

# Emerging research on social security and population health: New opportunities and challenges

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# Emerging research on social security and population health: New opportunities and challenges

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# Editorial: Emerging research on social security and population health: new opportunities and challenges

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## KEYWORDS

social security, population health, health expenditures, economic uncertainty, digital economy, new rural social pension insurance

## Editorial on the Research Topic

Emerging research on social security and population health: new opportunities and challenges

Academics have extensively explored the relationship between social security and population health, considering various aspects such as the mechanisms and economic implications of social security on health, as well as the influence of population health on the sustainability of social security. Recent years have witnessed the emergence of new economic and social dynamics, such as the rise of the digital economy, the economic downturn caused by the COVID-19 pandemic, and the acceleration of population aging. These factors have introduced both opportunities and challenges to the interplay between social security and population health. For instance, advancements in digital medical technology have enhanced the efficiency and health outcomes of medical insurance operations, whereas the aging population poses health risks to the older adult and increases their healthcare expenses by potentially reducing pension benefits. The complexity of these environmental changes complicates the understanding of the relationship between social security and population health, necessitating further research for analysis.

This Research Topic aims to gather original qualitative and/or quantitative research articles that deepen our comprehension of the relationship between social security and population health within the context of evolving social and economic conditions. The call for articles specifically focuses on exploring the opportunities and challenges presented by social security in influencing population health under new environmental circumstances. Additionally, contributions examining the connection between social security and population health from novel perspectives, including the underlying mechanisms and economic implications of social security's impact on population health, are encouraged. In sum, any original and significant research concerning social security and population health is of interest for this Research Topic.

In this editorial, we provide a summary of the articles published in the Research Topic “*Emerging research on social security and population health: new opportunities and challenges*” in the journal *Frontiers in Public Health*. [Li and Chen](#) identify a relative poverty standard based on medical needs, examines the impact of public health expenditures on medical expenses across various household types, and assesses the influence of public health spending on meeting the medical needs of households in relative poverty. Their findings reveal a crowding-out effect of public health expenditure on household medical spending, particularly pronounced in relatively poor households. [Bocean and Vărzaru](#) explore the association between social protection and health outcomes in EU countries using structural equation modeling (SEM) and cluster analysis. Their results demonstrate a significant positive relationship between social protection spending in EU countries and healthcare status. Increased social protection expenditure is linked to enhanced access to healthcare services and facilities.

[Liu](#) utilize a Bayesian panel vector autoregressive model to investigate the impact of economic uncertainty on public health. The analysis is based on an annual country-level panel dataset comprising 103 emerging markets and developing countries, covering the period from 1995 to 2019. Their results indicate that while the immediate effects of increased economic uncertainty on health appear to be minimal, it may lead to a longer life expectancy and reduced mortality rates over time. In a study conducted by [Zhou et al.](#), the relationship between the digital economy and residents' health is explored using data from the China Family Panel Studies (CFPS) in 2020. Their findings suggest that the digital economy has significantly enhanced the overall health status of residents, particularly those residing in the eastern region. The positive impact of the digital economy on residents' health primarily stems from its promotion of regional green development.

[Song et al.](#) utilize a multivariate ordered logistic regression model to investigate the impact mechanism and effects of the new rural social pension insurance (NRSPI) on the health of the older adult population in rural China. Based on survey data from the China Health and Retirement Longitudinal Study conducted in 2015 and 2018, their findings indicate that participation in the NRSPI leads to a significant improvement in the health of the rural older adult population. Moreover, the results of the heterogeneity analysis demonstrate that the NRSPI has a notable impact on the self-reported health of older adult individuals in rural areas, as well as a positive effect on both the mental and physical health of older adult women in rural regions.

[Pu et al.](#) explore the impact of the urban–rural resident basic medical insurance (URRBMI) on physical health of the rural older adult in China, utilizing data from the Chinese Longitudinal Healthy Longevity Survey (CLHLS) data in 2018. Their study reveals that URRBMI has a substantial positive impact on the physical health of rural older adults, particularly those in the eastern regions and those who are more advanced in age. In a separate study, [Li and Yuan](#) analyze data from the China Health and Retirement Longitudinal Study (CHARLS) spanning from 2011

to 2018, employing a staggered difference-in-differences model to evaluate the effects of integrating urban-rural health insurance on poverty vulnerability among rural residents. Their results indicate a significant reduction of 6.32% in poverty vulnerability due to the integration of urban-rural health insurance. Furthermore, the analysis of heterogeneity demonstrates that the integration of urban-rural medical insurance has a more pronounced impact on vulnerable groups with poorer health conditions than on those with better health, leading to a significant decrease in poverty vulnerability among individuals with chronic diseases.

[Fan and Hua](#) investigate the spillover effects and influencing mechanisms of the new rural insurance policy on human capital investments in rural households using data from the China Family Panel Studies (CFPS) in 2010, 2012, 2014, 2016, and 2018. The findings indicate that participation in the New Cooperative Medical Scheme (NCMS) significantly boosts human capital investments in rural households. Additionally, the spillover effects of the new policy vary significantly based on the gender, insurance stage, and family income of the insured individuals. The new rural insurance policy influences human capital investments in rural households through intergenerational interactions, impacting both the material aspects such as economic support, housework, and child care, as well as the non-material aspects like pension awareness.

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# The heterogeneous relationship between public health expenditures and household medical expenditures: evidence from relative poverty households in China

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Exploring the heterogeneous relationship between public health expenditures and household medical expenditures from the perspective of relative poverty has positive significance for improving the ability of relative poverty households to cope with the risk of large rigid expenditures and optimizing the public health resource allocation. This paper uses the China Family Panel Studies (CFPS) from 2016 to 2020 to identify relative poverty standard from the perspective of medical needs, analyzes the impact of public health expenditures on medical expenditures of different household types, and evaluates the effect of public health expenditures on ensuring the medical needs of relative poverty households. The panel threshold regression result shows that 19.36% of the provinces *per capita* disposable where the household is located is the identification standard of relative poverty households. Public health expenditures have a crowding-in effect on household medical expenditures and have a stronger impact on relative poverty households, an effect that is also confirmed by two-stage least squares regression. In addition, ensuring household medical needs through public health expenditures focuses on the level of basic medical needs, and the role of household healthcare expenditures that reflects high-level medical needs is not obvious. In the future, the government should establish a monitoring mechanism for relative poverty households, ensure the basic medical needs of relative poverty households, and clarify the heterogeneity among different types of households, provide targeted public health services.

## KEYWORDS

public health expenditures, household medical expenditures, relative poverty, crowding-in effect, heterogeneity

## Introduction

In recent years, with the increasing awareness of health investment, household medical expenditures, as an important component of household consumption, have grown rapidly. Data shows that Chinese household medical expenditures have increased from 4968.11 yuan in 2014 to 6236.9 yuan in 2020.<sup>1</sup> At the same time, the expenditure gap between households is also widening. Its growth is nearly three times compared with the absolute growth, which is particularly evident among households with different incomes and consumption needs. At present, the focus of poverty governance in China has shifted from “absolute poverty” to “relative poverty”.<sup>2</sup> Unlike absolute poverty, relative poverty reflects “relative deprivation” (1). It manifests as unequal access to public services by households, as well as a low level of social security, such as healthcare, education, and pensions (2). Compared with ordinary households, relative poverty households have a heavier healthcare burden, and are more vulnerable to exogenous shocks and return to poverty (3). Therefore, how to meet the medical needs of relative poverty households and improve their ability to cope with rigid expenditure risks will be an important guarantee for achieving relative poverty governance. Public health expenditures, as an effective means for the government to provide public medical services and meet the basic medical needs of the public, will also play a crucial role in relative poverty governance (4).

However, on the one hand, the identification standard of relative poverty households is not clear, and the relatively poverty group cannot be identified from the perspective of household medical needs. On the other hand, although public health expenditure aims to ease the healthcare burden of households (5), the heterogeneity effect of public health expenditures on household medical expenditures of relative poverty and ordinary households has not been empirically tested. The above reasons make it difficult to evaluate the effectiveness of public health expenditures on meeting household medical needs at present.

On the basis of the above background, this paper takes Chinese households as a research sample and uses the China Family Panel Studies (CFPS) from 2016 to 2020 to address two issues: Firstly, to determine the relative poverty standard and identify relative poverty groups from the perspective of household medical needs. Secondly, to explore public health expenditures, their relationship with household medical expenditures and the heterogeneity among groups, and then evaluate their effect on ensuring the relative poverty household medical needs. The results of this paper will help to understand the current relative poverty situation and the effectiveness of public health expenditure in meeting the relative poverty household medical needs. It is of great significance for improving the construction of public health service systems and governing relative poverty.

## Literature review

### Relative poverty measurements and governance

There are obvious differences between relative poverty and absolute poverty in terms of connotation, measurement standards and governance methods. At present, researches on relative poverty are still insufficient, especially regarding the identification of poverty objects and the determination of measurement standards. The common international identification methods and measurement standards of relative poverty are still similar to absolute poverty, which reflects the characteristics of monetization dimension of income and is defined as a certain percentage number lower than the median income, i.e., the relative income standard (6, 7). Referring to this practice, some studies further propose calculating the relative poverty standard using the average income level of residents (8) or a certain proportion of the median income of urban and rural residents (9). Some researches have proposed that the coverage of social assistance can be used as a reference for determining the proportion of the relative poverty population (10). Similarly, Au (11) uses a cost-of-living approach to measure relative poverty, where the poverty line is defined as the cost of essential goods and services. Although similar measures are easy to apply, they cannot reflect the unique demand (or expenditure) dimension of relative poverty compared with absolute poverty, leading to a serious underestimation of the depth of poverty. Recently, some scholars have called for the establishment of a relative poverty identification and measurement system that considers income type and demand type (12) and have proposed a plan based on demand (13). For example, He and Zhu (14) appeal for labor mobility as a measure to contain relative poverty. Zhang and Su (15) state that unfair allocation of social resources and the household registration system is partially responsible for the existence of relative poverty in China. However, no specific identification standards and quantitative measures have been established.

In recent years, scholars have analyzed the causes of relative poverty and countermeasures from an institutional perspective. Ravallion (16) concludes that the substantial difference in basic public services such as medical care and education constitutes national inequality, subsequently forming the problem of relative poverty that exists today. In the process of relative poverty governance, health human capital (17), educational human capital (18) and social capital (19) are replacing traditional capital, such as local economic development and infrastructure improvements, and have become the main factors in reducing poverty. Therefore, to safeguard publics' right to subsistence and development, it is necessary to establish a demand-oriented security system and address expenditures such as household medical care, education, and housing that have important impacts on publics' right to subsistence and development (20). The fair public policy system for the relative poverty further emphasizes the equalization of basic public services and maintenance of social equity (21).

### The heterogeneous relationship between public health expenditures and household medical expenditures

As a type of financial expenditure, the role of public health expenditures on household consumption is controversial in theory,

<sup>1</sup> The data comes from the CFPS database.

<sup>2</sup> At the Fourth Plenary Session of the 19th Central Committee of the Communist Party of China held on October, 2019, China announced a strategic change: in the future targeting relative poverty rather than absolute poverty which has been targeted since mid-1980s.

and the relationship between public health expenditures and household medical expenditures has not yet been determined empirically.

Some studies support the idea of a “crowding-out effect” between the two types of spending. This perspective emphasizes the impact of public health expenditures on the supply side of medical services and suggests that government public health expenditures reflect public finance support for medical and healthcare and that an increase in government investment in public health can directly or indirectly reduce personal medical expenditures (22, 23). Additionally, greater government investment in basic medical and health services can improve public health facilities and improve the level of medical security, and the popularization of basic medical and health services can improve individuals’ ability to prevent diseases, reduce individual morbidity rates, and reduce individual medical expenses. Many scholars have found through empirical research that public health expenditures are an important factor affecting personal medical expenditures and verified that public health expenditures have a crowding-out effect on personal medical expenditures (24, 25).

Other studies support the idea of a “crowding-in effect” between the two types of spending. This perspective emphasizes the impact of public health expenditures on the demand side of medical services and suggests that an increase in public health expenditures improves the level of government medical security, which in turn increases the budget constraints of personal medical consumption, releases part of the personal consumption demand for medical services, and ultimately improves the level of personal medical spending. For example, Long et al. (26) conducted a study on the effectiveness of China’s 2000–2010 healthcare system reforms and found that public health expenditures had a significant “crowding-in” effect on personal medical expenditures and the effect was more pronounced in rural and underdeveloped areas. Similarly, Dieleman et al. (27), by examining changes in public health spending and private health spending in the United States, found that public health spending significantly contributed to private health spending. From the perspective of the economic effects of public health spending, some scholars have also found that public health spending stimulates medical consumption while stimulating personal nonmedical consumption (28).

Due to the different directions of public health spending on the supply and demand sides, the final impact on household medical spending will depend on the magnitude of the positive and negative effects. While, some studies have noted that there is also heterogeneity in the final impact influenced by certain features. For example, business cycle (29), public expenditure content (30), household welfare situation (31), etc. Especially, household income is an important feature. As income increase, the promoting effect of public health expenditure on household consumption expenditure may gradually weaken (32, 33).

## Evaluation of existing research and contributions of this paper

The existing studies provide a useful reference and inspiration for this paper. From the research perspective, existing studies confirm that structural inequalities in household medical expenditures and “growth differentiation” exacerbate the cumulative health disadvantages of

relative poverty households, leading to the continuous expansion of the human capital gap between groups, which reflect the basic logic of relative poverty caused by household medical needs. However, few studies take this mechanism into account when analyzing relative poverty. This paper identifies the relative poverty standard from the perspective of household medical needs, considering the possibility of relative poverty caused by differences in medical needs between households. From the research content, the existing research on the relationship between public health expenditures and household medical expenditures has not reached a consistent conclusion. When examining the relationship between the two, the impact of public health expenditure on the medical needs of different household types has been ignored. This paper further explores the heterogeneity in the effects of public health expenditures across different types of households, which is an important mechanism for the governance of relative poverty through public health expenditures. From the research methods, there are many qualitative studies and few quantitative studies on the governance of relative poverty, and most of them focus on the policy support of public service supply. This paper uses the panel threshold model, fixed effect model, two-stage least squares method (2SLS) model and other research methods to obtain quantitative results on related issues to improve the pertinence of relative poverty governance strategies.

## Research design

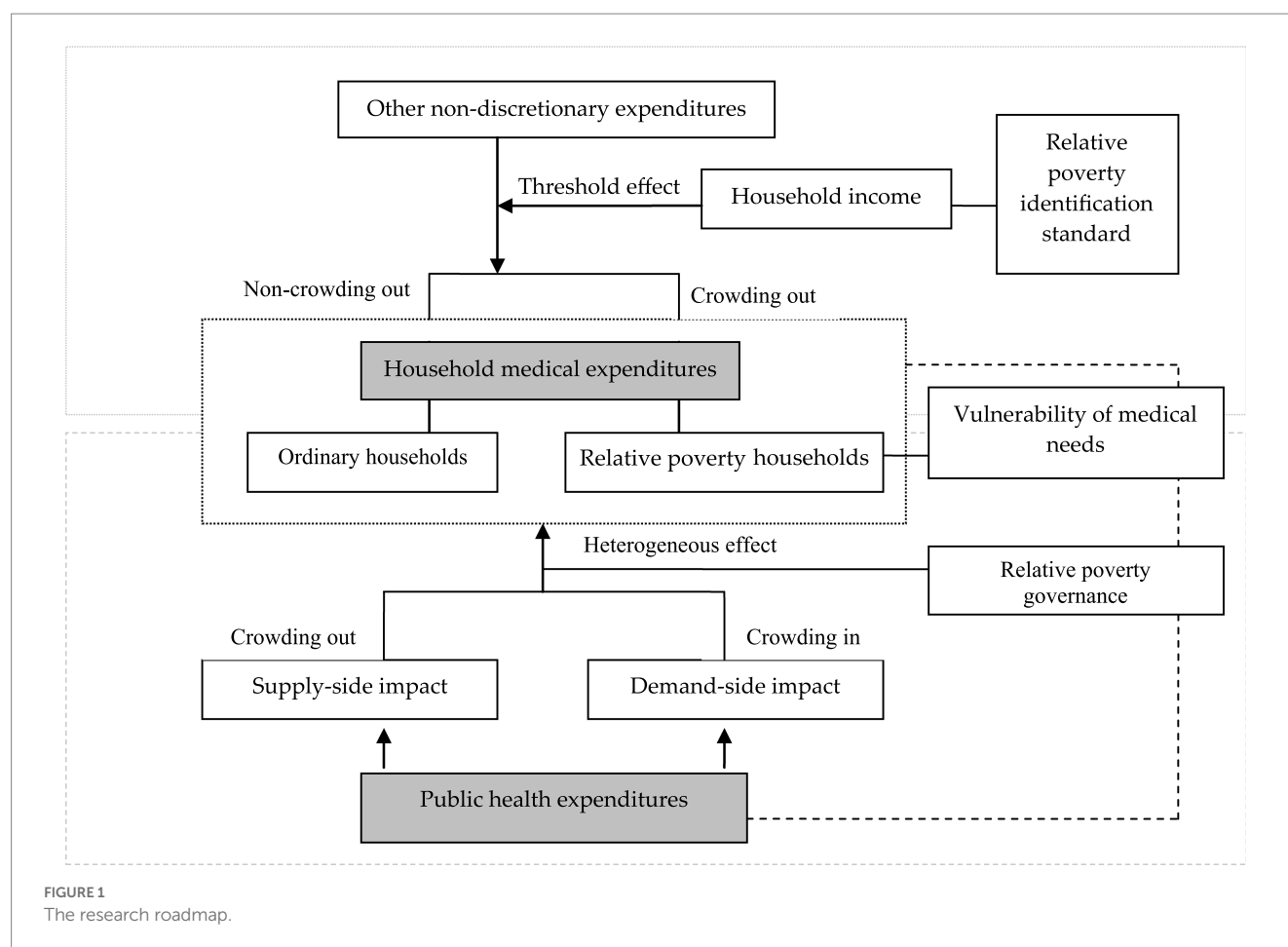
### Theoretical basis and research hypothesis

Figure 1 is the research roadmap for this paper, which mainly involves two issues: first, measuring relative poverty standards and identifying relative poverty households from the perspective of household medical needs; Second, to explore the heterogeneous relationship between public health expenditure and medical expenditure of different types of households, and to evaluate its effectiveness in ensuring the medical needs of relative poverty households.

For issue 1, human capital theory (34) proposes that human capital is the sum of the value of workers’ knowledge, health status, etc., and can improve by expanding investments in education, healthcare, etc. The household investment model proposed by Becker (35) provides a theoretical framework for studying household medical expenditure decisions. Under the household code of conduct in pursuit of utility maximization, household medical expenses are constrained by various factors, such as household background, household socioeconomic status, and medical service prices, which are the result of a series of external factors. Among the many factors, household income is the most prominent. Low-income households are more vulnerable to household medical expenditures due to risk aversion or borrowing constraints and are at higher risk of catastrophic medical expenditures. The uncertainty of household income and uncertainty of future returns of health investments have negative impacts on household medical expenditures, and this effect is more pronounced for low-income households (36).

Compared with absolute poverty, relative poverty involves not only household food expenditures but also household development expenditures (or household large rigid expenditures) such as healthcare, education, and housing. On the basis of the household





investment model, this paper argues that due to household consumption demand preferences and liquidity constraints, the large rigid expenditures of households on certain aspects in a certain period may far exceed household disposable income in the same period, thereby affecting other household investment decisions. When the *per capita* disposable income of a household is low, especially for relative poverty households, to meet the necessary expenditure needs, the household may maintain a large amount of rigid expenditures (such as household education expenditures), which may crowd out the household's medical expenditures in the same period, indicating that the two are negatively correlated. At this time, households are highly vulnerable and at potential risk of not meeting developmental consumption needs, especially medical needs. When the *per capita* disposable income of a household reaches a certain level, with the increase in capital investment demand and residents' active health awareness, the crowding out effect between the two types of expenditure may weaken or disappear, and a parallel growth relationship will appear.

Therefore, we propose H1: there is a certain income threshold value between household medical expenses and other rigid household expenditures. Above and below this income threshold value, the correlation between the two types of expenditures in the same period is completely different, and this threshold value can be used as an identification standard for relative poverty households from the perspective of household medical needs.

For issue 2, because household medical expenditures are the main component of large rigid household expenditures, these expenses are an important measure of household medical demand. Combined with theoretical analyses and existing research conclusions, public health expenditures on the supply side can improve the availability of medical and health resources, and the impact of these expenditures on household medical expenditures manifests as a crowding-out effect; in contrast, public health expenditures on the demand side can improve residents' medical treatment and meet residents' medical needs, and the impact on household medical expenses manifests as a crowding-in effect. In reality, since China launched its "new medical reform" policy in 2009,<sup>3</sup> the total amount of financial investment in primary medical and health services has increased rapidly, the serious shortage of supply capacity in the primary medical and health service system has been reversed, and the impact of public health expenditures on the supply side has been alleviated. Overall, the impact of public health spending on household medical spending may manifest as a crowding-in effect.

<sup>3</sup> The new medical reform has established the short-term goal of "effectively alleviating the 'difficulty and cost of seeing a doctor'," as well as the long-term goal of "establishing and improving the basic medical and health system that covers urban and rural residents, and providing safe, effective, convenient, and affordable medical and health services to the masses."

