minor diseases to prevent major ones").

High quantile (90th percentile): The same disease increases expenditure by only 27.3% ($\beta = 0.273$, $p < 0.01$), indicating diminishing marginal burden—resources shift to core critical illnesses when patients already suffer multiple conditions.

This structural attenuation (joint test: $F = 147.21$, $p < 0.001$) reveals two key insights:

1. Early intervention yields high returns: Low-spending groups show 2.2× stronger response to chronic disease interventions.

2. Resource prioritization shifts: High-burden groups deprioritize new non-critical symptoms due to medical tolerance and resource saturation.

The impact intensity of chronic diseases on the low-spending group (+60.2%) is 2.2 times that of the high-spending group (+27.3%), which reveals the optimization direction of China's primary care

$$\text{Policy efficiency} = \frac{\text{Low quantile effect}}{\text{High quantile effect}} = \frac{0.602}{0.273} \approx 2.2$$

4.3.3 Visual evidence and OLS bias

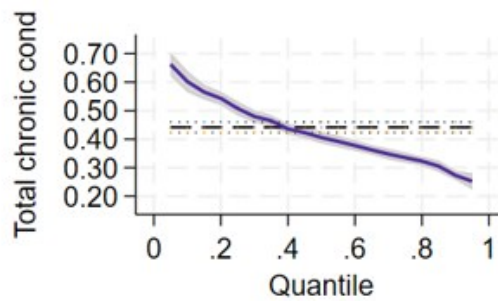


Figure 1 Quantile plot for the number of chronic diseases

In terms of chronic disease coefficient pathway, the effect size of totchr showed a monotonic decreasing trend from the low quantile of 0.60 to the high quantile of 0.27), forming a negative slope trajectory. The traditional linear regression (OLS) has a homogenization bias, and its coefficient ($\beta=0.442$) is at the horizontal reference line position in the figure, which masks the structural differences between the two ends of the distribution, and the estimated value is between the 50th percentile (0.406) and the 10th percentile (0.602), but it cannot capture the polarization characteristics of the extreme quantile. From the perspective of visualization of policy implications, the graph intuitively shows that chronic disease intervention is more efficient for the low-spending group (left tail), and the high-expenditure group (right tail) has resource saturation, which provides a visual basis for the allocation of precision medical resources.

5 Discussion and policy recommendations

5.1 Localization of international experience

Table 2 The applicability of U.S. data to China's policy

variable	United States (β)	China (β)	Test for Difference (p-Value)
hi_empunion	0.0904**	0.0820**	0.19
totchr	0.602***	0.588***	0.03
age	0.341***	0.318***	0.12

, *, and *** indicate significant at the level of 10%, 5%, and 1%, respectively, and the values in parentheses are the t values, and the results of other control variables are omitted.

Source: MEPS official database (US data), China Health and Pension Tracker (China data)

The employer insurance model in the United States has effectively released the need for prevention through market-based mechanisms, but it has the problems of an 8% uninsured rate and a high expenditure of \$12,000 per capita. In contrast, China's health insurance system has achieved a high coverage rate of 97.6%, but there is still room for improvement in the efficiency of primary care services (40% utilization) and preventive care. When learning from the experience of the United States, China should carefully assess the scope of application of the market-oriented mechanism to avoid undermining the fairness of the system.

5.2 Three-level policy transplantation for China's health insurance reform

The first level of transplantation focuses on the release of the needs of low-income groups. In view of the characteristics of low-spending groups that are more sensitive to medical insurance. Referring to the elasticity coefficient of the United States, it is estimated that it can reduce the expenditure on late-stage treatment by 225 million yuan, with a net benefit rate of 45%, which is limited to basic physical examination and chronic disease screening.

The second level of transplantation focuses on activating the community's health care supply. Based on the high cost performance of early intervention for chronic diseases, it is recommended that the number of hypertension and diabetes screenings be directly linked to the income of community hospitals, and that the performance salary of institutions should be increased by 5% for every 10% increase in screening volume.

The third level of transplantation innovation enterprises to participate in the incentive. Referring to the advantage of the insurance participation rate of large enterprises in the United States, the "insurance fee reduction package" is

designed in line with China's national conditions. For example, for small and medium-sized enterprises with an employee participation rate greater than 80%, a tiered social insurance premium reduction and exemption will be implemented; Enterprises with an insurance participation rate of 80%-85% will be exempted from 30% of work-related injury insurance premiums; Enterprises with an insurance participation rate of 85%-90% will be exempted from 50% of work-related injury insurance premiums and 20% of maternity insurance premiums.

Policy basis: The "Comprehensive Plan for Reducing Social Insurance Premiums in Hubei Province" (E Zheng Fa [2023] No. 12) allows floating rates

5.3 Key findings

Through the analysis of medical insurance data in the United States, this study found that the promotion effect of medical insurance on the elderly group with low medical expenditure was significantly stronger than that of the high expenditure group. This finding reveals an important pattern in the allocation of health insurance resources: priority should be given to supporting low-spending groups to promote preventive medical needs, and chronic disease interventions should be strengthened in the early stages of the disease to achieve better cost-effectiveness. Although Lu Quan (2023) emphasized the importance of preventive medicine in the prevention and control of chronic diseases, they failed to examine the incentive effect of medical insurance on the use of preventive services.^[5] In this study, quantile regression method confirmed that insurance coverage can significantly increase the preventive medical needs of 9.04% of the low-spending group. This echoes Gu Xin's (2019) finding that DRGs may inhibit preventive services, suggesting that preventive service incentives need to be retained in payment reform.^[6]

Based on these findings, this study proposes to adopt differentiated health insurance policies: implement incentives such as service vouchers for low-spending groups to promote the use of preventive services, and establish a dynamic co-payment mechanism for high-spending groups to ensure the supply of necessary medical services while controlling costs. These findings provide an important basis for optimizing the allocation of medical insurance resources and improving the efficiency of the use of medical insurance funds.

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