However, due to the vulnerability of relative poverty households in terms of living security, there is still a large gap between their expected medical needs and affordable medical needs, and the gap in medical consumption needs is larger for relative poverty households than for ordinary households. The government's investment in basic medical services and medical security has improved accessibility to medical services, lowered the price of medicines, and to a certain extent lifted the budget constraints of low-income groups, greatly stimulating their willingness to consume. In contrast, ordinary households, especially the high-income households, have a strong ability to pay. On the premise that the needs of basic medical services are fully met, these households consume high-quality and high-level medical services. The basic medical services and medical security provided by the government finance may not be very attractive for their consumption.

Therefore, we propose H2: generally, there is a crowding-in effect between public health expenditures and household medical expenditures, but this effect is heterogeneous between ordinary households and relative poverty households, and the crowding-in effect on relative poverty households may be more obvious.

## Methods and variable selection

To test H1, identifying possible income thresholds is a necessary part of determining the identification standard of relative poverty households. Hansen (37) believes that the threshold effect between economic factors can be analyzed using the threshold panel model. Therefore, based on the theory of human capital, this paper uses the panel threshold regression model to systematically analyze the changing relationship between the household medical expenditures and another important household large rigid expenditure, household education expenditures with different income levels in the same period, and then determine the identification standard and identify relative poverty households from the perspective of household medical needs.

The model can be expressed as:

$$ME_{it} = \beta_1 EDU_{it} \cdot 1(I_{it} \leq \gamma) + \beta_2 EDU_{it} \cdot 1(I_{it} > \gamma) + \beta_3 X + \mu_i + \varepsilon_{it} \quad (\text{Model 1})$$

$1(\cdot)$  is an indicative function, and  $I$  is a threshold variable, which is determined by the ratio of the *per capita* disposable income of household  $i$  in year  $t$  to one-third of the *per capita* disposable income of the province where the household is located. The reasons for choosing this indicator are as follows. First, the selection of threshold variables should reflect the consumption demand and budget constraints faced by households, and reflect the different changing relationships between the explanatory variables and the explained variables above and below the threshold value; therefore, the threshold variable is constructed using the *per capita* income of households. Second, two dimensions of income and expenditure (or demand) included in the concept of relative poverty are considered in this indicator. It is reasonable to assume that households with lower income levels are more vulnerable to no meeting their medical needs than are higher income households. Additionally, to take into account the other rigid expenditure burdens of the household to maintain

basic life, when the threshold variable is constructed, one-third of the *per capita* disposable income of each province is used as the standard to delineate the high-probability groups that are prone to falling into relative poverty;<sup>4</sup> the regression samples were screened using this standard. On this basis, relative poverty households are identified from the perspective of medical needs. Finally, to enhance the relevance of the measurement standard, the use of relative indicator can provide different relative poverty identification standards in different provinces.  $\gamma$  is the threshold value to be measured in this paper. There are different correlations between  $EDU_{it}$  and  $ME_{it}$  in the two cases of  $I_{it} \leq \gamma$  and  $I_{it} > \gamma$ .  $\beta_1$  and  $\beta_2$  represent the influence coefficients between household medical expenditures and education expenditures above and below the threshold  $\gamma$ , respectively. If there is a threshold  $\gamma^*$  such that  $\beta_1 < 0$  and  $\beta_2 > 0$ , then  $\gamma^*$  is the identification standard of relative poverty households from the perspective of household medical needs.

The explained variable  $ME_{it}$  used in this paper is the sum of the medical expenditures of household  $i$  in year  $t$ .<sup>5</sup> The explanatory variable  $EDU_{it}$  is the sum of the education expenditures of household  $i$  in year  $t$ . The reason for choosing household education expenditures is mainly because existing researches have merged four types of expenditures: education, medical, housing, and older adult care into large rigid household expenditures from the perspective of Chinese household expenditure (38). In these four types of expenditures, the two large rigid expenditures, i.e., household housing and older adult care, are more susceptible to the influence of macro policies and greater uncertainty. Additionally, the other two large rigid expenditures are difficult to measure and obtain data in existing databases. Both the explanatory variables and explained variables are in logarithmic form. Based on available data, referring to related studies on factors that influence household spending decisions (39),  $X$  is a series of control variables. Such as age, gender, health level, smoking, marital, medical insurance, household registration, household size.  $\mu_i$  is the individual effect,  $\varepsilon_{it}$  is the disturbance term.

To test H2, the following fixed effects model is constructed as benchmark regression. Furthermore, the samples are grouped based on the relative poverty identification standard above. The heterogeneity of the impact of public health expenditures on different types of household medical expenditures is examined. The specific standard for sample grouping is determined using the threshold value  $\gamma^*$  in Model 1.

The benchmark regression model is as follows:

$$ME_{iyt} = \delta_1 PHE_{iyt} + \delta X + \mu_y + \varepsilon_{iyt} \quad (\text{Model 2})$$

4 The main reason for selecting 1/3 of the *per capita* disposable income as the basis for delimitation is that currently, the World Bank regards social members whose income is lower than 1/3 of the average social income as relative poverty people. In addition, in some provinces in China that have already defined a relative poverty line, such as Zhejiang, Fujian, the identification standard is also basically based on 1/3 of the *per capita* income of households.

5 This indicator mainly includes the self paid portion of household medical expenditures, excluding expenditures that have been reimbursed and are expected to be reimbursed, but includes the portion lent or paid by relatives and friends.



The explained variable  $ME_{ijt}$  is still the medical expenditures of household  $i$  in year  $t$ , and the core explanatory variable  $PHE_{ijt}$  is the public health expenditure of province  $y$  where household  $i$  is located in year  $t$ , measured by “*per capita* government health expenditures.” Both explanatory variables and explained variables are in logarithmic form.  $\delta_1$  represents the impact of public health expenditures on household medical expenditures. Control variables  $X$  includes all the control variables in Model 1 in addition to macro indicators such as regional GDP *per capita* and other indicators that can represent the local medical service level of province  $y$ .  $\mu_y$  is the regional effect,  $\varepsilon_{ijt}$  is the disturbance term.

Furthermore, this paper introduces “the sum of healthcare expenditures of household  $i$  in the past 12 months” in Model 2 as a substitute variable for the explained variable  $ME_{ijt}$ . In the database, household healthcare expenditures measure the consumption of fitness exercise and purchasing related products, equipment, healthcare products, etc. Compared with household medical expenditures, household healthcare expenditures can reflect a household’s medical and health needs at a higher level.

Finally, to eliminate possible endogeneity in the model, this paper uses the two-stage least squares method (2SLS) to estimate the relationship between public health expenditure and household medical expenditure. Due to the strong subjective purpose of some macro policies, they can also affect the current household medical expenditure while affecting the public health expenditure. With reference to similar researches (40, 41), this paper takes the “*per capita* government health expenditures of each province in the previous year” as the Instrumental variables estimation. There is reason to believe that the level of government health investment during a certain period is continuous, and there is a high correlation between *per capita* government health expenditure in adjacent periods. And because it is a predetermined variable that has already occurred in the previous period, and its value is fixed from the perspective of the current period, it can be considered unrelated to the disturbance term in the current period. Model 3 and Model 4 are the first and second stage estimation models of 2SLS, respectively, and focus on the sign and significance of  $\theta_1$  in Model 4.

$$PHE_{ijt} = \eta_1 PYPHE_{ijt} + \eta X + \mu_y + \varepsilon_{ijt} \quad (\text{Model 3})$$

$$ME_{ijt} = \theta_1 \overline{PHE}_{ijt} + \theta X + \mu_y + \varepsilon_{ijt} \quad (\text{Model 4})$$

## Dataset

This paper takes Chinese households as the research sample. The micro data used is derived from panel data from the China Family Panel Studies (CFPS), which was released by the China Social Science Survey Center of Peking University in 2016, 2018, and 2020. The main reason for choosing this database is that it involves micro level data from individuals, households, and communities, providing rich information about public health conditions and residents’ consumption, and vividly depicting changes in health and social welfare. The macro data on public health expenditure and so on in various provinces are from the China Health Statistical Yearbook and

China Statistical Yearbook of each year. During the analysis process, expenditure variables were deflated using 2016 as the benchmark, and values were assigned at the micro level based on the province where the household locates. For the processing of outliers, this article intercepts the data between the upper and lower 1% quantiles of the relevant variables for sampling.

## Results

### Descriptive statistics

Table 1 shows the results of the data descriptive analysis. From the perspective of household level, the *per capita* disposable income of Chinese households continued to grow from 2016 to 2020. As two important large rigid expenditures, household expenditures on medical and education accounted for 8.52% and 6.65% of total household disposable income in 2020. If only the income dimension relative poverty sample is considered, the total proportion of the two types of expenditures is close to 50%. The higher proportion of two expenditures also lays the foundation for this paper to determine the relative poverty standard. In addition, the consumption gap between households is continuing to widen. Due to the impact of household essential medical expenses and severe illness shocks, the standard deviation of household medical expenses is greater, and household education expenditures are more rigid. In addition, the noteworthy indicator is “medical insurance.” The average value in 2016 was 0.93, indicating that 93% of the samples have medical insurance, reflecting the significant increase in medical insurance coverage since the implementation of China’s “new medical reform” policy, which also provides protection for the release of household medical needs. From the perspective of macro data, *per capita* government health expenditure continued to increase from 2016 to 2020, but the investment gap between provinces continued to widen. The *per capita* government health expenditure has increased by about 493 yuan. Government investment is playing an increasingly important role in the entire health system. From the perspective of medical service level, the number of hospital personnel per 10,000 people and the number of beds in medical institutions per 10,000 people have also increased significantly, but the standard deviation between provinces has also expanded, and the horizontal fairness of public health services needs to be strengthened.

### Relative poverty standard measurement from the perspective of household medical needs

Table 2 shows the regression results for the panel threshold model. The regression process is divided into two steps. The first step is the threshold effect test, that is, the number of thresholds is determined, and then, the model form is determined. The second step is a test of the estimated threshold value. In the first step, Model 1 is estimated under the settings of a single threshold and double threshold. The obtained  $F$  statistics are shown in Table 2. The results indicate that the  $F$ -statistic of the single-threshold test is 19.77 and that the single-threshold effect is rejected at the 1% significance level. The  $F$ -statistic of the double-threshold test is 6.20 and not significant, i.e., no

TABLE 1 Descriptive statistics.

Year	Variables		
	2016	2018	2020
	Mean (standard deviation)	Mean (standard deviation)	Mean (standard deviation)
Household medical expenses (yuan)	5350.19 (13438.54)	5828.46 (15170.11)	6236.90 (16887.40)
Household education expenditure (yuan)	4459.66 (6224.68)	5163.86 (7020.78)	5529.73 (7413.57)
<i>Per capita</i> disposable income of households (yuan)	22109.13 (31554.08)	25959.28 (35409.36)	27682.28 (38981.32)
Age	47.24 (14.02)	49.15 (14.08)	51.15 (14.08)
Gender (male = 1, female = 0)	0.51 (0.49)	0.52 (0.49)	0.52 (0.49)
Health level (from 0 to 5, the higher the value, the worse the health level)	3.04 (1.20)	3.08 (1.20)	3.04 (1.21)
Marital status (married = 1, unmarried = 0)	0.82 (0.35)	0.82 (0.36)	0.82 (0.35)
Household register (rural = 1, urban = 0)	0.73 (0.42)	0.72 (0.44)	0.72 (0.44)
Household size	3.69 (1.89)	3.55 (1.88)	3.71 (1.88)
Medical insurance (yes = 1, no = 0)	0.93 (0.25)	0.93 (0.24)	0.93 (0.26)
Smoking (yes = 1, no = 0)	0.28 (0.45)	0.29 (0.45)	0.28 (0.45)
<i>Per capita</i> public health expenditure (yuan)	972.42 (264.46)	1121.66 (317.49)	1465.18 (410.69)
<i>Per capita</i> GDP (yuan)	52259.73 (23782.56)	60544.65 (27505.64)	65365.45 (30028.97)
Number of hospital personnel per 10,000 people	82.73 (12.85)	90.54 (13.42)	95.54 (14.51)
Number of beds in medical institutions per 10,000 people	53.59 (6.91)	59.88 (8.09)	64.84 (8.74)

threshold effect. Therefore, there is a single threshold in the model setting. Regarding the 95% confidence interval threshold, the estimated value of the single threshold is 0.5807, that is, the *per capita* disposable income of the household accounts for 58.07% of one-third of the *per capita* disposable income of the province where the household is located. In the second step of the threshold test, the threshold value is estimated. The regression results for each variable are shown in Table 2. Because a single threshold is accepted as the setting, the regression results in the second column of Table 2 are pertinent. The relationship between household education expenditures and medical expenditures is significantly different around the first threshold  $\gamma_1$ . When the threshold variable value is less than  $\gamma_1$ , there is a significant negative relationship between the two expenditures at the 1% significance level. When the threshold variable value is more than  $\gamma_1$ , there is a significant positive relationship between the two expenditures at the 1% significance level. The crowding out effect between the two disappears, and parallel growth characteristics appear instead.

To test whether the estimated threshold value  $\gamma_1$  is consistent with the true value, we drew a threshold effect test LR function diagram. The dashed line in Figure 2 represents a confidence value of 7.35 at the 5% significance level, while the solid line represents the likelihood ratio statistic LR of the threshold variable. When LR is equal to 0, the threshold estimate value can be obtained. In Figure 2, it can be seen that the threshold value  $\gamma_1$  obtained in this paper exactly matches the corresponding value of the lowest point of the solid line. At the same time, the areas below the intersection of the solid and dashed lines fall within the 95% confidence interval of  $\gamma_1$ , indicating that the estimated threshold value  $\gamma_1$  is consistent with the true value.

Therefore, we propose that the threshold variable should be 0.5807. Because households below this standard cannot meet their medical needs or have rigid expenditure vulnerabilities from the perspective of medical needs, 58.07% of one-third of the province's *per capita* disposable where the household is located should be considered as relative poverty standard under the perspective of household medical needs.<sup>6</sup>

Regarding the regression results for the other variables in column 2 of Table 2, we focus on two variables: the health level and medical insurance of householder. The poorer is the health level of the householder, the more household medical expenses. Due to the lower threshold of medical insurance reimbursement and the increase in the reimbursement ratio, participating in medical insurance will significantly increase household medical expenses.

## The heterogeneous relationship between public health expenditures and household medical expenditures

Table 3 shows the regression results for Model 3. For the total sample (column 2 of Table 3), an increase in public health expenditures will increase household medical expenditures at the 10% significance level,

<sup>6</sup> The standard can also be expressed as 19.36% of the province's *per capita* disposable where the household is located.

TABLE 2 Panel threshold regression results.

	Single threshold	Double threshold
Threshold value	$\gamma_1 = 0.5807$	$\gamma_1 = 0.5807$ $\gamma_2 = 0.1321$
F	19.77***	6.20
Household medical expenses ( $I_{it} < \gamma_1$ )	-0.0615*** (0.0223)	-0.0709*** (0.0205)
Household medical expenses ( $\gamma_1 \leq I_{it} \leq \gamma_2$ )	0.0714*** (0.0218)	0.0065 (0.225)
Household medical expenses ( $I_{it} > \gamma_2$ )		0.0711*** (0.0218)
Age	-0.0956*** (0.0237)	-0.0982*** (0.0237)
Gender	0.3719 (1.9528)	0.3830 (1.9522)
Health level	0.1330*** (0.0510)	0.1346*** (0.0510)
Marital status	0.7381** (0.3628)	0.7251** (0.3628)
Household register	0.0090 (0.0315)	0.0094 (0.0315)
Household size	0.0756 (0.0529)	0.0795 (0.0529)
Medical insurance	0.4801*** (0.1780)	0.4851*** (0.1780)
Smoking	-0.1571 (0.2442)	-0.1589 (0.2441)
Intercept term	10.3596*** (1.7323)	10.4903*** (1.7336)
N	3,189	3,189
Adjusted R <sup>2</sup>	0.2015	0.2026

(1) The brackets are heteroscedasticity robust standard errors. (2) \*, \*\* and \*\*\* are statistically significant at the significance levels of 10%, 5% and 1%, respectively.

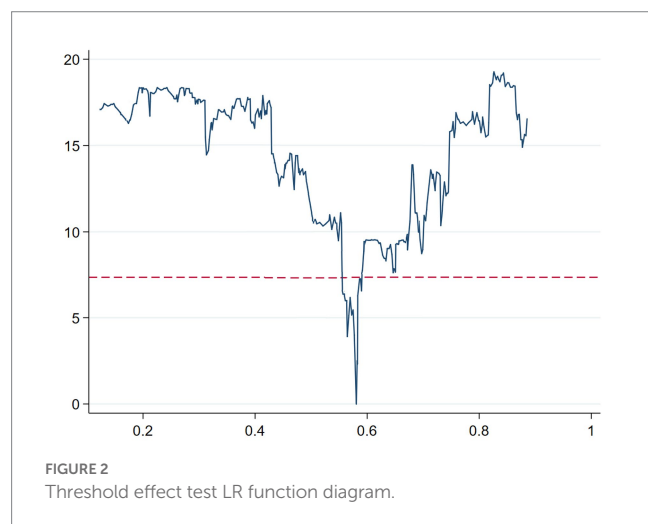


FIGURE 2  
Threshold effect test LR function diagram.

and public health expenditures have a crowding-in effect on household medical expenditures. This result indicates that with the continuous increase in Chinese government medical expenditures since the “new medical reform” policy, the supply of medical resources has increased, and the availability of medical services has improved. Additionally, government subsidies, expanding medical insurance coverage and the reimbursement ratio have lowered the threshold for seeing a doctor and eased the medical needs of households to a certain extent. The past predicament of “do not dare to seek medical treatment” caused by a household’s economic capacity limitations has improved.

The samples are grouped into relative poverty households and ordinary households from the perspective of household medical

needs. The regression results (columns 3–4 in Table 3) indicate that the crowding-in effect of public health expenditures on the medical expenditures of relative poverty households is significant at the 5% level; importantly, the impact on ordinary households is small and nonsignificant. We use the Fisher combination test to perform a significance test on the differences in coefficients between two types of households. It can be seen that the empirical  $p$ -value obtained based on the core explanatory variable regression coefficient is 0.008, indicating that the heterogeneity of the relationship between public health expenditures and household medical expenditures is significant at the 1% significance level. This is consistent with H2. During the transition from low to high income, due to the large gap in the basic medical needs of relative poverty households, the consumption of medical services and drugs is largely constrained by income. The government’s investment in basic health services and health care coverage has eased the income constraints for relative poverty households to access health care and has a strong crowding-in effect. For ordinary households, especially high-income households, the basic medical needs have been met, and more emphasis is placed on the consumption of high-quality, high-level healthcare products and services. This cannot stimulate an increase in medical consumption, and the crowding-in effect is weak.

The regression results for other variables are not significantly different among the three samples. Taking the regression results for relative poverty households as an example, age, health level, marital status and medical insurance all significantly increase the level of household medical expenditures. The household medical expenditures of rural residents are significantly lower than that of urban residents. Participating in medical insurance significantly increases the medical expenditure level of relative poverty households; however, this variable is not significant for ordinary households. This, to some extent, illustrates the stronger impact of public health expenditures on the medical needs of relative poverty households. Among the macro variables, the number of hospital personnel and beds in medical institutions per 10,000 people has a significant positive effect in the full sample and ordinary households, the others are not significant. This finding indicates that at the household level, especially for relative poverty households, macro factors such as economic development and medical services have little impact on household medical expenditures and that the level of household medical expenditures is more limited by household income, health status and financial security.

The above perspective is supported by the regression results (columns 5–7 in Table 3) with “household healthcare expenditures” as the explained variable. The impact of public health expenditures on household healthcare expenditures is negative and not significant. This finding indicates that the increase in the supply of medical services cannot significantly effect household healthcare consumption. The protection of public health expenditures for household medical needs is more reflected in basic medical services, for the higher-level healthcare needs of households, the effect of financial expenditures is not obvious. High-level medical needs are more limited by the environment and economic development level where the household is located. The coefficient of household register and *per capita* GDP are significant.

Finally, from the regression results of the 2SLS model (columns 2–4 in Table 4), the impact of *per capita* government health expenditures on household medical expenditures is slightly larger than that calculated using Model 3 but remains stable. There is a

TABLE 3 Fixed effects regression results.

Variables	Model					
	“Household medical expenses” as the explanatory variable			“Household healthcare expenditure” as the explanatory variable		
	All Sample	Relative poverty households ( $I_{it} \leq 0.5807$ )	Ordinary households ( $I_{it} > 0.5807$ )	All Sample	Relative poverty households ( $I_{it} \leq 0.5807$ )	Ordinary households ( $I_{it} > 0.5807$ )
<i>Per capita</i> public health expenditure	0.1727* (0.1016)	0.2,606** (0.1448)	0.1686 (0.1054)	−0.2418 (0.2207)	−0.1139 (0.6842)	−0.2436 (0.2216)
Age	0.0329*** (0.0114)	0.0424*** (0.0010)	0.0358*** (0.0121)	0.0262 (0.0295)	−0.0074 (0.0672)	0.0323 (0.0296)
Gender	0.0114 (0.3493)	0.0215 (0.4775)	0.1792 (0.3648)	0.3263 (0.6360)	0.1737 (1.8931)	0.3456 (0.6317)
Health level	0.0942*** (0.0093)	0.1477*** (0.0368)	0.0919*** (0.0103)	0.0564** (0.0281)	−0.0790** (0.0387)	0.0493* (0.0284)
Marital status	0.3186*** (0.0569)	0.3150*** (0.0619)	0.2898 (0.2521)	0.0844 (0.1409)	0.0016 (0.2648)	0.1057 (0.1408)
Household register	−0.0026 (0.0044)	−0.1134* (0.0673)	−0.0013 (0.0045)	−0.2055*** (0.0106)	−0.1405 (0.0916)	−0.1978*** (0.0106)
Household size	0.1185*** (0.0089)	0.0542 (0.0475)	0.1348*** (0.0099)	0.0511* (0.0286)	0.0056 (0.0491)	0.0333 (0.0290)
Medical insurance	0.0598* (0.0353)	0.1959* (0.1152)	0.0493 (0.0387)	0.1785* (0.0965)	0.1504 (0.1372)	0.1693* (0.0971)
Smoking	−0.1812*** (0.0434)	−0.4083** (0.1696)	−0.1432*** (0.0479)	−0.2233* (0.1222)	−0.0113 (0.1750)	−0.2584** (0.1245)
<i>Per capita</i> GDP	0.0038 (0.0868)	0.3426 (0.4840)	−0.0212 (0.0916)	0.4507* (0.2361)	0.3384 (0.4815)	0.5067** (0.2357)
Number of hospital personnel per 10,000 people	0.0066** (0.0027)	0.0067 (0.0168)	0.0058** (0.0029)	−0.0035 (0.0062)	−0.0033 (0.0179)	−0.0054 (0.0062)
Number of beds in medical institutions per 10,000 people	0.0088*** (0.0032)	0.0148 (0.0192)	0.0079** (0.0034)	0.0064 (0.0077)	−0.0287 (0.0193)	0.0074 (0.0078)
Intercept term	3.5006*** (0.9064)	5.4826 (5.0021)	7.3455*** (0.9509)	1.6907 (2.301)	−3.1082 (5.0479)	1.0244 (2.2951)
Regional fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
<i>N</i>	19,152	3,441	15,711	3,783	246	3,537
Adjusted <i>R</i> <sup>2</sup>	0.3501	0.2808	0.3402	0.2135	0.1773	0.20896
The empirical <i>p</i> -value		0.008***			0.226	

(1) The brackets are heteroscedasticity robust standard errors. (2) \*, \*\* and \*\*\* are statistically significant at the significance levels of 10%, 5% and 1%, respectively. (3) The empirical *p*-value is calculated using Fisher combination test (bootstrap 1,000 times).

crowding-in effect of government health expenditure on household medical expenditures, and it is stronger for relative poverty households. The Fisher combination test indicates that this difference between two groups is statistically significant at the 10% significance level. The  $\chi^2$  value of the *C* statistic of the endogeneity test and the *F* value of the Cragg–Donald Wald statistic of the weak instrumental variable test are both statistically significant at the 1% level, indicating that *per capita* government health expenditures are endogenous and that the instrumental variable used in this paper is not weak.

## Conclusions and implications

### Conclusion

On the basis of the characteristics of relative poverty caused by household medical needs, this paper uses the China Family Panel Studies (CFPS) from 2016 to 2020 to identify relative poverty standard, analyzes the impact of public health expenditures on medical expenditures of different household types, and evaluates the heterogeneous effect of public health expenditures on ensuring the medical needs of relative poverty

TABLE 4 2SLS regression results.

Variables	Model		
	All sample	Relative poverty households ( $I_{it} \leq 0.5807$ )	Ordinary households ( $I_{it} > 0.5807$ )
<i>Per capita</i> public health expenditure	0.2226* (0.1333)	0.3087* (0.1784)	0.1863 (0.1194)
Control variables	Yes	Yes	Yes
N	19,152	3,441	15,711
Endogeneity test	26.38**	14.52***	22.26***
Weak identification test	16.96***	12.45***	15.22***
The empirical <i>p</i> -value	0.086*		

(1) The endogenous test reports the *C* statistic (Chi<sup>2</sup> value), and the weak instrumental variable test reports the Cragg–Donald Wald statistic (*F* value). (2) \*, \*\* and \*\*\* are statistically significant at the significance levels of 10%, 5% and 1%, respectively. (3) The empirical *p*-value is calculated using Fisher combination test (bootstrap 1,000 times).

households. The panel threshold regression results show that 19.36% of the province's *per capita* disposable income where the household is located is the identification standard of relative poverty households from the perspective of medical needs. Public health expenditures have a crowding-in effect on household medical expenditures and have a stronger impact on relative poverty households, an effect that is also confirmed by 2SLS regression. In addition, ensuring household medical needs through public health expenditures focuses on the level of basic medical needs, and the role of household healthcare expenditures that reflect high-level medical needs are not obvious.

## Implications and policy-making

In the future, to further improve the ability of households to cope with the risk of large rigid expenditures, and improve the efficiency of public health investment allocation, this paper proposes the following suggestions.

Firstly, a monitoring mechanism for relative poverty households should be established from the perspective of medical needs. There is no unified identification standard or measurement method for relative poverty households currently. For the formulation of the identification standard in this paper, the large rigid expenditures for medical and education by households are included in the analysis. The indicator is multidimensional and can be adjusted according to the household income and expenditure level. In the future, with continuous improvements in medical security policies, we can use the construction idea of this indicator to establish a dynamic monitoring mechanism for relative poverty households and include low-income and vulnerable groups with medical needs in the assistance and security system. This will improve the accuracy of the objective identification for relative poverty households.

Secondly, attention should be given to ensuring the basic medical needs of relative poverty households. According to Wagner's Law, rigid expenditures can only continue to grow with social development. At present, relative poverty households have a higher vulnerability in maintaining large rigid household expenditures, and public health expenditures have a stronger crowding in effect on relative poverty households. This indicates that the basic medical needs of relative poverty households are still strong. Therefore, attention should be given to ensuring the basic medical needs of relative poverty households. The government needs to further increase investment in medical insurance, continuously improve the level of medical security,

and reduce the medical burden of relative poverty households through transfer payments, medical assistance, special subsidies, etc. Avoid the phenomenon of returning to absolute poverty due to illness.

Thirdly, efforts should be made to clarify the heterogeneity among different types of households, provide targeted public health services. The conclusion indicates that the medical needs of relative poverty households and ordinary households are significant heterogeneous. The release effect of public health expenditures on relative poverty households' medical needs is stronger, while the guarantee effect on public's high-level medical needs is not significant. The government can encourage social forces to intervene, improve the competitiveness of the public health service market, enrich the supply types of public health services, and meet the differentiated healthcare needs of different income groups.

## Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: [<http://www.issp.pku.edu.cn/cfps/index.htm>].

## Author contributions

ZL: conceptualization, methodology, and writing-original draft preparation. XY: formal analysis, data collection, and processing. ZZ: formal analysis and validation. YC: translation polishing, editing, writing-review, and supervision. All authors contributed to the article and approved the submitted version.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.



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## References

- Wan G, Hu X, Liu W. China's poverty reduction miracle and relative poverty: focusing on the roles of growth and inequality. *China Econ Rev.* (2021) 68:101643. doi: 10.1016/j.chieco.2021.101643
- Fan Z, Zou W. A three-component decomposition of the change in relative poverty: an application to China. *Land.* (2023) 12:205. doi: 10.3390/land12010205
- Fang Y, Zhang F. The future path to China's poverty reduction-dynamic decomposition analysis with the evolution of China's poverty reduction policies. *Soc Indic Res.* (2021) 158:507–38. doi: 10.1007/s11205-021-02716-5
- Zhang X, Luo Y, Chen W. Relative acquisition evaluation of health poverty alleviation project: a quantitative study of data from different regions of China. *BMC Public Health.* (2022) 22:2204. doi: 10.1186/s12889-022-14703-7
- Pu X, Wang Y, Zhang W, Zeng M. Can basic medical insurance reduce elderly family income inequality in China? *Front Public Health.* (2022) 10:838733. doi: 10.3389/fpubh.2022.838733
- Alkire S, Foster J. Counting and multidimensional poverty measurement. *J Public Econ.* (2007) 95:476–87. doi: 10.1016/j.jpubeco.2010.11.006
- Martin R, Chen S. Global poverty measurement when relative income matters. *J Public Econ.* (2019) 177:104046. doi: 10.1016/j.jpubeco.2019.07.005
- Gustafsson B, Sai D. Growing into relative income poverty: urban China, 1988–2013. *Soc Indic Res.* (2020) 147:73–94. doi: 10.1007/s11205-019-02155-3
- Yang X, Hung K. Poverty alleviation via tourism cooperatives in China: the story of Yuhu. *Int J Contemp Hosp Manag.* (2014) 26:879–06. doi: 10.1108/IJCHM-02-2013-0085
- Yang YN, Williamson JB, Shen C. Social security for China's rural aged: a proposal based on a universal non-contributory pension. *Int J Soc Welfare.* (2010) 19:236–45. doi: 10.1111/j.1468-2397.2009.00658.x
- Au A. Reassessing the econometric measurement of inequality and poverty: toward a cost-of-living approach. *Humanit Soc Sci Commun.* (2023) 10:228. doi: 10.1057/s41599-023-01738-3
- Meng L. Evaluating China's poverty alleviation program: a regression discontinuity approach. *J Public Econ.* (2013) 101:1–11. doi: 10.1016/j.jpubeco.2013.02.004
- Dong Y, Jin G, Deng X, Wu F. Multidimensional measurement of poverty and its spatio-temporal dynamics in China from the perspective of development geography. *J Geogr Sci.* (2021) 31:130–48. doi: 10.1007/s11442-021-1836-x
- He J, Zhu Q. Empirical analysis on the influencing factors of relative poverty of rural migrants in the three gorges area—based on the survey of Hubei reservoir area. *Surv World.* (2016) 10:23–7. doi: 10.13778/j.cnki.11-3705/c.2016.10.005
- Zhang W, Su D. An empirical analysis on the influencing factors of relative poverty of residents in mega cities—based on the research of Beijing, Shanghai and Guangzhou. *J CCPS.* (2020) 3:100–9. doi: 10.14119/j.cnki.zgxb.2020.03.013
- Ravallion M. On measuring global poverty. *Annu Rev Econ.* (2020) 12:167–88. doi: 10.1146/annurev-economics-081919-022924
- Li Z, Wang X, Chu Y. Health shocks and household education burden—a study from the perspective of relative poverty alleviation in China. *Front Public Health.* (2022) 10:877052. doi: 10.3389/fpubh.2022.877052
- Xu L, Deng X, Jiang Q, Ma F. Identification and alleviation pathways of multidimensional poverty and relative poverty in counties of China. *Acta Geograph Sin.* (2021) 6:1715–36. doi: 10.1007/s11442-021-1919-8
- Luo M, Liu Z, Guo R. Cooperative participation, social capital accumulation, and relative poverty alleviation of farmers: from the perspective of farmers' participation in professional cooperatives. *Res Agric Mod.* (2021) 5:930–40. doi: 10.13872/j.1000-0275.2021.0070
- Khaled N. Poverty-alleviation programs in Tunisia: selection processes and targeting performance indicators at the regional level. *Int J Soc Econ.* (2022) 49:629–50. doi: 10.1108/IJSE-03-2021-0157
- Bibi S, Duclos JY. Equity and policy effectiveness with imperfect targeting. *J Dev Econ.* (2007) 1:109–40. doi: 10.1016/j.jdevco.2005.12.001
- Murthy NR, Ukpolo V. Aggregate health care expenditure in the United States: evidence from cointegration test. *Appl Econ.* (1994) 26:797–02. doi: 10.1080/00036849400000094
- Kumara AS, Samarasinghe R. Impact of ill-health on household consumption in Sri Lanka: evidence from household survey data. *Soc Sci Med.* (2017) 195:68–76. doi: 10.1016/j.socscimed.2017.11.015
- Maingi JN. The impact of government expenditure on economic growth in Kenya: 1963–2008. *Adv Econ Bus.* (2017) 12:635–62. doi: 10.13189/aeb.2017.051201
- Catto JWF. Health care spending, social policy, public health, and life expectancy: what cancer outcomes can tell us beyond treatment efficacy. *Eur Urol.* (2011) 60:16–8. doi: 10.1016/j.eururo.2011.04.004
- Long Q, Xu L, Bekedam H. Changes in health expenditures in China in 2000s: has the health system reform improved affordability. *Int J Equity Health.* (2013) 12:40. doi: 10.1186/1475-9276-12-40
- Dieleman JL, Baral R, Birger M, Bui AL, Bulchis A, Chapin A, et al. US spending on personal health care and public health, 1996–2013. *JAMA.* (2016) 316:2627–46. doi: 10.1001/jama.2016.16885
- Wagstaff A, Lindelow M, Jun G, Xu L, Qian J. Extending health insurance to the rural population: an impact evaluation of China's new cooperative medical scheme. *J Health Econ.* (2009) 28:1–19. doi: 10.1016/j.jhealeco.2008.10.007
- Pu X, Zeng M, Luo Y. The effect of business cycles on health expenditure: a story of income inequality in China. *Front Public Health.* (2021) 9:653480. doi: 10.3389/fpubh.2021.653480
- Loughnane C, Murphy A, Mulcahy M, McInerney C, Walshe V. Have bailouts shifted the burden of paying for healthcare from the state onto individuals. *Irish J Med Sci.* (2019) 188:5–12. doi: 10.1007/s11845-018-1798-x
- Choi R, Kang H. Medical expenditures and its determinants depending on receipt of public pension in South Korea. *Medicine.* (2019) 28:e16294. doi: 10.1097/MD.00000000000016294
- Stavroula Z, Stamatina H. Households health expenditure in interannual correlation with public health expenditure in Greece. *Front Public Health.* (2020) 8:448. doi: 10.3389/fpubh.2020.00448
- Behera DK, Dash U. Is health expenditure effective for achieving healthcare goals? Empirical evidence from South-East Asia Region. *Asia-Pac J Reg Sci.* (2020) 4:593–618. doi: 10.1007/s41685-020-00158-4
- Schultz TW. *Education and economic growth.* Chicago: University of Chicago Press (1961).
- Becker GS. Investment in human capital: a theoretical analysis. *J Polit Econ.* (1962) 70:9–49. doi: 10.1086/258724
- Verguet S, Memirie ST, Norheim OF. Assessing the burden of medical impoverishment by cause: a systematic breakdown by disease in Ethiopia. *BMC Med.* (2016) 14:164–75. doi: 10.1186/s12916-016-0697-0
- Hansen BE. Threshold effects in non-dynamic panels: estimation, testing and inference. *J Econ.* (1999) 2:345–68. doi: 10.1016/s0304-4076(99)00025-1
- Meng H. Research on consumption behavior difference of urban and rural residents in China. *Stat Res.* (2016) 10:78–85. doi: 10.19343/j.cnki.11-1302/c.2016.09.010
- Brown S, Gray D, Harris MN, Spencer C. Household portfolio allocation, uncertainty, and risk. *J Empir Finance.* (2021) 63:96–117. doi: 10.1016/j.jempfin.2021.05.004
- Gancia EG. Trade, markup heterogeneity and misallocations. *J Int Econ.* (2011) 83:1–13. doi: 10.1016/j.jinteco.2010.10.005
- Zhao X, Zhu R. The digital economy and informal employment: an empirical study based on the dynamic survey of China's labor force. *Jilin Univ J Soc Sci Ed.* (2022) 5:72–83. doi: 10.15939/j.jusjse.2022.05.sh2



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# Economic uncertainty and population health: insights from emerging markets and developing countries

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This study employs a Bayesian panel vector autoregressive model to examine the impact of economic uncertainty on public health, using an annual, country-level panel dataset of 103 emerging markets and developing countries spanning the years 1995 through 2019. The results from the full sample suggest that the immediate effects of heightened economic uncertainty on health are marginal, yet it may engender prolonged life expectancy and lowered mortality rates. The analysis unveils considerable heterogeneities among various country classifications. The health-enhancing effects of economic uncertainty are predominantly discernible in emerging markets, low-income and upper-middle-income countries. Additionally, a diminution in suicide rates, attributed to escalated economic uncertainty, is uniquely detected in upper-middle-income countries. Furthermore, economic growth and healthcare expenditure emerge as paramount determinants in bolstering overall population health, particularly in lower-middle-income countries. The detrimental effect of environmental pollution on health is more pronounced in emerging markets and middle-income nations. Excluding high-income countries, it is essential to emphasize the beneficial health outcomes resulting from financial development and globalization, as well as the deleterious effects of environmental pollution. Lastly, several policy implications aligned with the findings are outlined, providing a roadmap for decision-makers in these diverse economies to promote better health outcomes.

## KEYWORDS

economic uncertainty, health, emerging markets, developing countries, Bayesian panel vector autoregressive model JEL I150, C59, E66

## 1. Introduction

As reported by the World Health Organization (1), significant strides in global human development, particularly in health status, were observed before 2020. The worldwide average life expectancy at birth, a well-recognized indicator of population health, rose from 52.58 years in 1960 to 72.74 years in 2019. Fascinatingly, emerging markets and developing countries experienced a remarkable life extension of approximately 25 years. These advancements in health primarily mirror the progress made in reducing child mortality rates and combating infectious diseases (2), subsequently sparking burgeoning interests in investigating the impact of economic activity on population health, particularly within emerging markets and developing countries.

Since late 2019, the world has been grappling with the COVID-19 pandemic for nearly 3 years. This period has seen two striking phenomena: the pandemic has not only wheeled up economic uncertainty to unprecedented levels but also posed a profound threat to public health.



The World Uncertainty Index (WUI) and the Global Economic Policy Uncertainty Index (GEPU), two prominent measures of economic uncertainty developed by Ahir et al. (3) and Baker et al. (4), respectively, reached record highs in early 2020, coinciding with the global spread of the pandemic. Concurrently, COVID-19 became a leading cause of worldwide death and has remarkably shortened life expectancy in many countries (1). Increased anxiety, depression, and other harmful health behaviors have been monitored during the COVID-19 pandemic (5–7). Besides its direct epidemiological damage, the pandemic could indirectly impact population health through heightened economic uncertainty, which is known to sway economic activities.

While previous studies have substantiated the roles of the macroeconomy in population health, the effects of economic uncertainty—a principal source of economic disturbances (8)—on population health are not fully understood. Recent studies have attempted to probe the aftermath of economic uncertainty on mental health indicators, but a comprehensive understanding of its role in public health remains elusive. For instance, the evidence by Antonakakis and Gupta (9), Vondoros et al. (10), Abdou et al. (11), Abdou et al. (12), and Claveria (13) suggests that spikes in economic uncertainty may contribute to human mental disorders and suicides. Kalcheva et al. (14) argue that economic uncertainty can lead to unhealthy lifestyle habits. Furthermore, Vondoros et al. (15) posit that excessive mental strain and poor lifestyle habits induced by heightened economic uncertainty may increase the occurrence of accidents.

However, the health outcomes of economic uncertainty are not unequivocal. On the one hand, increased economic uncertainty would diminish household income and exacerbate income unpredictability, significantly undermining public well-being and daily-life happiness (16). Anxiety, worry, and even depression stemming from economic uncertainty might drive individuals to adopt lousy lifestyle choices (14), further impairing their physical health. Additionally, under heightened economic uncertainty, households and governments might be motivated to cut healthcare spending, which could negatively impact public health. On the other hand, following spikes in economic uncertainty, investment and industrial production declines could potentially reduce the incidence of industrial accidents and pollutant emissions, yielding beneficial repercussions for public health. Crucially, whether and how economic uncertainty impacts public health is still unclear in the literature related to health topics. Against these backdrops, this paper aims to bridge this gap in the literature by exploring the general health outcomes of economic uncertainty through a cross-country lens.

Notably, I emphasize emerging markets and developing countries (hereafter EMDCs). The reasons are threefold. First, compared to developed countries, these nations are more susceptible to internal and external shocks (17) because of imperfect economic and financial systems. Second, uncertainty shocks may trigger more substantial macroeconomic declines in EMDCs (18), resulting in more significant health deterioration consequentially due to inadequate medication and modern medical infrastructure in these countries (19). Third, given that the epicenter of the COVID-19 pandemic has been dramatically shifting to EMDCs (1), exploring the health impact of uncertainty shocks in these countries can help governments better understand the determinants of population health, particularly health

dynamics under elevating economic uncertainty, and subsequently narrow the health gap among countries.

To my knowledge, this study presents the first comprehensive examination of the linkages between economic uncertainty and public health. Understanding the endogenous relationships between population health and the macroeconomy is essential as they are inextricably connected. Moreover, the macroeconomy predominantly functions as a dynamic system with interacting and interdependent economic variables. As such, addressing the features of endogeneity is critical when examining the connections between health and the macroeconomy. In this study, I first disentangle the theoretical linkages between economic uncertainty and population health by discussing four channels through which economic uncertainty could affect population health. Given the theoretical analysis and recognizing the interconnectedness of population health and the macroeconomy, I then apply the Bayesian panel vector autoregressive (BPVAR) model proposed by Beetsma et al. (20) to a well-assembled annual panel dataset of 103 EMDCs from 1995 to 2019 to implement the empirical investigation.

The empirical findings from the whole sample show that, in EMDCs, the effects of heightened economic uncertainty on public health are relatively marginal and less perceptible in the short term. A transient beneficial impact on health, evident in prolonging life expectancy and reducing aggregate mortality rates, emerges from rising economic uncertainty. However, surges in economic uncertainty may considerably curtail life expectancy and raise mortality rates, while paradoxically lowering suicide rates in the long term. This finding remains robust across different model specifications, including VAR lag length and model dimensionality. Economic growth and healthcare expenditure emerge as salient factors augmenting overall population health in EMDCs, with additional verification of the health-promoting influences of financial development and globalization. The detrimental health effects induced by environmental pollution are also accentuated.

Further, the subsample analysis uncovers significant heterogeneities among distinct categorizations of the sample countries, providing additional empirical evidence on uncertainty–health relations. Concentrating on life expectancy, aggregate mortality, and child mortality, the results disclose that the health-enhancing effects of economic uncertainty are more conspicuous in emerging markets, low-income and upper-middle-income countries. Notably, surges in economic uncertainty may precipitate elevated child mortality rates in high-income and lower-middle-income countries. The positive impacts of healthcare expenditure on health are reaffirmed, with more noticeable health gains from healthcare expenditure in developing, low-income, and lower-middle-income countries. The beneficial health outcomes associated with economic growth are more emphatic in lower-middle-income countries but are fleeting and negligible in low-income countries.

Conversely, high-income countries may experience health deterioration alongside economic growth. The pernicious effects of environmental pollution on health are solely discernible in emerging markets, lower-middle-income, and upper-middle-income countries. Financial development has no apparent impact on health in developing and high-income countries, while the significant salutary effects of globalization are observed in all nation classifications except high-income countries. A substantial decline in suicide rates following rising economic uncertainty shocks is

exclusively evident in upper-middle-income countries. Increased economic growth and healthcare expenditure are succeeded by escalating suicide rates in emerging markets, developing countries, and all income countries, except low-income countries.

The remainder of this paper is organized as follows. Section 2 offers a review of recent studies relevant to this research. Section 3 discusses the theoretical channels through which economic uncertainty could impact population health and outlines the empirical methodology utilized in this study. Section 4 presents the empirical analysis, including the results of baseline models, the subsequent robustness checks, and heterogeneity analysis. The final section concludes the whole paper, underscores the policy implications, and discusses the limitations of this study and directions for future research.

## 2. Literature review

The influence of economic uncertainty, a complex variable to quantify, on population health, has only recently been scrutinized in a handful of studies. Individuals dwelling in environments rife with high levels of uncertainty may experience a range of psychological distress, such as anxiety, worry, and even mental disorders, particularly if they exhibit high intolerance towards uncertainty (21). Considering this analysis, several efforts have been dedicated to evaluating the mental repercussions of shocks in economic uncertainty. Yagil and Cohen (22) further demonstrate that financial uncertainty can trigger anxiety during the COVID-19 pandemic, based on survey data gathered from Israeli citizens.

Given that mental disorders are a primary trigger for suicide, several studies have explored the impact of EPU on suicide mortality. Antonakakis and Gupta (9), Abdou et al. (11), Abdou et al. (12) examine US subpopulations in terms of age and gender, while Vondoros et al. (10) provide insights for England and Wales. Claveria (13) extends this analysis to 183 economies. Antonakakis and Gupta (9) conclude that rises in economic policy uncertainty (EPU) cause higher suicide mortality among the youngest and oldest males, while US females seem to show a minimal response to such shocks. Moreover, Abdou et al. (11) find a significant impact of financial uncertainty on U.S. suicide rates among the youngest males and middle-aged females. Subsequently study by Abdou et al. (12) observes significant asymmetric effects of EPU on U.S. suicide rates in middle-aged males and older females, with only extreme unexpected surges in EPU triggering suicide crises within these demographics. The gender-dependent aspect of these findings is echoed by Vondoros et al. (10), who find that increases in EPU result in a rise in suicide rates within 2 days. However, the results presented in Claveria (13) are mixed and inconsistent.

Another strand of the literature investigates the outcomes of economic uncertainty shocks on physical health. Hikes in economic uncertainty may impose psychological pressures on individuals, promoting them to adopt unhealthy lifestyle behaviors. Kalcheva et al. (14) report a positive correlation between EPU and the tendency towards unhealthy lifestyle habits, such as increased alcohol consumption and smoking. Additionally, excessive mental stress and unhealthy lifestyle habits may lead to a higher incidence of accidents.

Vondoros et al. (15), utilizing daily data from the UK, identify sudden jumps in motor vehicle collisions following spikes in UK EPU.

In summary, prior research has made significant strides in examining the relationship between economic uncertainty and population health outcomes, such as mental health, suicide mortality, and unhealthy behaviors. Preliminary evidence suggests economic uncertainty may harm mental health and increase risky behaviors. However, exploring how economic uncertainty might impact public health needs to be more thorough and merits further investigation. Moreover, most previous studies have focused on a single economy, leaving global evidence needing more attention, particularly in emerging markets and developing countries. To bridge these gaps, this paper aims to concentrate on emerging markets and developing countries, evaluating the impact of economic uncertainty on general public health.

## 3. Theoretical background and empirical methodology

### 3.1. Theoretical background

The impact of economic uncertainty on population health is manifold, operating through both direct and indirect channels. The direct channel primarily implicates mental health, often called the psychological channel. Concurrently, three indirect channels are mediated through the effects of economic uncertainty on health-related economic indicators, specifically economic growth, healthcare expenditure, and environmental pollution (quality).

#### 3.1.1. Psychological channel

Economic uncertainty can provoke widespread public apprehension regarding economic stability, potentially inciting anxiety about dwindling income, the threat of unemployment, and even the emergence of mental disorders or suicidal tendencies (10–12). While mental health deterioration is a grave concern, it is merely one facet of population health and does not inevitably portend a decline in overall health conditions.

#### 3.1.2. Economic growth channel

Economic output and population health share a reciprocal relationship (23, 24). Economic growth boosts *per capita* income, enhances national purchasing power for goods and services, and improves living standards. Furthermore, economic advancements engender superior and high-quality healthcare and medical services, culminating in improved population health. Although the health-growth literature is not entirely conclusive, the preponderance of studies substantiates the positive ramifications of economic development on health, see O'Donoghue et al. (25), Subramanian et al. (26), Tapia Granados and Ionides (27), Renton et al. (28), Morgado (29), Cole (30), amongst others. Recent studies by Wang (31), Breuer (32), and Wang et al. (33) assert a synchronization of mortality with unemployment across various countries. Therefore, while economic growth is vital for health, contractions in economic growth driven by heightened economic uncertainty could bring adverse health consequences.

### 3.1.3. Healthcare expenditure channel

Within the realm of health economics, health is conceptualized as an output of healthcare services, with consumers deriving utility from both consumption and health outcomes (34). Greater healthcare expenditure generally promotes health (35). However, healthcare expenditure often hinges on economic growth (36). Governments may curtail public healthcare expenditure in response to declined economic output following a surge in economic uncertainty (37, 38). Also, according to the absolute income hypothesis (39), households tend to reduce consumption in the face of declining income. Existing literature reveals that economic uncertainty can trigger precautionary incentives among families. As healthcare expenditure constitutes a significant segment of household consumption, potential income reductions due to escalating economic uncertainty could compel households to cut private healthcare expenditure, thereby hampering better health outcomes.

### 3.1.4. Environmental pollution (quality) channel

Environmental pollution and degradation are associated with economic growth, especially in developing countries (40–42). Pollution can exert a direct, deleterious effect on human health (43–45). Hence, environmental improvements and concomitant health benefits might be expected during economic downturns. From this perspective, a surge in economic uncertainty may reduce investment activities and pollution, potentially facilitating public health enhancements. However, exacerbated economic uncertainty could also incentivize governments to ease environmental regulations to counter potential economic recessions, encouraging firms to augment pollutant emissions (46), which could detrimentally affect public health.

## 3.2. Empirical methodology

In this study, I utilize a panel vector autoregressive model (hereafter referred to as panel VAR) to implement empirical investigation. To preserve model parsimony, the panel VAR model comprises five endogenous variables: population health indicator(s), economic uncertainty, economic growth, healthcare expenditure, and environmental pollution. Notably, given that the characteristics of the sample data—short  $T$  and large  $N$ —I abstain from incorporating cross-sectional interactions and parameter variations across both time and units. Adopting such a complex model would make the estimation overly complicated. Instead, I employ the more restrictive Bayesian panel VAR model proposed by Beetsma et al. (20). Still, I continue to assess the heterogeneous effects across countries by dividing the samples according to country characteristics.

Compactly, the annual panel VAR with fixed effects can be expressed in a concise vector form as follows:

$$Y_{it} = \alpha_i + \beta_{it} + \sum_{j=1}^P A_j Y_{it-j} + u_{it}, \quad (1)$$

where  $i$  denotes the country and  $t$  represents the year,  $Y_{it}$  is a vector of endogenous variables of interest,  $\alpha_i$  measures country-fixed effects,  $\beta_{it}$  is the term reflecting country-specific linear trend effect, and  $u_{it}$  is

a vector of residuals assumed to follow a normal distribution with zero-mean and constant variance  $\Omega$ . The lag length chosen for the VAR process is denoted by  $P$ , and  $A_j$  is the matrix of coefficients of the  $j$ -th lag of the endogenous variables.

As highlighted by previous studies, economic conditions and population health may have simultaneous relationships, which warrant consideration in the empirical framework. To this end, I introduce a lower triangular matrix  $A_0$  to capture the contemporaneous impact and identify the structural shocks by implementing a Cholesky decomposition of the residual covariance matrix  $\Omega$ , i.e.,

$$\Omega = A_0 A_0'. \quad (2)$$

In the baseline model, variables in  $Y_{it}$  are ordered as follows,

$$Y_{it} = \begin{pmatrix} \text{economic\_uncertainty}_{it}, \text{economic\_growth}_{it}, \\ \text{envirommental\_quality}_{it}, \text{healthcare\_expenditure}_{it}, \\ \text{health\_indicator}_{it} \end{pmatrix} \quad (3)$$

The economic uncertainty indicator is ordered first since it can be predominantly regarded as a variable with low degrees of endogeneity to economic activity (47). In the baseline model, population health is placed last, reflecting the immediate impact of economic conditions on health, with the inverse less likely. Following Beetsma et al. (20), I estimate the models using a Markov chain Monte Carlo (MCMC) Gibbs sampling algorithm.

Consider a dataset that spans over  $T$  years and across  $N$  countries. The designed MCMC Gibbs algorithm operates as follows<sup>1</sup>:

The model parameters to be estimated are stacked in a vector  $B$ , where  $B = \text{vec}([\alpha_i, \beta_i, A_j])$ , and the regressors in Eq. (1) are defined as  $X$ . Hence, given the prior distribution, the posterior distribution is inferred sequentially from two conditional posterior distributions,  $G(B|\Omega)$  and  $G(\Omega|B)$ .

$G(B|\Omega)$  rests on a normal density  $N(B^*, \Omega \otimes (X^* X^*)^{-1})$ , where  $B^* = (X^* X^*)^{-1} (X^* Y^*)$ . Here,  $X^* = \begin{pmatrix} X \\ X_D \end{pmatrix}$  and  $Y^* = \begin{pmatrix} Y \\ Y_D \end{pmatrix}$  represent the stacked vector of actual data with dummy observations.  $G(\Omega|B)$  adheres to an inverse Wishart

distribution  $IW(S^*, NT + T_D - K)$ , where

$S^* = (Y - XB)'(Y - XB)$ .  $T_D$  is the size of dummy observations and  $K$  stands for the number of regressors in each equation in the VAR system. The algorithm continues to iterate until the draws converge.

<sup>1</sup> Here, I briefly discuss the principles and routines of the algorithm; for further implementation and theories about the algorithm, the reader is referred to Bayesian econometrics textbooks.

For setting the prior, two  $T_D$  dummy observations are defined as

$$Y_D = \begin{pmatrix} Y_{D1} \\ Y_{D2} \end{pmatrix} \text{ and } X_D = \begin{pmatrix} X_{D1} \\ X_{D2} \end{pmatrix}, \text{ where } Y_{D1} = \begin{pmatrix} \text{diag}(\gamma\sigma_1, \dots, \gamma\sigma_N) \\ 0_{N(P-1) \times N} \\ \dots \\ \text{diag}(\sigma_1, \dots, \sigma_N) \\ \dots \\ 0_{1 \times N} \end{pmatrix},$$

$$X_{D1} = \begin{pmatrix} \frac{\text{diag}(1, \dots, P) \times \text{diag}(\sigma_1, \dots, \sigma_N)}{\tau} & 0_{NP \times 1} \\ 0_{N \times NP} & 0_{N \times 1} \\ \dots & \dots \\ 0_{1 \times NP} & c \times I_{ex} \end{pmatrix},$$

$$Y_{D2} = \frac{\text{diag}(\gamma\mu_1, \dots, \gamma\mu_N)}{\lambda}, \quad X_{D2} = \left( \frac{(I_{1 \times P}) \otimes \text{diag}(\gamma\mu_1, \dots, \gamma\mu_N)}{\lambda} \right) 0_{N \times 1},$$

$\gamma$  symbolizes the mean of the prior,  $\sigma_i$  is scaling factor set by initial AR(1) regressions,  $\tau$  signifies the tightness of the prior of the autoregressive coefficients, and  $c$  controls the prior for the exogenous regressors in the equation (the number of which is denoted as  $ex$ ). The prior on the VAR coefficients and error covariance is implemented through  $Y_{D1}$  and  $X_{D1}$ , while  $Y_{D2}$  and  $X_{D2}$  are used for the prior on the sum of coefficients on the lagged endogenous variables. Following Beetsma et al. (20), in the following empirical study, the hyperparameters are set to reflect a loose prior belief with  $\tau = 1$ ,  $c = 0.001$ ,  $\lambda = 10$ , respectively.

## 4. Data and results

### 4.1. Data

This study draws upon an annual, country-level dataset encompassing 103 emerging markets and developing countries from 1995 to 2019. The dataset selection is primarily dictated by data availability,<sup>2</sup> with the specifics of the countries in the sample and their corresponding characteristics provided in Table A1 in Appendix A.

In evaluating economic uncertainty, I use an innovative metric known as the World Uncertainty Index (WUI), introduced by Ahir et al. (3). Employing text-mining methodologies, the WUI effectively monitors uncertainties stemming from economic and political events across 143 countries. The WUI uniquely extracts information from a single, consistent source—the economist intelligence unit country reports—thereby facilitating cross-country comparisons of uncertainty levels and their subsequent effects. Consequently, aligning with the studies of Gozgor et al. (48), Afzali et al. (49), and Fang et al. (50), I adopt the WUI as the measure of economic uncertainty. The

quarterly index retrieved from [worlduncertaintyindex.com](https://worlduncertaintyindex.com) is converted into an annual average for each sample country.

To encapsulate the state of public health, I use four commonly adopted indicators in the literature as proxies for population health: life expectancy at birth, the crude death rates per 1,000 people,<sup>3</sup> child mortality rates under five per 1,000 live births, and suicide mortality rates per 100,000 people.

In the preceding theoretical analysis, the ways in which economic uncertainty impacts public health are divided into direct and indirect channels. The indirect channels—economic growth, healthcare expenditure, and environmental pollution—are relatively straightforward to quantify. However, the direct channel, which pertains to psychological disorders with typical symptoms of depression, psychopathy, and aggressiveness, is more challenging to measure due to the lack of available data at the country level for the sample countries. While it is not always the case that suicides are the result of psychological disorders (51, 52), a significant proportion of suicides are indeed closely linked to such conditions (53). Therefore, I use suicide mortality rates as a rough indicator of the nationwide prevalence of psychological disorders to examine the direct effects of economic uncertainty on health.

Consistent with previous studies, economic growth is represented by GDP *per capita* in 2017 international dollars, while healthcare expenditure is gauged by healthcare expenditure *per capita* in 2017 international dollars. Following Neves et al. (54), Munir (55), and Ongan et al. (56), environmental pollution is measured by CO<sub>2</sub> emissions in metric tons *per capita*. Health indicators, healthcare expenditure, and carbon emissions were sourced from the World Bank database, with GDP data from the IMF WEO database. Barring the economic uncertainty proxy, all variables are taken as logarithms.<sup>4</sup>

### 4.2. Results of baseline models

#### 4.2.1. Model estimation and convergence diagnosis

To optimize computational efficiency and maintain a parsimonious model specification, only one health indicator is included in each model. This strategy results in five panel VAR models, each employing different health proxies.<sup>5</sup> Following the common practice for annual panel data and guided by the results explicated in Table A2 in Appendix A,<sup>6</sup> I set the VAR lag length to 1 in the baseline

<sup>3</sup> In the following analysis, I will refer to mortality or aggregate mortality.

<sup>4</sup> The WUI occasionally contains zeros, indicating that the absence of uncertainty-related words in the report. Taking the logarithm in such cases can lead to errors. If I apply logarithmic transformation to the WUI while retaining the zeros, it may significantly diminish the fluctuations of the WUI, potentially producing biased results.

<sup>5</sup> One mild caveat is that this strategy overlooks potential intercorrelations among health indicators. However, specifying a model that accommodates all possible intercorrelations presents a conundrum. Incorporating all health indicators into a single model could increase dimensionality and, consequently, the computational complexity, even though it might improve model fitness.

<sup>6</sup> In Bayesian econometrics, model performance evaluation often hinges on the deviance information criterion (DIC). Nevertheless, drawing inferences from this statistic is a formidable challenge given the large country-level units.

<sup>2</sup> The outbreak of the COVID-19 pandemic in 2020 propelled world economic uncertainty to unprecedented levels and imposed tremendous threats to public health. Including data from 2020 onward in the analysis may introduce a bias that health and economic uncertainty are highly correlated. Therefore, considering this backdrop and data availability, I limit the sample to 2019.



models. The models are estimated by an MCMC sampling procedure with 55,000 replications, of which the initial 45,000 replications are used for burn-in, retaining 10,000 effective draws.<sup>7</sup>

To confirm the convergence of the posterior draws, inefficiency factors for VAR coefficients and covariance are computed. In the model incorporating life expectancy,<sup>8</sup> the inefficiency factors for the VAR coefficients and covariance fall within relatively low ranges of (0.7298, 1.3304) and (1.08, 1.389), respectively. These results signify the excellent performance of the MCMC draws, rendering them suitable for further inference.

#### 4.2.2. Responses of the macroeconomy to economic uncertainty shocks

I subsequently direct the analysis towards the impulse response functions (IRFs) estimated using posterior MCMC draws to how economic uncertainty impacts population health. [Figure B1A](#) in [Appendix B](#) illustrates the macroeconomic dynamics following a 1% surge in economic uncertainty. To concentrate on the consequences of the shock, I refrain from displaying the response of the shock variable itself. As depicted in the figure, an upsurge in economic uncertainty precipitates significant reductions in economic growth, environmental pollution, and healthcare expenditure.

The marked response of real GDP to the uncertainty shocks is consistent with the majority of uncertainty literature, including Bachmann et al. (57), Baker et al. (4), and Baker et al. (58). These studies collectively highlight the detrimental impact of economic uncertainty on economic output. Moreover, the response of environmental pollution aligns, to some extent, with the findings by Ahmed et al. (59). However, recent evidence regarding the impact of economic uncertainty on environmental pollution remains contentious. While Adams et al. (60), Atsu and Adams (61), Adedoyin et al. (62), and Yu et al. (63) claim that heightened economic uncertainty causes increased carbon emissions, Abbasi and Adedoyin (64) and Zhang et al. (65) find no discernible impact of EPU on carbon emissions. Furthermore, it is worth considering the adverse impact of economic uncertainty on healthcare expenditure, as it presents a contrasting viewpoint to the findings of (66) who observe positive effects of EPU on healthcare expenditure in China. However, this partially aligns with the conclusions drawn by Cheng and Witvorapong (67), who argue that healthcare policy uncertainty diminishes healthcare expenditure in the United States.

The above findings raise the question: why do environmental pollution and health expenditure respond negatively to economic uncertainty? To answer this question, I estimate the IRFs of shocks to GDP and CO<sub>2</sub> emissions, as shown in [Figure B1B](#) in [Appendix B](#). An increase in economic growth is likely to cause more severe environmental pollution and higher healthcare expenditures. As the economy grows, social investments and consumption increase in

tandem, leading to higher environmental pollution, consistent with Davis (68), who states that economic downturns often coincide with improvements in the natural environment. This, in turn, necessitates greater healthcare expenditure to manage the deteriorating environment (as depicted in the right panel of [Figure B1B](#)). An increment in GDP also raises national income, endowing the nation with improved abilities to fund healthcare. These findings support the well-known Environmental Kuznets curve hypothesis, which presumes that higher economic output correlates with reduced environmental quality in EMDCs, see Tucker (69), Grossman and Krueger (70), and Zhang and Zhang (71), among others. Moreover, I demonstrate the synchronicity of health expenditure with economic growth and environmental pollution, consistent with the recent study by Ampon-Wireko et al. (72), who propose that carbon emissions and income growth are significant factors influencing healthcare expenditure in non-OCED countries. Thus, following a hike in economic uncertainty, economic growth declines, and environmental pollution and healthcare expenditure tend to decrease correspondingly.

#### 4.2.3. Responses of health indicators to economic uncertainty shocks

Similarly, the IRFs of health indicators to a 1% shock to economic uncertainty are computed and displayed in [Figure 1](#). The first health indicator, life expectancy, as shown in [Figure 1A](#), undergoes a marginal and statistically insignificant increase in the 2 years following an upsurge in economic uncertainty. However, the median IRF of life expectancy progressively decreases thereafter, turning negative response approximately 5 years after the shock and converging around the ninth year. Moreover, as reported in [Figure 1C](#), an increase in environmental pollution is followed by a persistent decline in life expectancy. However, the corresponding error band is too wide to encompass zero, suggesting environmental pollution may deteriorate population health. This finding is consistent with Steinberger et al. (73), who contend that life expectancy weakly correlates with carbon emissions. Brunner and Maruyama (74), conversely, report a positive association between life expectancy and CO<sub>2</sub> emissions in low-income and lower-middle-income countries. Given the reactions of environmental pollution to economic uncertainty and economic growth (as shown in [Figure 1B](#)), the initial health gains post-shock may be attributed to the environmental improvements resulting from economic downturns. Nevertheless, as disclosed in [Figures 1B,D](#), buildups in output and healthcare expenditure are critical drivers of life expectancy improvement (75, 76). Hence, the health detriments from contractions in economic growth and healthcare expenditure become apparent in the long run, evincing a significant and persistent diminution in life expectancy.

The remainder of [Figure 1](#) illustrates the effects of distinct shocks on aggregate mortality (crude death rates), child mortality, and suicide rates. The IRFs depicted in [Figures 1B–D](#) compellingly demonstrate that augmentations in economic growth and healthcare spending significantly contribute to the reduction of both aggregate mortality and child mortality in EMDCs, corroborating the evidence reported in Nishiyama (77). Conversely, an increase in environmental pollution may engender a subtle and persistent rise in child mortality across the response horizon, alongside a marginal leap in aggregate mortality within a year, affirming the findings of Bressler (78).

However, as [Figure 1](#) conveys, the response of aggregate mortality shifts from a negative trajectory in the first 6 years after a

Thus, despite their intrinsic differences from the Bayesian approach, I have chosen to rely on information criteria statistics derived from frequentist estimation methods.

<sup>7</sup> I did not perform panel unit root tests to validate variable stationarity. This is because such a condition is not required in panel VAR model settings or Bayesian econometrics.

<sup>8</sup> Models with other health indicators generate similar results, which are available upon request.

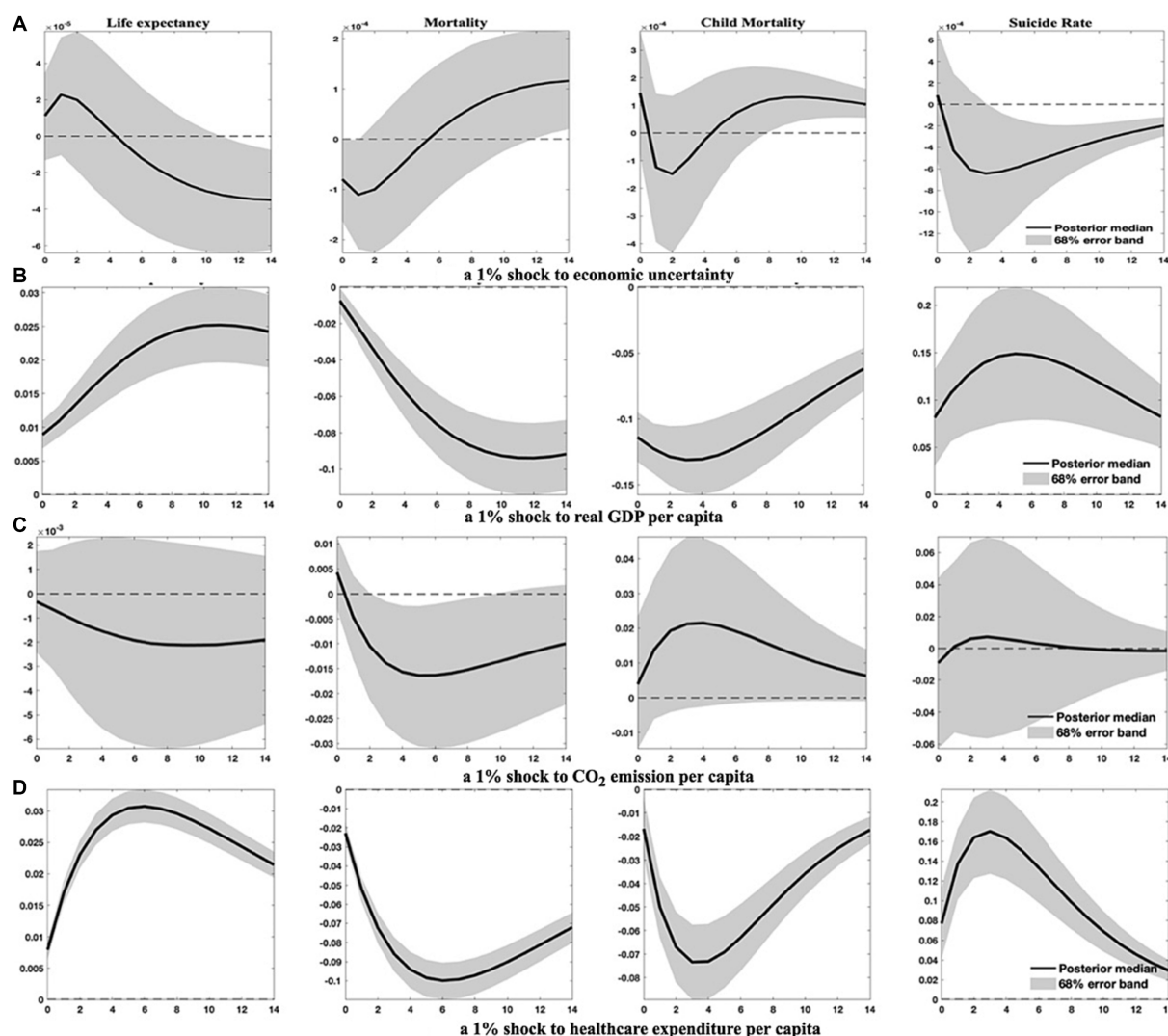


FIGURE 1

Health indicator dynamics in response to specified shocks. This figure elucidates how health indicators, such as life expectancy, aggregate mortality, child mortality, and suicide rates, react to 1% increases in economic uncertainty, economic growth, environmental pollution, and healthcare expenditure. Solid lines represent the median of posterior estimates of the impulse response functions (IRFs). The area shaded in grey is the 68% error band, constructed from the 16th and 84th percentiles of posterior estimates of the IRFs.

1% uncertainty shock to a positive one thereafter. This suggests that while an increase in economic uncertainty may initially reduce aggregate mortality in the short term due to improved environmental quality, it could considerably impair public health by raising mortality rates in the wake of economic downturns. This inference diverges from the conclusion drawn by Ahmad et al. (40), who posit that CO<sub>2</sub> emissions have no significant role in adult mortality in developing countries. In contrast, the response of child mortality to uncertainty shocks oscillates dramatically between positive and negative trajectories. Specifically, child mortality rises following uncertainty shocks but swiftly descends into the negative region for approximately 3 years before reverting and converging to a significant level. This indicates that the economic growth channel may dominate and substantially increase child mortality in the long run.

Pertaining to suicide rates, they exhibit nominal responses to environmental pollution shocks but react significantly and positively

to economic growth and healthcare expenditure shocks. This observation substantiates Lynn's hypothesis (79, 80) that higher economic growth can lead to anxiety and elevate suicide rates. Additionally, heightened economic uncertainty initially triggers a minor increase in suicide rates, providing additional evidence to support the findings of Vondoros et al. (10) and Claveria (13). In the long run, nevertheless, rises in economic uncertainty, alongside declines in economic output and healthcare expenditure, can significantly lower suicide rates.

### 4.3. Robustness checks

To assess the sensitivity of the results from the baseline models, I consider two alternative model specifications: (1) establishing a larger VAR lag length, and (2) incorporating additional relevant variables.

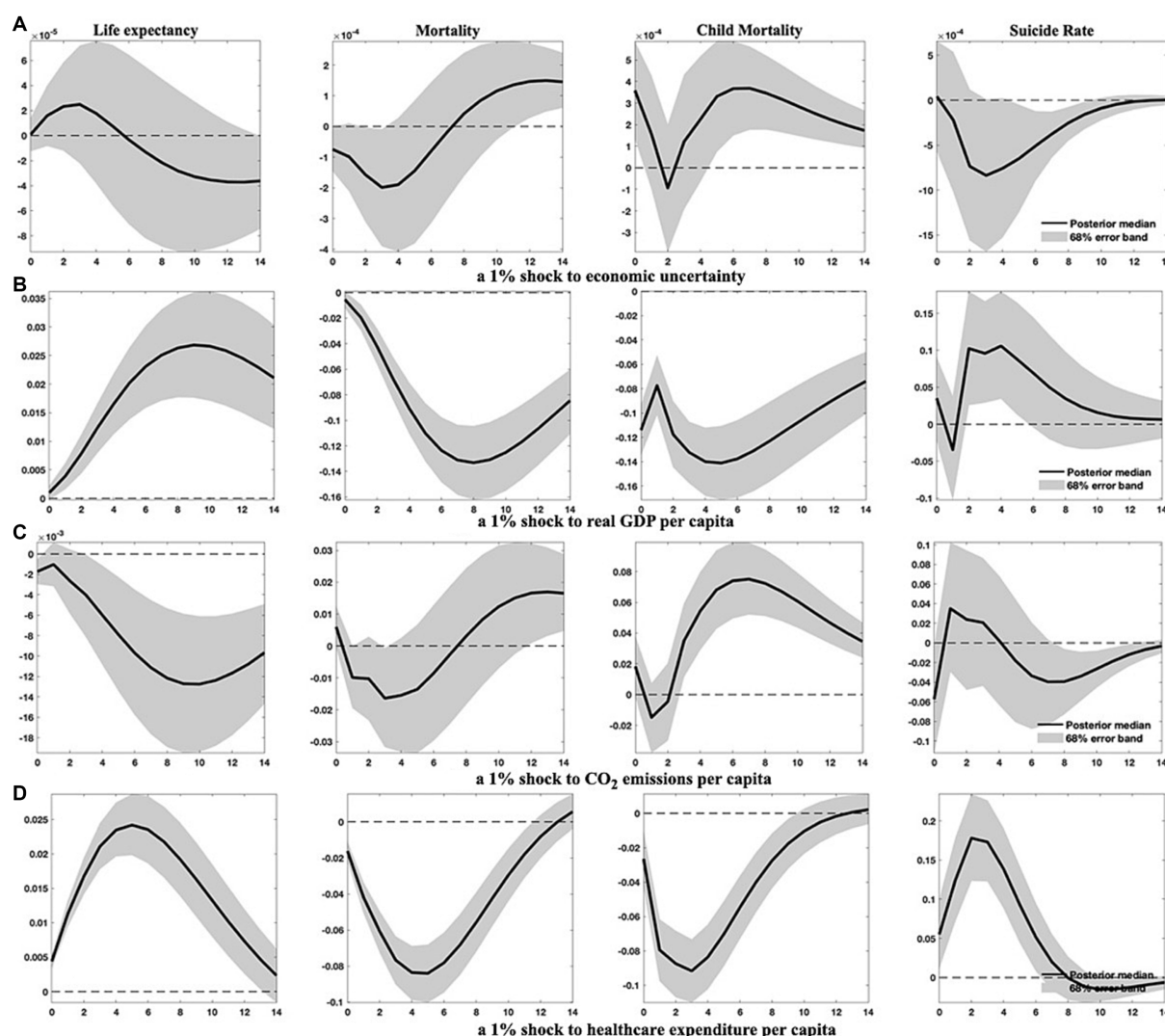


FIGURE 2

Health indicator responses to specified shocks in panel VAR (3) models. This figure presents how four health indicators evolve following 1% increases in economic uncertainty, economic growth, environmental pollution, and healthcare expenditure, when the VAR lag length is set at 3. Solid lines denote the median of posterior estimates of the IRFs, while the grey-shaded area stands for the 68% error band constructed using the 16th and 84th percentiles of posterior estimates of the IRFs.

First, I set a larger VAR lag length of 3, capturing almost a complete Kitchin cycle, and re-estimate the models. The estimated IRFs under this specification are presented in [Figure 2](#); [Figure B2](#) in [Appendix B](#).<sup>9</sup>

Comparatively and generally, setting a larger VAR lag length does not substantially alter the results from the baseline models. However, the impact of environmental pollution on health indicators becomes more conspicuous, suggesting that environmental degradation has significantly delayed adverse effects on public health.

Second, I integrate an additional variable into the baseline models to verify the robustness of the findings. Given the relevance of financial development [proxied by a broad index

established by Svirydzhenka (81)] and globalization [measured by the KOF index of overall globalization developed by Dreher (82)] to the macroeconomy and their influence on population health, I choose to include these variables individually,<sup>10</sup> yielding several 6-variate panel VAR(1) models. The IRFs estimated for these augmented models are exhibited in [Figure 3](#); [Figure B3](#) in [Appendix B](#).

As depicted in [Figure 3](#), the impact of economic uncertainty on population health remains substantial. Both models predict less pronounced increases in life expectancy within approximately 2 years following a surge in economic uncertainty, accompanied by a marked decline in aggregate mortality. Child mortality and suicide rates

<sup>9</sup> In this section, I will not report the IRFs like those in [Figure 1B](#), as they are not my primary focus. However, these IRFs are available upon request.

<sup>10</sup> Following the literature, financial development and globalization are ordered before economic output.



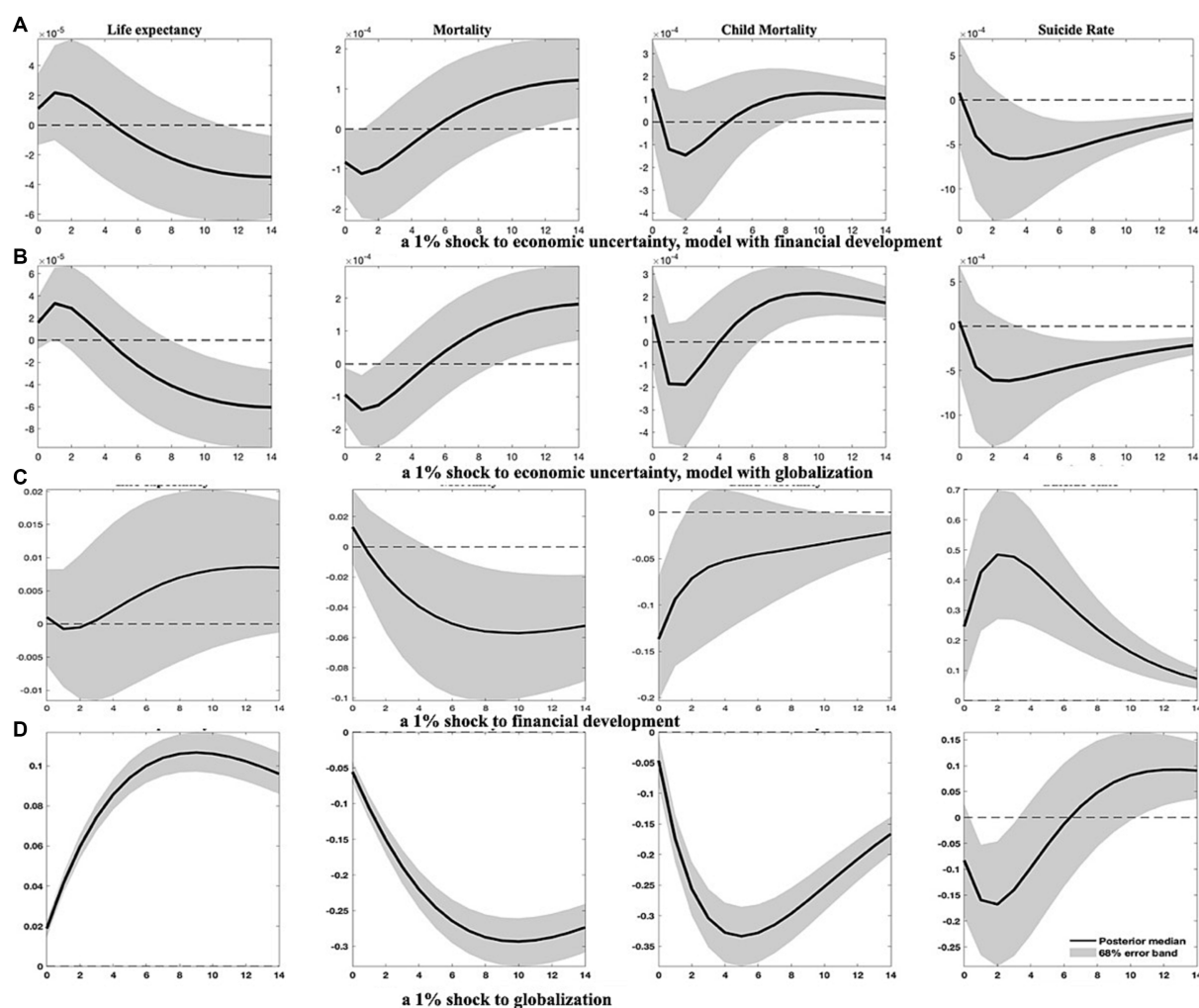


FIGURE 3

Health indicator responses to specified shocks in augmented models. This figure outlines how four health indicators respond to increases in economic uncertainty, as well as improvements in financial development and globalization. As in previous figures, solid lines represent the median of posterior estimates of the IRFs, and the grey-shaded regions denote the 68% error band constructed from the 16th and 84th percentiles of posterior estimates of the IRFs.

exhibit less responsiveness to economic uncertainty shocks in the short run. However, a discernible rise in child mortality and a decline in suicide rates transpire about 5 years after an upswing in economic uncertainty.

In addition, the mechanism through which economic uncertainty impacts population health could be accentuated by financial development and globalization. As shown in Figures B3B,C, EMDCs generally benefit from invigorated globalization and financial development, which stimulate economic growth and improve population health. Precisely, heightened globalization unequivocally yields positive outcomes for all health indicators, corroborating the findings of Cole and Neumayer (83). Upgraded financial development significantly reduces child mortality and has a lagged effect in reducing aggregate mortality. However, advancements in financial development may not be conducive to lower suicide rates. Notwithstanding the favorable implications of financial development and globalization, elevated economic uncertainty impedes these two variables, as shown in Figure B3A.

## 4.4. Heterogeneity analysis

The findings from the above analysis indicate that economies with higher income levels frequently exhibit better population health, owing to their typically greater healthcare expenditure, advanced financial development, and a higher degree of globalization. Higher-income levels are associated with increased demand for environmental protections (69), promoting governments to pursue eco-friendly economic growth strategies that ultimately enhance overall health conditions. As a result, heterogeneities may emerge due to disparities in development. To investigate this proposition, I divide the sample into (1) emerging markets and developing economies, as well as (2) countries categorized by four income tiers—low, lower-middle, upper-middle, and high-income levels. I then re-estimate the models to compile the relevant empirical results presented in Figures 4–7; Figures B4–B6 in Appendix B.<sup>11</sup>

<sup>11</sup> My emphasis in this section is primarily on the baseline models. However, to provide further insights into the importance of financial development and

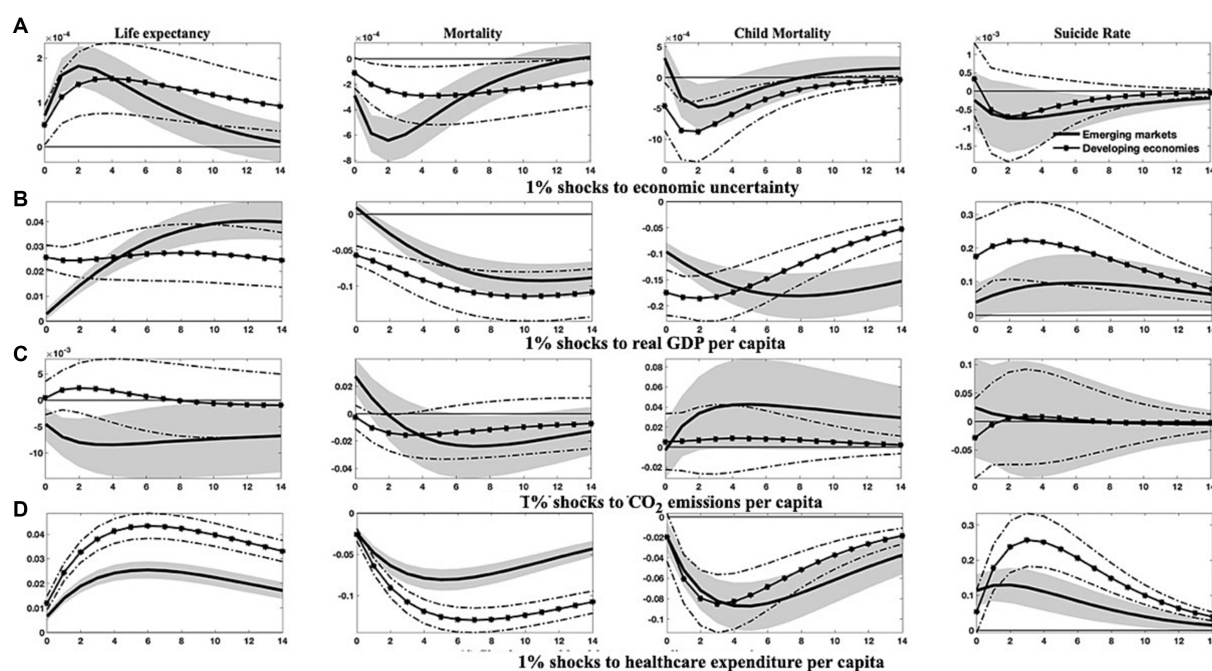


FIGURE 4

Differential responses of health indicators to 1% shocks to specific variables in emerging markets and developing countries. This figure differentiates the changes in four health indicators between emerging markets and developing countries in reaction to 1% increases in economic uncertainty, economic growth, environmental pollution, and healthcare expenditure. Solid lines and solid asterisk-marked lines denote the median of the posterior estimates of the corresponding IRFs, while grey-shaded regions and dash-dotted lines represent the 68% error bands constructed from the 16th and 84th percentiles of the posterior estimates of the corresponding IRFs.

#### 4.4.1. Comparison between emerging markets and developing countries

The IRFs depicted in Figures 4, 5; Figure B4 provide compelling evidence for the heterogeneous effects across these distinct country classifications. Specifically, after an upsurge in economic uncertainty, both emerging markets and developing countries exhibit discernible improvements in population health. The responses of life expectancy and mortality rates in emerging markets, along with the child mortality rates in developing countries, appear more significant. However, economic uncertainty seems to have minimal impact on suicide rates within both country classifications, particularly in the short term. Excepting suicide rates, the health gains generated from economic growth, healthcare expenditure, and globalization are appreciably more substantial in developing countries than in emerging markets.

Contrastingly, health indicators for both country classifications respond markedly and differently to shocks in environmental pollution and financial development. It is noteworthy that the adverse effects of environmental pollution and the salutary effects of financial development on life expectancy and mortality rates are more evident in emerging markets, whereas developing countries demonstrate lesser responsiveness to these shocks.

In the aftermath of an escalation in economic uncertainty, emerging markets suffer more considerable drops in economic output, environmental pollution, healthcare expenditure, and financial development. In comparison, developing countries confront more drastic reductions in the degree of globalization.

#### 4.4.2. Comparison among countries with different income levels

The differences among countries at varying income levels are starkly apparent in this study. Regarding health outcomes resulting from economic uncertainty (Figures 5C,D), all economies, except those at high-income levels, are likely to see significant improvements in public health after a hike in economic uncertainty. Conversely, high-income countries may withstand an increase in aggregate mortality and child mortality rates, as well as a transient diminution in life expectancy. Among all income categories, the responses of health indicators to uncertainty shocks are the most pronounced in upper-middle-income countries.

Concerning other health-influencing factors, it is evident that upper-middle-income and notably lower-middle-income countries could realize substantial benefits from progressive economic growth and enhanced healthcare expenditure, like the potential gains for low-income countries with enlarged healthcare expenditure. These advantages are observable in the prolonged life expectancy and reduced mortality rates (Figures 6, 7). However, it should be noted that in low-income countries, health improvements attributable to economic growth tend to be relatively modest and less persistent, as shown in Figure 6A. In contrast, health indicators in high-income countries demonstrate a lower

globalization, I also examine augmented models that incorporate these two variables.

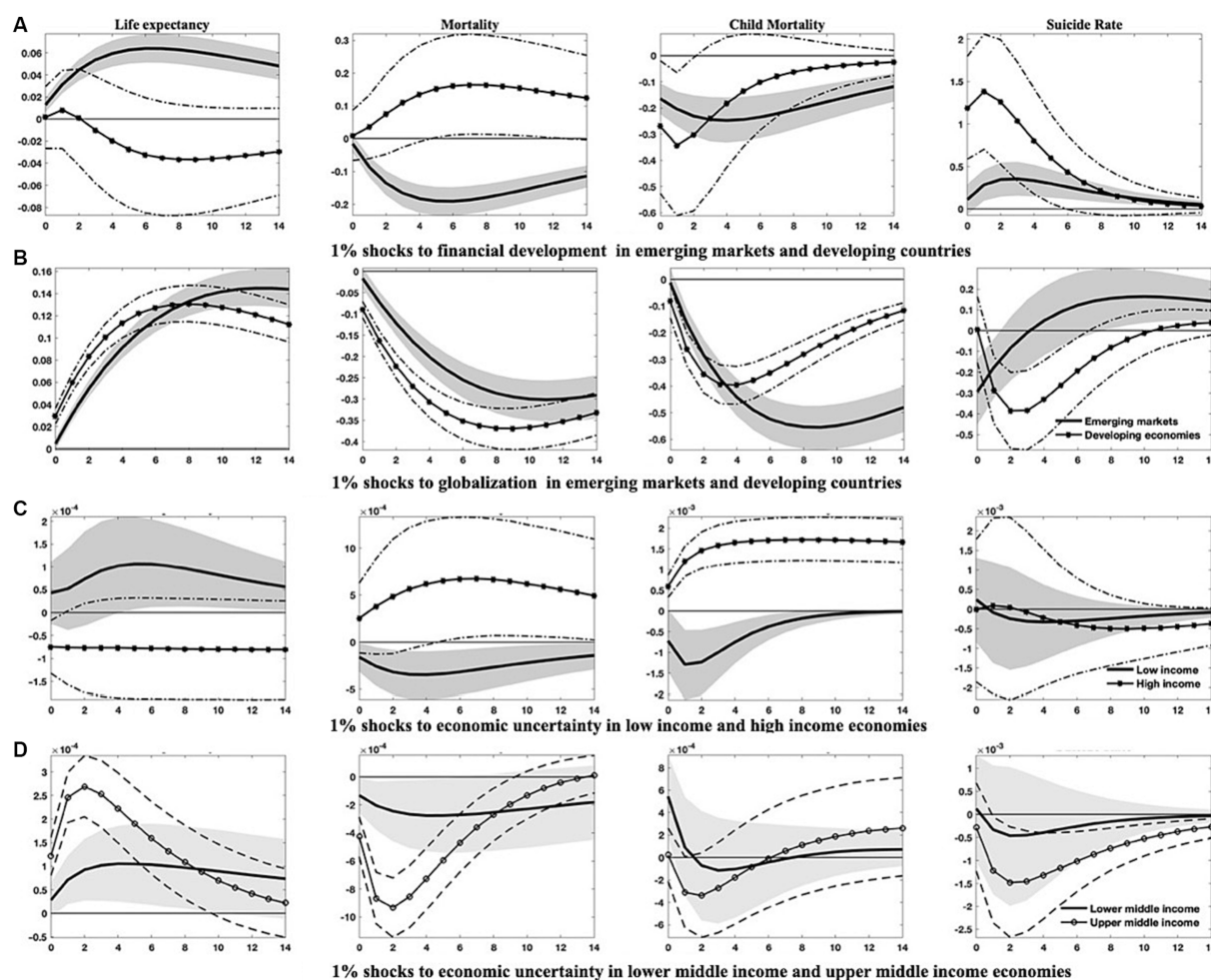


FIGURE 5

Responses of health indicators to 1% shocks in financial development, globalization, and economic uncertainty across varied countries. This figure delineates (1) the differential trajectories of health indicators between emerging markets and developing countries following enhancements in financial development and globalization, and (2) the varied responses of health indicators to surges in economic uncertainty across countries with disparate income levels. Solid lines and solid dot/asterisk-marked lines represent the median of the posterior estimates of the corresponding IRFs, while grey-shaded regions and dash(-dotted) lines are the 68% error bands constructed using the 16th and 84th percentiles of the posterior estimates of the corresponding IRFs.

sensitivity to fluctuations in economic growth and healthcare expenditure, with the notable exception of suicide rates, which may comove positively with economic growth and healthcare expenditure across all country classifications. In the context of mounting environmental pollution (Figures 6C,D), upper-middle-income countries are likely to confront significant health deterioration, manifested by curtailed life expectancy and increased mortality rates, including both aggregate and child mortality. Conversely, high-income countries may only endure a slight decrement in life expectancy, along with an increment in aggregate mortality in the short run. Yet, health indicators in other income groupings exhibit negligible responses to changes in environmental pollution.

Furthermore, as illustrated in Figures 7C,D, economic growth, environmental pollution, and healthcare expenditure in countries of varying income levels display distinct dynamics after a rising shock in economic uncertainty. Following an uptick in economic uncertainty, low-income and upper-middle-income countries would experience more stringent economic contractions than lower-middle-income

countries, while high-income countries show a reduced reactivity. Additionally, concerning environmental pollution and healthcare expenditure, shocks from economic uncertainty exert an immediate and persistent impact on upper-middle-income countries, with a delayed effect on high-income countries.

Upon considering the income levels of different countries, the favorable health outcomes associated with financial development do not consistently manifest across all nations. The IRFs in Figures B5A,B in Appendix B intimate that the health benefits of financial development are predominantly evident in upper-middle-income countries. Paradoxically, financial development could potentially precipitate adverse effects on health indicators within high-income countries. Globalization, meanwhile, ostensibly fosters positive health effects, particularly within low-income, lower-middle-income, and upper-middle-income countries (Figures B5C,D). For low-income and upper-middle-income countries, the benefits conferred by globalization may be negated by economic uncertainty, which has been identified as a significant factor in attenuating globalization degrees within these countries (Figure B6 in Appendix B).



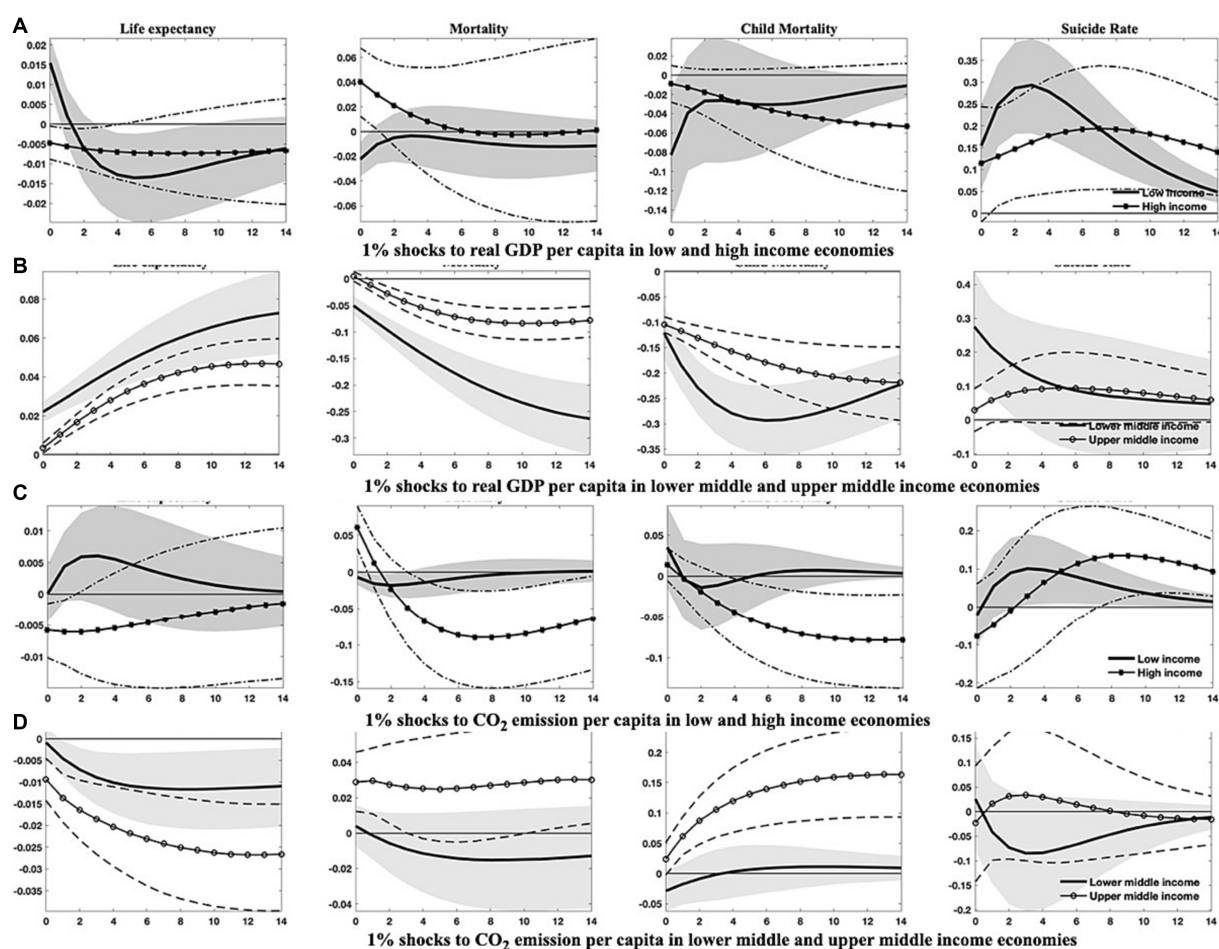


FIGURE 6

Responses of health indicators to 1% shocks to real GDP *per capita* and CO<sub>2</sub> emissions across economies with diverse income levels. This figure outlines the distinct dynamics of health indicators in response to economic growth and environmental pollution among countries of varying income levels. Solid lines and solid dot/asterisk-marked lines symbolize the median of posterior estimates of the corresponding IRFs, while grey regions and dash(-dotted) lines indicate the 68% error bands derived from the 16th and 84th percentiles of posterior estimates of the corresponding IRFs.

Interestingly, lower-middle-income countries could potentially glean health gains from economic uncertainty, given that it tends to impose impediments to financial development in both lower-middle-income and high-income countries (Figure B6 in Appendix B).

## 5. Conclusion

In recent years, the global economy has been marked by unprecedented levels of uncertainty. This has sparked extensive academic interest, particularly concerning the subsequent effects on economic activities, agent behavior, and asset prices. Theoretically, economic uncertainty impacts public health through a direct psychological channel and three indirect channels: economic growth, healthcare expenditure, and environmental quality. This paper turns its focus to emerging markets and developing countries (EMDCs), as these regions are most vulnerable to increased economic uncertainty due to their inadequate medical infrastructure and services. I assess the impact of economic uncertainty on public health by analyzing a comprehensive annual, country-level dataset for 103 countries through a Bayesian panel VAR model developed by Beetsma et al. (20).

Based on the entire sample, the empirical findings reveal a transient and marginal beneficial health impact from heightened economic uncertainty. This is evidenced by increased life expectancy and reduced mortality rates. However, in the long run, nations tend to experience an overall decline in health due to persistent decreases in economic growth and healthcare expenditure, both of which are crucial determinants of health. Robustness checks confirm that the results remain largely unaffected by VAR lag length and model dimensionality. Additionally, environmental pollution exerts significant detrimental effects on health. I also present further evidence supporting the positive health outcomes associated with financial development and globalization, both of which respond negatively to economic uncertainty shocks.

The subsample analysis underscores considerable heterogeneities across diverse types of countries within EMDCs. I concentrate on three health indicators—life expectancy, aggregate mortality, and child mortality—and find that the health-enhancing effects of economic uncertainty are more pronounced in emerging markets, low-income, and upper-middle-income countries. Notably, surges in economic uncertainty may trigger increased child mortality rates in high-income and lower-middle-income nations. Additionally, the health benefits derived from

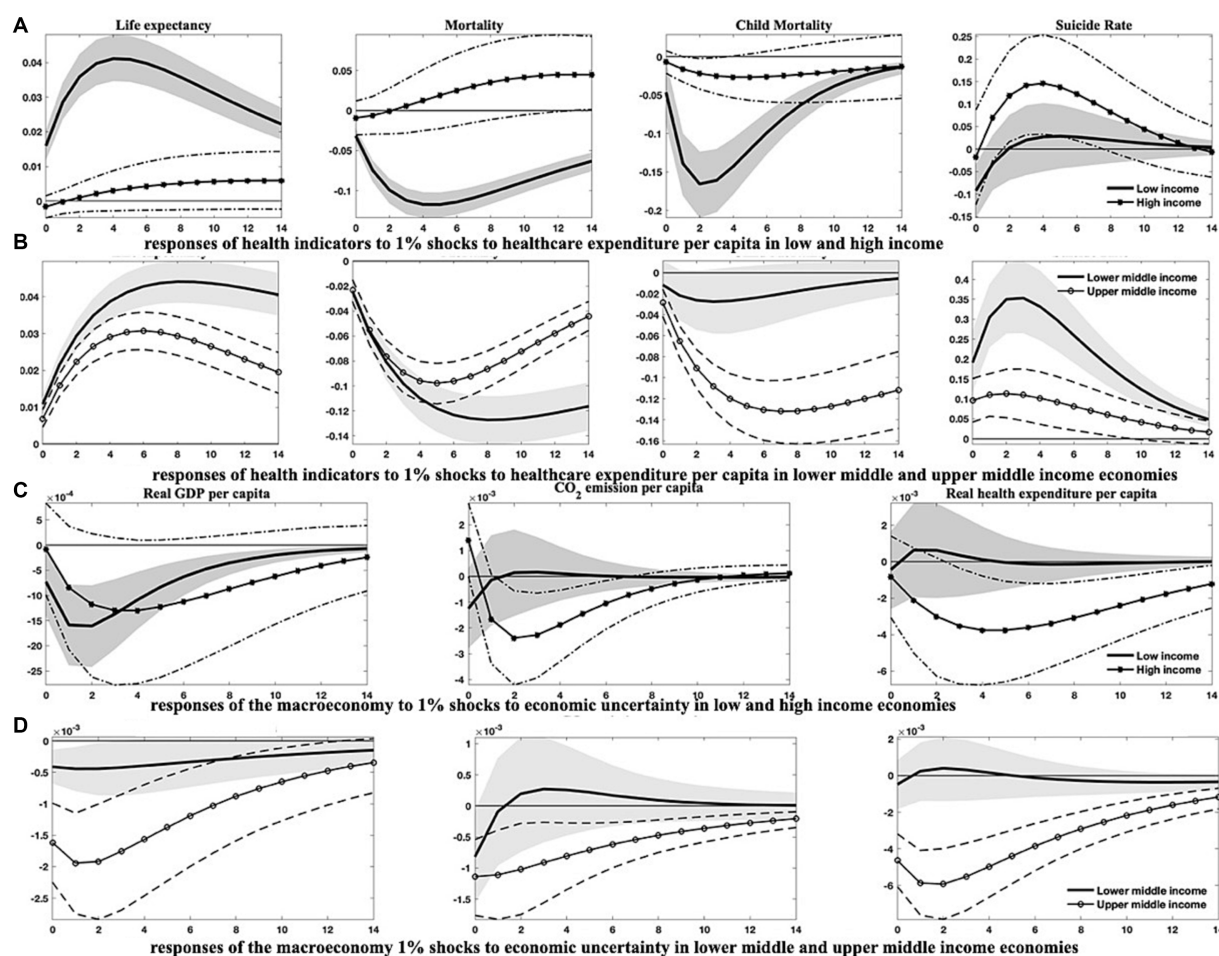


FIGURE 7

Responses of health indicators to 1% shocks to healthcare expenditure *per capita* and macroeconomic responses to 1% shocks to economic uncertainty across economies of diverse income levels. This figure demonstrates (1) the varied dynamics of health indicators in response to growth in healthcare expenditure among countries with differing income levels, and (2) the differential responses in economic growth, environmental pollution, and healthcare expenditure in the face of escalating economic uncertainty across countries of disparate income levels. Solid lines and solid dot/asterisk-marked lines depict the median of posterior estimates of the corresponding IRFs, while grey regions and dash(-dotted) lines indicate the 68% error bands constructed from the 16th and 84th percentiles of posterior estimates of the corresponding IRFs.

healthcare expenditure are more apparent in developing, low-income, and lower-middle-income countries, while economic growth may not consistently improve health outcomes in high-income countries. The deleterious effects of environmental pollution on health are predominantly observable in emerging markets, lower-middle-income, and upper-middle-income countries. Lastly, financial development does not significantly affect health outcomes for developing and high-income countries. In contrast, globalization has a positive health impact for all classifications of nations except high-income countries. Following escalations in economic uncertainty, only upper-middle-income countries exhibit a substantial decline in suicide rates. Contrary to common belief, economic growth and healthcare expenditure may not contribute to reduced suicide rates in countries other than low-income nations. Furthermore, I explore the interlinkages among economic uncertainty, environmental pollution, and healthcare expenditures, within the context of this study, themes which have been extensively examined in previous studies.

The findings yield several policy implications. First, EMDCs should be aware of the potentially detrimental impact of economic

uncertainty and contemplate implementing proactive measures to mitigate the adverse effects of economic downturns during periods of heightened economic uncertainty, such as social safety nets and targeted healthcare interventions. Second, EMDCs should continue investing in their healthcare systems, as they have been demonstrated to be salient factors contributing to positive health outcomes (84). Third, EMDCs need to be vigilant of potential health detriments resulting from environmental degradation and endeavor to pursue eco-friendly economic growth trajectories. Fourth, EMDCs should strive to develop a more sophisticated financial system and enhance globalization, promoting economic development and public health. Lastly, EMDCs should consider enacting policies that reduce economic uncertainty, such as refining the business environment, augmenting the credibility and transparency of economic policies, and encouraging economic diversification. These actions may facilitate sustainable economic growth and, consequently, improve population health.

Moreover, the findings provide critical insights into the primary policy interventions for enhancing public health in countries of

varying income levels. For low-income countries, it is essential to foster economic growth, bolster globalization, and make considerable investments in healthcare expenditure, particularly in times of significant economic uncertainty (85). Lower-middle-income countries should prioritize interventions to reduce child mortality rates that may increase amid economic uncertainty, while also endeavoring to embrace globalization to reap health benefits. In the case of upper-middle-income countries, the expansion of healthcare access and coverage during economic uncertainty is recommended. Additionally, these countries should strengthen environmental regulations to improve environmental quality and promote financial inclusion to maximize the positive effects of financial development (86). High-income economies, on the other hand, should implement policies to mitigate the adverse health impacts of economic uncertainty, with a particular emphasis on child mortality. Investment in green technologies and renewable energy is necessary to address environmental degradation and its detrimental health effects (87, 88). In addition, these economies should strive to optimize the efficiency of healthcare expenditure, monitor suicide rates diligently, and ensure the provision of adequate mental health resources during periods of heightened economic uncertainty.

Notwithstanding, this study retains several limitations that warrant further investigation. For example, the increasing integration of economies and financial markets worldwide necessitates accounting for international spillovers and dynamic interdependencies between countries (89, 90). Nonetheless, the sample used in this study precludes extensive examination of cross-country interdependencies. A potential future study could concentrate on a specific region with a limited number of countries and employ the panel VAR model with the stochastic search specification selection algorithm proposed by Koop and Korobilis (91) to allow for all potential dynamic interdependencies and heterogeneities. In addition, regime shifts might prevail in the relationship between health and its determinants due to economic and political events. Future studies could employ models incorporating potential regime shifts, such as Markov-regime switching and time-varying parameters models, to offer more insights. Furthermore, the extant literature has uncovered many other economic and social variables influencing health, such as income inequality, democracy, military expenditure, natural resource dependence, and education. However, I primarily excluded these variables from this study due to data availability constraints and the desire for model parsimony. Incorporating these variables to construct a more comprehensive model is left for future work.

## References

1. WHO. *World health statistics 2021: monitoring health for the SDGs, sustainable development goals*. (2021). Available at: [https://cdn.who.int/media/docs/default-source/gbo-documents/world-health-statistic-reports/2021/whs-2021\\_20may.pdf?sfvrsn=55c7c6f2\\_18](https://cdn.who.int/media/docs/default-source/gbo-documents/world-health-statistic-reports/2021/whs-2021_20may.pdf?sfvrsn=55c7c6f2_18). (Accessed March 3, 2023)
2. WHO. *World health statistics 2020: monitoring health for the SDGs, sustainable development goals*. (2020). Available at: <https://apps.who.int/iris/bitstream/handle/10665/332070/9789240005105-eng.pdf>. (Accessed March 3, 2023).
3. Ahir H, Bloom N, Furceri D. 60 years of uncertainty. *Finance Dev*. (2020) 60:57–8. doi: 10.1525/fq.2006.60.2.57
4. Baker SR, Bloom N, Davis SJ. Measuring economic policy uncertainty. *Q J Econ*. (2016) 131:1593–636. doi: 10.1093/qje/qjw024
5. Ben Salah A, DeAngelis BN, Al'Absi M. Uncertainty and psychological distress during COVID-19: what about protective factors? *Curr Psychol*. (2022) 42:21470–7. doi: 10.1007/s12144-022-03244-2
6. Hansel TC, Saltzman LY, Melton PA, Clark TL, Bordnick PS. COVID-19 behavioral health and quality of life. *Sci Rep*. (2022) 12:961. doi: 10.1038/s41598-022-05042-z
7. Randall AK, Leon G, Basili E, Martos T, Boiger M, Baldi M, et al. Coping with global uncertainty: perceptions of COVID-19 psychological distress, relationship quality, and dyadic coping for romantic partners across 27 countries. *J Soc Pers Relat*. (2022) 39:3–33. doi: 10.1177/02654075211034236
8. Caldara D, Fuentes-Albero C, Gilchrist S, Zakrajšek E. The macroeconomic impact of financial and uncertainty shocks. *Eur Econ Rev*. (2016) 88:185–207. doi: 10.1016/j.eurocorev.2016.02.020

## Data availability statement

The original contributions presented in the study are included in the article/[Supplementary Material](#), further inquiries can be directed to the corresponding author.

## Author contributions

LL: Writing – original draft, Writing – review & editing.

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## Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2023.1292236/full#supplementary-material>



9. Antonakakis N, Gupta R. Is economic policy uncertainty related to suicide rates? Evidence from the United States. *Soc Indic Res.* (2017) 133:543–60. doi: 10.1007/s11205-016-1384-4
10. Vondoros S, Avendano M, Kawachi I. The association between economic uncertainty and suicide in the short-run. *Soc Sci Med.* (2019) 220:403–10. doi: 10.1016/j.socscimed.2018.11.035
11. Abdou R, Cassells D, Berrill J, Hanly J. An empirical investigation of the relationship between business performance and suicide in the US. *Soc Sci Med.* (2020) 264:113256. doi: 10.1016/j.socscimed.2020.113256
12. Abdou R, Cassells D, Berrill J, Hanly J. Revisiting the relationship between economic uncertainty and suicide: an alternative approach. *Soc Sci Med.* (2022) 306:115095. doi: 10.1016/j.socscimed.2022.115095
13. Claveria O. Global economic uncertainty and suicide: worldwide evidence. *Soc Sci Med.* (2022) 305:115041. doi: 10.1016/j.socscimed.2022.115041
14. Kalcheva I, McLemore P, Sias R. Economic policy uncertainty and self-control: evidence from unhealthy choices. *J Financ Quant Anal.* (2021) 56:1446–75. doi: 10.1017/s0022109020000265
15. Vondoros S, Avendano M, Kawachi I. The short-term impact of economic uncertainty on motor vehicle collisions. *Prev Med.* (2018) 111:87–93. doi: 10.1016/j.ypmed.2018.02.005
16. Killingsworth MA, Kahneman D, Mellers B. Income and emotional well-being: a conflict resolved. *Proc Natl Acad Sci U S A.* (2023) 120:e2208661120. doi: 10.1073/pnas.2208661120
17. Almansour A, Aslam A, Bluedorn J, Duttagupta R. How vulnerable are emerging markets to external shocks? *J Policy Model.* (2015) 37:460–83. doi: 10.1016/j.jpolmod.2015.03.009
18. Carrière-Swallow Y, Céspedes LF. The impact of uncertainty shocks in emerging economies. *J Int Econ.* (2013) 90:316–25. doi: 10.1016/j.jinteco.2013.03.003
19. Ursache SA, Gabor VR, Muntele I, Maffei M. Mortality trends by causes of death and healthcare during a period of global uncertainty (1990–2017). *Healthcare.* (2021) 9:748. doi: 10.3390/healthcare9060748
20. Beetsma RMWJ, Furtuna O, Giuliodori M, Mumtaz H. Revenue-versus spending-based fiscal consolidation announcements: follow-up, multipliers and confidence. *J Int Econ.* (2021) 131:103455. doi: 10.1016/j.jinteco.2021.103455
21. Dugas MJ, Schwartz A, Francis K. Brief report: intolerance of uncertainty, worry, and depression. *Cognit Ther Res.* (2004) 28:835–42. doi: 10.1007/s10608-004-0669-0
22. Yagil D, Cohen M. Financial uncertainty and anxiety during the COVID-19 pandemic. *Eur J Health Psychol.* (2023) 30:65–73. doi: 10.1027/2512-8442/a000119
23. French D. Causation between health and income: a need to panic. *Empir Econ.* (2012) 42:583–601. doi: 10.1007/s00181-011-0541-5
24. Swift R. The relationship between health and GDP in OECD countries in the very long run. *Health Econ.* (2011) 20:306–22. doi: 10.1002/hec.1590
25. O'Donoghue B, Howden-Chapman P, Woodward A. Why do Australians live longer than new Zealanders? *Health Educ Behav.* (2000) 27:307–16. doi: 10.1177/109019810002700305
26. Subramanian SV, Belli P, Kawachi I. The macroeconomic determinants of health. *Annu Rev Public Health.* (2002) 23:287–302. doi: 10.1146/annurev.publhealth.23.100901.140540
27. Tapia Granados JA, Ionides EL. The reversal of the relation between economic growth and health progress: Sweden in the 19th and 20th centuries. *J Health Econ.* (2008) 27:544–63. doi: 10.1016/j.jhealeco.2007.09.006
28. Renton A, Wall M, Lintott J. Economic growth and decline in mortality in developing countries: an analysis of the World Bank development datasets. *Public Health.* (2012) 126:551–60. doi: 10.1016/j.puhe.2012.03.011
29. Morgado SMA. Does health promote economic growth? Portuguese case study: from dictatorship to full democracy. *Eur J Health Econ.* (2014) 15:591–8. doi: 10.1007/s10198-013-0497-9
30. Cole WM. Wealth and health revisited: economic growth and wellbeing in developing countries, 1970 to 2015. *Soc Sci Med.* (2019) 77:45–67. doi: 10.1016/j.ssrsearch.2018.09.003
31. Wang Q. The effects of unemployment rate on health status of Chinese people. *Iran J Public Health.* (2015) 44:28–35.
32. Breuer C. Unemployment and suicide mortality: evidence from regional panel data in Europe. *Health Econ.* (2015) 24:936–50. doi: 10.1002/hec.3073
33. Wang M-C, Lin F-L, Su H-H, Kuo PL. Revisiting the relationship between suicide and unemployment in Mexico: evidence from linear and non-linear co-integration. *Front Public Health.* (2020) 8:60. doi: 10.3389/fpubh.2020.00060
34. Barros PP, Martinez-Giral X. *Health economics: an industrial organization perspective.* New York: Routledge (2012).
35. Hassan SA, Zaman K, Zaman S, Shabir M. Measuring health expenditures and outcomes in SAARC region: health is a luxury? *Qual Quant.* (2014) 48:1421–37. doi: 10.1007/s11135-013-9844-2
36. Jakovljevic M, Timofeyev Y, Ranabhat CL, Fernandes PO, Teixeira JP, Rancic N, et al. Real GDP growth rates and healthcare spending – comparison between the G7 and the EM7 countries. *Glob Health.* (2020) 16:64. doi: 10.1186/s12992-020-00590-3
37. Bokhari FA, Gai Y, Gottret P. Government health expenditures and health outcomes. *Health Econ.* (2007) 16:257–73. doi: 10.1002/hec.1157
38. Makuta I, O'Hare B. Quality of governance, public spending on health and health status in sub Saharan Africa: a panel data regression analysis. *BMC Public Health.* (2015) 15:932. doi: 10.1186/s12889-015-2287-z
39. Keynes JM. *The general theory of employment, interest, and money.* London: Macmillans (1936).
40. Ahmad NA, Ismail NW, Ahmad Sidique SF, Mazlan NS. Air pollution effects on adult mortality rate in developing countries. *Environ Sci Pollut Res Int.* (2021) 28:8709–21. doi: 10.1007/s11356-020-11191-3
41. Gangadharan L, Valenzuela MR. Interrelationships between income, health and the environment: extending the environmental Kuznets curve hypothesis. *Ecol Econ.* (2001) 36:513–31. doi: 10.1016/s0921-8009(00)00250-0
42. Katrakilidis C, Kyritsis I, Patsika V. The dynamic linkages between economic growth, environmental quality and health in Greece. *Appl Econ Lett.* (2016) 23:217–21. doi: 10.1080/13504851.2015.1066482
43. Bouchoucha N. The effect of environmental degradation on health status: do institutions matter? *J Knowl Econ.* (2020) 12:1618–34. doi: 10.1007/s13132-020-00680-y
44. Kahn ME, Lozano-Gracia N, Soppelsa ME. Pollution's role in reducing urban quality of life in the developing world. *J Econ Surv.* (2021) 35:330–47. doi: 10.1111/joes.12404
45. Lu Z-N, Chen H, Hao Y, Wang J, Song X, Mok TM. The dynamic relationship between environmental pollution, economic development and public health: evidence from China. *J Clean Prod.* (2017) 166:134–47. doi: 10.1016/j.jclepro.2017.08.010
46. Wen Q, Zhang T. Economic policy uncertainty and industrial pollution: the role of environmental supervision by local governments. *China Econ Rev.* (2022) 71:101723. doi: 10.1016/j.chieco.2021.101723
47. Angelini G, Fanelli L. Exogenous uncertainty and the identification of structural vector autoregressions with external instruments. *J Appl Econ.* (2019) 34:951–71. doi: 10.1002/jae.2736
48. Gozgor G, Demir E, Belas J, Yesilyurt S. Does economic uncertainty affect domestic credits? An empirical investigation. *J Int Financ Mark Inst Money.* (2019) 63:101147. doi: 10.1016/j.intfin.2019.101147
49. Afzali M, Çolak G, Fu M. Economic uncertainty and corruption: evidence from public and private firms. *J Financ Stabil.* (2021) 57:100936. doi: 10.1016/j.jfs.2021.100936
50. Fang J, Gozgor G, Nolt JH. Globalisation, economic uncertainty and labour market regulations: implications for the COVID-19 crisis. *World Econ.* (2022) 45:2165–87. doi: 10.1111/twec.13230
51. Gorelik G, Shackelford TK. Suicide and the moralistic fallacy: comment on Joiner, Hom, Hagan, and Silva (2016). *Evolution.* (2017) 3:287–9. doi: 10.1007/s40806-017-0087-7
52. Pompili M. Exploring the phenomenology of suicide. *Suicide Life Threat Behav.* (2010) 40:234–44. doi: 10.1521/suli.2010.40.3.234
53. Lyu J, Zhang J, Hennessy DA. Characteristics and risk factors for suicide in people with schizophrenia in comparison to those without schizophrenia. *Psychiatry Res.* (2021) 304:114166. doi: 10.1016/j.psychres.2021.114166
54. Neves SA, Marques AC, Patrício M. Determinants of CO<sub>2</sub> emissions in European union countries: does environmental regulation reduce environmental pollution? *Econ Anal Policy.* (2020) 68:114–25. doi: 10.1016/j.eap.2020.09.005
55. Munir K. Energy use and environmental degradation in Europe: evidence from panel nonlinear ARDL. *Qual Quant.* (2022) 57:2529–43. doi: 10.1007/s11135-022-01473-y
56. Ongan S, Isik C, Amin A, Bulut U, Rehman A, Alvarado R, et al. Are economic growth and environmental pollution a dilemma? *Environ Sci Pollut Res Int.* (2023) 30:49591–604. doi: 10.1007/s11356-023-25698-y
57. Bachmann R, Elstner S, Sims ER. Uncertainty and economic activity: evidence from business survey data. *Am Econ J Macroecon.* (2013) 5:217–49. doi: 10.1257/mac.5.2.217
58. Baker SR, Bloom N, Davis SJ, Terry SJ. *COVID-induced economic uncertainty.* (2020). Available at: <https://www.nber.org/papers/w26983> (Accessed February 5, 2023).
59. Ahmed Z, Cary M, Shahbaz M, Vo XV. Asymmetric nexus between economic policy uncertainty, renewable energy technology budgets, and environmental sustainability: evidence from the United States. *J Clean Prod.* (2021) 313:127723. doi: 10.1016/j.jclepro.2021.127723
60. Adams S, Adedoyin F, Olaniran E, Bekun FV. Energy consumption, economic policy uncertainty and carbon emissions: causality evidence from resource rich economies. *Econ Anal Policy.* (2020) 68:179–90. doi: 10.1016/j.eap.2020.09.012
61. Atsu F, Adams S. Energy consumption, finance, and climate change: does policy uncertainty matter? *Econ Anal Policy.* (2021) 70:490–501. doi: 10.1016/j.eap.2021.03.013
62. Adedoyin FF, Ozturk I, Agboola MO, Agboola PO, Bekun FV. The implications of renewable and non-renewable energy generating in sub-Saharan Africa: the role of economic policy uncertainties. *Energy Policy.* (2021) 150:112115. doi: 10.1016/j.enpol.2020.112115
63. Yu J, Shi X, Guo D, Yang L. Economic policy uncertainty (EPU) and firm carbon emissions: evidence using a China provincial EPU index. *Energy Econ.* (2021) 94:105071. doi: 10.1016/j.eneco.2020.105071



64. Abbasi KR, Adedoyin FF. Do energy use and economic policy uncertainty affect CO<sub>2</sub> emissions in China? Empirical evidence from the dynamic ARDL simulation approach. *Environ Sci Pollut Res Int.* (2021) 28:23323–35. doi: 10.1007/s11356-020-12217-6
65. Zhang W, Huang Y, Wu H. The symmetric and asymmetric effects of economic policy uncertainty and oil prices on carbon emissions in the USA and China: evidence from the ARDL and non-linear ARDL approaches. *Environ Sci Pollut Res.* (2022) 29:26465–82. doi: 10.1007/s11356-021-17839-y
66. Bai P, Tang Y, Zhang W, Zeng M. Does economic policy uncertainty matter for healthcare expenditure in China? A spatial econometric analysis. *Front Public Health.* (2021) 9:673778. doi: 10.3389/fpubh.2021.673778
67. Cheng CHJ, Witvorapong N. Health care policy uncertainty, real health expenditures and health care inflation in the USA. *Empir Econ.* (2019) 60:2083–103. doi: 10.1007/s00181-019-01818-x
68. Davis ME. Recessions and health: the impact of economic trends on air pollution in California. *Am J Public Health.* (2012) 102:1951–6. doi: 10.2105/AJPH.2012.300658
69. Tucker M. Carbon dioxide emissions and global GDP. *Ecol Econ.* (1995) 15:215–23. doi: 10.1016/0921-8009(95)00045-3
70. Grossman GM, Krueger AB. Economic growth and the environment. *Q J Econ.* (1995) 110:353–77. doi: 10.2307/2118443
71. Zhang Y, Zhang S. The impacts of GDP, trade structure, exchange rate and FDI inflows on China's carbon emissions. *Energy Policy.* (2018) 120:347–53. doi: 10.1016/j.enpol.2018.05.056
72. Ampon-Wireko S, Zhou L, Dauda L, Xu X, Larnyo E, Kwame ENN. Does carbon emission, energy consumption and income matter? Investigating factors affecting healthcare expenditure among 61 nations. *Singap Econ Rev.* (2023):1–17. doi: 10.1142/s0217590823500030
73. Steinberger JK, Lamb WF, Sakai M. Your money or your life? The carbon-development paradox. *Environ Res Lett.* (2020) 15:044016. doi: 10.1088/1748-9326/ab7461
74. Brunner E, Maruyama K. SP4-32 health and sustainability: international ecological study of carbon dioxide emissions and life expectancy. *J Epidemiol.* (2011) 65:A442–3. doi: 10.1136/jech.2011.142976p.26
75. He L, Li N. The linkages between life expectancy and economic growth: some new evidence. *Empir Econ.* (2020) 58:2381–402. doi: 10.1007/s00181-018-1612-7
76. Wang Z, Asghar MM, Zaidi SAH, Nawaz K, Wang B, Zhao W, et al. The dynamic relationship between economic growth and life expectancy: contradictory role of energy consumption and financial development in Pakistan. *Struct Change Econ Dyn.* (2020) 53:257–66. doi: 10.1016/j.strueco.2020.03.004
77. Nishiyama A. Economic growth and infant mortality in developing countries. *Eur J Dev Res.* (2011) 23:630–47. doi: 10.1057/ejdr.2011.17
78. Bressler RD. The mortality cost of carbon. *Nat Commun.* (2021) 12:4467. doi: 10.1038/s41467-021-24487-w
79. Lynn R. Anxiety and economic growth. *Nature.* (1968) 219:765–6. doi: 10.1038/219765b0
80. Lynn R. National rates of economic growth, anxiety and suicide. *Nature.* (1969) 222:494. doi: 10.1038/222494a0
81. Svirydenko K. *Introducing a new broad-based index of financial development.* (2016). Available at: <https://elibrary.imf.org/view/journals/001/2016/005/001.2016.issue-005-en.xml> (Accessed March 15, 2023)
82. Dreher A. Does globalization affect growth? Evidence from a new index of globalization. *Appl Econ.* (2006) 38:1091–110. doi: 10.1080/00036840500392078
83. Cole MA, Neumayer E. The impact of poor health on total factor productivity. *J Dev Stud.* (2006) 42:918–38. doi: 10.1080/00220380600774681
84. Guo B, Feng W, Cai H, Lin J. Influence of public hospital reform on public health: evidence from a quasi-natural experiment in China. *Front Public Health.* (2023) 11:11. doi: 10.3389/fpubh.2023.1104328
85. Zhang W, Zhang X, Tian X, Sun F. Economic policy uncertainty nexus with corporate risk-taking: the role of state ownership and corruption expenditure. *Pac. Basin Finance J.* (2021) 65:101496. doi: 10.1016/j.pacfin.2021.101496
86. Su D, Xu S, Tong Z. Credit availability and corporate risk-taking: evidence from China's green credit policy. *Post-Communist Econ.* (2023) 35:236–70. doi: 10.1080/14631377.2023.2169516
87. Qin M, Zhang X, Li Y, Badarcea RM. Blockchain market and green finance: the enablers of carbon neutrality in China. *Energy Econ.* (2023) 118:106501. doi: 10.1016/j.eneco.2022.106501
88. Zhang W, Zeng M, Zhang Y, Su C-W. Reducing carbon emissions: can high-speed railway contribute? *J Clean Prod.* (2023) 413:137524. doi: 10.1016/j.jclepro.2023.137524
89. Canova F, Ciccarelli M. Panel vector autoregressive models: a survey In: TB Fomby, L Kilian and A Murphy, editors. *VAR models in macroeconomics—new developments and applications: essays in honor of Christopher A. Sims.* Bingley: Emerald Group Publishing Limited (2013). 205–46.
90. Huber F, Krisztin T, Pfarrhofer M. A Bayesian panel VAR model to analyze the impact of climate change on high-income economies. *arXiv.* (2021). Available at: <http://arxiv.org/abs/1804.01554>. (Accessed January 18, 2023). (Epub ahead of preprint).
91. Koop G, Korobilis D. Model uncertainty in panel vector autoregressive models. *Eur Econ Rev.* (2016) 81:115–31. doi: 10.1016/j.eurocorev.2015.09.006



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# Impact of the new rural social pension insurance on the health of the rural older adult population: based on the China health and retirement longitudinal study

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The health issues of China's older adult population in rural areas have been receiving increasing attention with the continuous expansion of the nation's ageing population and the continuous promotion of urban-rural integration. The impact of the new rural social pension insurance (NRSPI) on the health of the rural older adult population, the mechanism of its action and how old-age service can be improved and optimised according to the health needs of the rural older adult population are urgent and realistic challenges. Based on survey data from the China Health and Retirement Longitudinal Study in 2015 and 2018, this study applies a multivariate ordered logistic regression model to explore the impact mechanism and effect of the NRSPI on the older adult population health in rural China while controlling for endogeneity. The results show that participation in the NRSPI can significantly improve the health of the rural older adult population at a 1% level. The results of the heterogeneity test reveal that the NRSPI has a significant impact on the self-reported health of the rural older adult at a 1% level, with a significantly positive impact on the mental and physical health of rural female older adult, whereas the impact on male older adult is not significant. The mediating effect test results show that medical services, food access and entertainment activities have a mediating effect on the new rural social endowment insurance. The results of the moderating effect test indicate that the NRSPI regulates 7.8% of the effect of physical health on mental health and 10.7% of the effect of mental health on physical health. Based on these findings, this study proposes to strengthen the construction of healthy lifestyle guidance and emotional support systems while improving the NRSPI's participation rate and treatment level to meet the diverse health service needs of different older adult groups.

## KEYWORDS

new rural social pension insurance, rural older adult population health, logistic regression model, mediating effect, moderating effect

## Introduction

Since the 1990s, China has experienced a sustained rapidly ageing population (1). The scale and proportion of the older adult population are generally on the rise and the rate of growth has been accelerating (2). According to the 2020 National Ageing Development Bulletin issued by the National Health Commission of China and the seventh national census data, the number of

older adult people aged 60 and over and 65 and over in China reached 264 million and 190 million, respectively. The proportion of the total population increased from 13.26% and 8.87% during the sixth national census to 18.7% and 13.5%, respectively. More than 50% of the older adult live in rural areas with relatively limited economic and social development, and the degree of ageing in rural areas has been consistently higher than that in cities and towns. Due to imbalanced economic development and inadequate social security benefits, the health service needs of the older adult in rural China are particularly severe (3). The health problems of the rural older adult are reflected in self-reported health as well as actual physical and mental health figures. In addition, the relative poverty caused by the considerable income gap of the rural older adult and health inequality caused by urban–rural differences and uneven distribution of pensions must also be urgently addressed. To improve the health of the older adult in rural areas, the Outline of the 14th Five-Year Plan for China's National Economic and Social Development, the (14th Five-Year) National Plan for the Development of the Cause of Ageing and the Pension Service System and the 14th Five-Year Plan for Healthy Ageing in 2022 clearly recognised that the health of the older adult must be raised as a national strategy, and a plan to promote the achievement of a comprehensive and continuous health service system for the older adult covering urban and rural areas, rationally allocate health services for the older adult (particularly health service resources for the rural older adult) and continuously improve the health of the rural older adult population.

In the face of China's increasingly severe ageing trend and the health inequality of the older adult population in urban and rural areas, the traditional family pension model in rural areas has been weakened. Further improving the social pension insurance system is crucial for ensuring the basic lives of the rural older adult and improving the health of the rural older adult population. In this context, the State Council of China began to conduct pilot reform via the new rural social pension insurance (NRSPI) in 2009, basically achieving full coverage in rural areas in 2012. The purpose of the NRSPI is to address the problem of inadequate health services for the rural older adult to achieve a sense of security. As a continuation of China's livelihood security system, the NRSPI is the core of the existing rural social old-age security system and the key to ensuring the equalisation of urban and rural old-age services. Its biggest characteristic is to adopt the mode of combining three financing channels of individual payment, collective subsidy and government subsidy. Through the external subsidy support of the government, it provides a new pension income for the rural older adult to alleviate their living pressure, improve their living standards, and bring some support and guarantee to their economic life. Accordingly, investigations of the socio-economic effects of the NRSPI have also attracted academic attention. As the basic insurance system for the older adult in rural China, can the NRSPI achieve the goal of improving the health of the rural older adult population? If so, through what channels does the NRSPI effectively advance health protection for the rural older adult? What is its mechanism of action? These questions require investigation. Based on China's population ageing, the goal of healthy ageing and the policy orientation of the Healthy China initiative, this study use the multivariate ordinal logistic regression model, narrows the traditional research scope to the impact of the NRSPI on the health status of rural older adult population by constructing the mediating effect and moderating effect

hypothesis to propose corresponding policy implications regarding the optimal path for pension service in the current NRSPI system.

## Literature review

Since the end of the 20th century, an increasing number of nations have experienced rapidly ageing societies. The issues of pension insurance and older adult population health have become urgent challenges for many governments. As the academic community has increasingly examined health inequality among older adult populations, the impact of China's NRSPI on the health of the rural older adult population has become a popular topic of academic research. Based on previous research, this study primarily presents three topics in the relevant literature, including the effects of NRSPI policy implementation, the influencing factors of older adult population health and the impact of the NRSPI on older adult population health.

### Research on the effect of NRSPI implementation and its impact

In previous research, although the NRSPI was merged with urban residents' basic pension insurance in 2014, the academic community is still accustomed to referring to it as the NRSPI. The NRSPI is significant aspect of China's social security system reform and development and a crucial measure to protect the livelihoods and welfare of the older adult in rural areas. As the research object of interdisciplinary fields such as economics, politics, demography and sociology, the challenge of rural old-age care has been a popular research topic. Since NRSPI policy implementation, previous research has conducted a series of studies on the conditions, methods and effects of insurance participation (4). These studies have focused on analysing the advantages and disadvantages of NRSPI implementation (5–8), and the majority of the research has focused on the impact of the NRSPI on the economic status of rural older adult (9). Some studies have analysed the effect of the NRSPI on older adult population income and poverty reduction, consumption promotion and crowding out effects of savings from an economic perspective (10–14). Some studies have also explored the impact of the NRSPI on the family lives of the rural older adult, its impact on the traditional family pension model and its impact on grandchild care from the perspective of inter-generational support (15–20). Some studies have examined the impact of the NRSPI on the labour supply of the rural older adult, including agricultural labour supply and other labour supply related to land transfer (21–24).

### Research on the influencing factors of older adult population health

With growing emphasis on investigating older adult population health in the academic community, based on Grossman's health needs theory and associated model (25), considerable research has examined the health of the older adult population from multiple fields and perspectives, exploring a variety of factors, including individual characteristics, urban–rural differences, socio-economic status and

social security (26–33). In addition, based on the factors affecting health inequality proposed by Fleurbaey and Schokkaert (34, 35), combined with the environmental factors of China's unique urban and rural household registration system, some studies have focused on the health inequality of the rural older adult population (36–42).

## Research on the impact of NRSPI implementation on older adult population health

In recent years, with the implementation of China's policy to promote basic old-age care services for all older adult citizens, the academic community has also applied a variety of data resources and conducted extensive and in-depth research on the impact mechanism between the NRSPI and the challenges of addressing older adult population health from multiple perspectives. Some research has examined whether the NRSPI policy has promoted older adult population health, including physical and psychological depression and subjective well-being dimensions (43–47). In terms of research methods, some scholars have explored the impact mechanism of the NRSPI on older adult population health based on micro-sectional data using propensity score matching (PSM) or instrumental variable approaches. Some studies have constructed balanced panel data using the PSM difference-in-differences (PSM-DID) method to evaluate NRSPI impacts. These studies have primarily empirically tested the impact of the NRSPI on income, consumption, labour supply, inter-generational support, poverty reduction and other aspects of its impact on the older adult (48–51).

## Related literature review

The literature review reveals that previous research has generally investigated the correlation between pension insurance and older adult population health, conducting research on the performance of pension insurance on older adult population health from multiple perspectives; however, some considerations need to be deepened and improved. First, the existing research objects primarily include the entire older adult population, and a limited number of studies have conducted research on the rural older adult population based on China's unique urban and rural household registration. In addition, previous research on older adult population health has been largely based on self-reported or physical health, and few scholars have included mental health considerations. Second, previous literature has rarely explored the path through which the NRSPI system promotes rural older adult health, lacking considerations of the impact path of the NRSPI system and mediating effect analyses. It is challenging to accurately quantify how the NRSPI system has improved the health of the rural older adult. Third, primary research conclusions regarding the impact of the NRSPI system on the health of the older adult are contradictory. This could be related to the year(s) of the survey data examined. The time span of the cross-sectional data examined in the previous research has been earlier, and the span of the balanced panel data constructed has been shorter, without consideration of the inherent hysteresis of the NRSPI's institutional effects.

Based on the above, this study uses data from the most recent China Health and Retirement Longitudinal Study (CHARLS) which

were conducted in 2015 and 2018, takes the rural older adult population in China as the main research object, using self-reported health, mental health and physical health as explanatory variables to evaluate the health of the older adult and applies health demand, life cycle and social support theories as the primary theoretical basis. Using a multivariate ordered logistic model, this study examines the effects of NRSPI implementation on the health status of the older adult in rural China and its heterogeneous effects on rural older adult of different genders. The study also proposes mediating and moderating effect hypotheses to analyse and test the effect of the NRSPI on rural older adult population health, providing scientific and feasible theoretical insights for China to further improve the basic rural pension insurance system and improve rural older adult health.

## Marginal contributions

Referencing previous research ideas, this study aims to comprehensively explore the impact of the NRSPI on China's rural older adult population health, with the following four contributions. First, in terms of research objects, this study takes the rural older adult divided by China's unique urban and rural household registration as the research object, classifies older adult health into self-rated, mental and physical health and empirically analyses the impact of the NRSPI on the health of the rural older adult to provide a valuable policy reference for improving China's NRSPI system and rural older adult health. Second, in terms of research methods, this study applies the multivariate ordinal logistic regression model to the latest CHARLS data in 2015 and 2018 to analyse the impact of the NRSPI on rural older adult population health. The research conclusions provide valuable insights for improving the implementation of this new rural insurance policy. Third, in terms of theoretical mechanisms, this study constructs a theoretical model to quantify the effects of the NRSPI on rural older adult health and proposes research hypotheses regarding mediating and moderating effects to deepen the understanding of the relationship between the NRSPI and rural older adult health and investigates how the NRSPI has improved medical service, leisure and entertainment activities and nutrition for China's rural older adult.

## Theoretical analysis and research hypotheses

This study reference the research of Wu et al. (52), through theoretical analysis, explain how the implementation of NRSPI will affect the health of the older adult population from the theoretical logic, and puts forward three propositions as the hypothesis of this empirical research.

Based on the health demand theory of Grossman (25), this study includes age, gender, marital status, income level, recreational activities, social class and social insurance as potential influencing factors. This study argues that health can be considered as an investment product in which income and recreational activities can increase individuals' health stock. Individuals can protect their health by procuring medical services and spending leisure and entertainment time. As a social insurance factor in the health demand function, the NRSPI increases older adult pension income and leisure and entertainment time, which subsequently improves rural older adult



health (52). Specifically, income is a significant factor in determining the health of the older adult in rural areas. Pension income can improve individuals' socio-economic status, which allows the older adult to have sufficient risk resistance, less mental stress and higher self-reported health when facing health risks (53). Pension income can also improve health awareness and mental health, cause the older adult to prioritise their own health, provide more choices in medical treatment and positively impact physical health (43). In addition, when the rural older adult secure a stable pension income, leisure and entertainment activities are expected to increase, which also improves rural older adult health. Therefore, this study proposes Hypothesis 1.

**Hypothesis 1:** The NRSPI has a positive impact on rural older adult population health.

Referencing the life cycle theory of Modigliani (54), this study argues that rational economic individuals will allocate income and make decisions regarding consumption and savings across the entire life cycle according to the principle of utility maximisation. As a stable source of income, the NRSPI has impacted the medical consumption decisions of the rural older adult throughout the life cycle, increasing consumption expenditure for disease prevention (55), reducing the occurrence of chronic diseases, promoting the use of medical services and improving the activities of daily life, which significantly enhances the physical health of the insured older adult (56, 57). The NRSPI has also increased rural older adult families' disposable income, reduced the uncertainty of future income and inhibited current pension-saving practices, with a significant effect on healthy consumption and nutritious dietary consumption (58). The policy has increased the variety of food intake and promoted improved eating habits and dietary balance, ultimately enhancing the health performance and physical health status of the rural insured older adult (43). Therefore, this study proposes Hypothesis 2.

**Hypothesis 2:** The NRSPI has a positive impact on the physical health of the older adult in rural areas by increasing medical services through health care disbursement and diversifying the variety of food intake to promote a balanced diet.

Based on the theory of social support, this study contends that when the economic support of the children of the older adult in rural areas is inadequate to support the older adult (26), support at the macro level of society can alleviate the economic pressure experienced by the older adult. Therefore, as a formal social support provided by the government, the NRSPI delivers stable pension income for the older adult in rural areas, replacing labour income, reducing labour time, increasing disposable leisure time to participate in more leisure and other recreational activities, alleviating concerns regarding old age, improving life satisfaction and boosting mental health and subjective well-being (44). Increased recreational activities also improve the cognitive functions of the older adult, generating confidence in the future, increasing happiness and satisfaction and more optimism regarding personal health evaluation, which improves the level of self-reported health (47, 59). Therefore, this study proposes Hypothesis 3.

**Hypothesis 3:** The NRSPI improves the mental and self-reported health of the rural older adult by increasing opportunities for recreational activities (Figure 1).

## Empirical analysis

### Model setting

#### Benchmark regression model

Based on the above theoretical analysis, to examine the impact of the NRSPI on rural older adult population health, this study refers to Werner et al. (60), and uses the health level of the rural older adult (self-reported health evaluation, mental health and physical health) as the explained variable, and whether the NRSPI was implemented as the explanatory variable. The mediating variables are also incorporated and other variables that may affect health are introduced as control variables, and the multivariate ordered logistic model is used as the benchmark regression model. The details are as follows:

$$sfe_{it} = \alpha_0 + \alpha_1 nrspi_{it} + \alpha_2 controls_{it} + \psi_i + \psi_t + \varepsilon_{it} \quad (1)$$

$$mth_{it} = \alpha_3 + \alpha_4 nrspi_{it} + \alpha_5 controls_{it} + \psi_i + \psi_t + \varepsilon_{it} \quad (2)$$

$$psh_{it} = \alpha_6 + \alpha_7 nrspi_{it} + \alpha_8 controls_{it} + \psi_i + \psi_t + \varepsilon_{it} \quad (3)$$

where subscripts  $i$  and  $t$  represent the rural older adult individual and year, respectively;  $sfe_{it}$ ,  $mth_{it}$  and  $psh_{it}$  represent the self-reported health evaluation, mental and physical health of individual  $i$  in year  $t$ ;  $nrspi_{it}$  represents whether individual  $i$  participated in the NRSPI in year  $t$ ;  $\psi_i$  and  $\psi_t$  represent individual and year fixed effects, respectively;  $controls_{it}$  is a series of related control variables at the individual level; and  $\varepsilon_{it}$  represents the random disturbance term.

#### Mediating mechanism test model

In addition to the direct effects embodied in Eqs 1–3, to explore possible indirect effects, this study references Wen et al. (61), testing the mediating effects of medical services, food acquisition and recreational activities between the NRSPI and rural older adult population health. The specific form of the model is set as follows:

$$\ln Mid_{it} = \beta_0 + \beta_1 nrspi_{it} + \beta_2 controls_{it} + \psi_i + \psi_t + \varepsilon_{it} \quad (4)$$

$$sfe_{it} = \eta_0 + \eta_1 nrspi_{it} + \eta_2 \ln Mid_{it} + \eta_3 controls_{it} + \psi_i + \psi_t + \varepsilon_{it} \quad (5)$$

$$mth_{it} = \eta_4 + \eta_5 nrspi_{it} + \eta_6 \ln Mid_{it} + \eta_7 controls_{it} + \psi_i + \psi_t + \varepsilon_{it} \quad (6)$$

$$psh_{it} = \eta_8 + \eta_9 nrspi_{it} + \eta_{10} \ln Mid_{it} + \eta_{11} controls_{it} + \psi_i + \psi_t + \varepsilon_{it} \quad (7)$$

Equations 4–7 examine the mediating effect of  $\ln Mid_{it}$  using a step-wise regression. The potential mediating variables include medical services ( $msv$ ), food acquisition ( $fas$ ) and recreational activities ( $rac$ ), and the remaining variables are the same as above.

#### Moderating effect test model

Referencing Jiang (62), this study constructs the following moderating effect model:



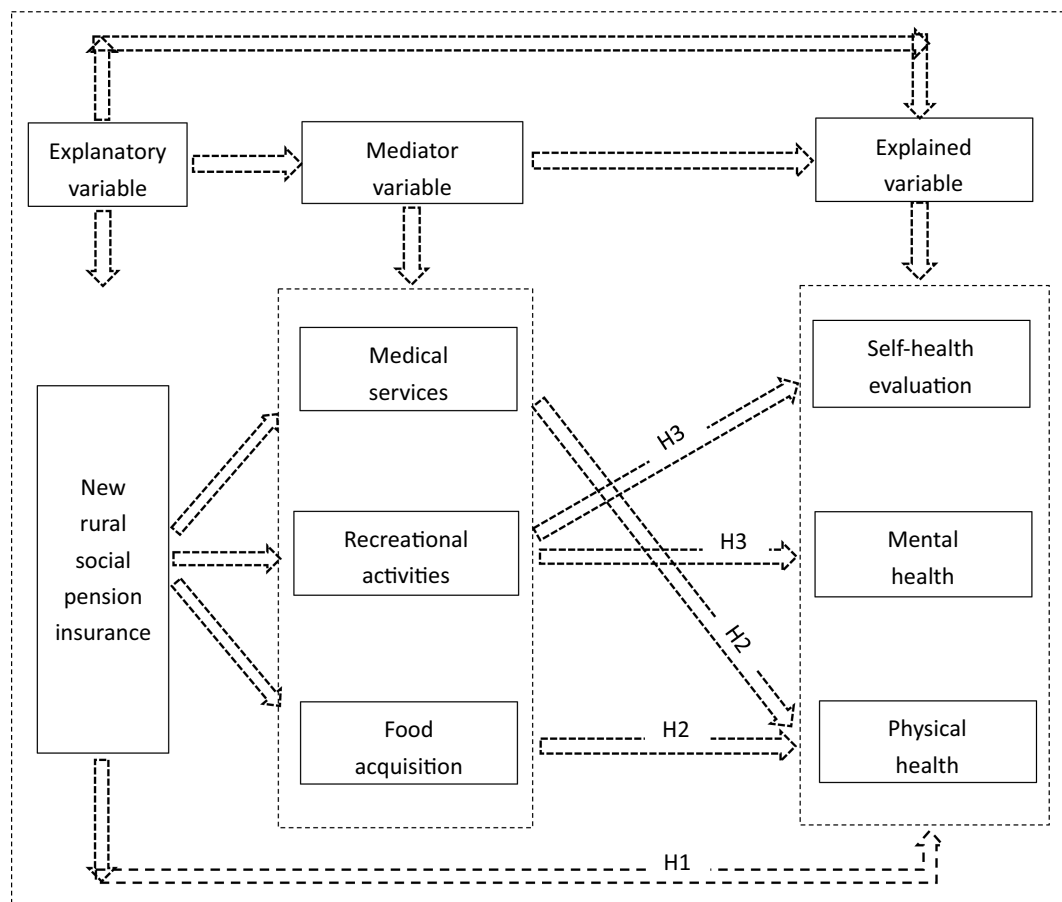


FIGURE 1  
The research roadmap.

$$mth_{it} = \sigma_0 + \sigma_1 nrspi_{it} + \sigma_2 mth_{it} \times psh_{it} + \sigma_3 psh_{it} + \sigma_4 controls_{it} + \psi_i + \psi_t + \varepsilon_{it} \quad (8)$$

$$psh_{it} = \sigma_5 + \sigma_6 nrspi_{it} + \sigma_7 mth_{it} \times psh_{it} + \sigma_8 mth_{it} + \sigma_9 controls_{it} + \psi_i + \psi_t + \varepsilon_{it} \quad (9)$$

The results of the moderating effect test primarily concern the significance of the interaction term coefficients  $\sigma_2$  and  $\sigma_7$  to verify the positive and negative and significance of the product coefficients of mental and physical health in Eqs 8, 9. The remaining variables are the same as above.

## Variable descriptions

### Explanatory variables

The explanatory variable in this study is rural older adult individuals' participation in the NRSPI, which comes from the question: Do you participate in the new rural insurance? In the CHARLS questionnaire. This is a dummy variable, taking the value of 1 if the respondent participated in the NRSPI, otherwise, a 0 value is assigned.

## Explained variables

### Measurement model

This study refers to the practice of Haan and Uhlenhorff (63), and prepares five options for the design of the questionnaire on the health status of the rural older adult: very good, good, general, bad, very bad. This is the explanatory variable of this study, covering the possible aspects of the health status of the rural older adult. Self-reported health evaluation, mental health and physical health, which are all ordered categorical variables with values of 1–5, which is a typical sortable choice. Therefore, the multivariate ordered Logistic model is used to estimate this effect, and the basic model is constructed as follows:

$$P(y = j|x_i) = \frac{1}{1 + e^{-(\alpha + \beta x_i)}} \quad (10)$$

where  $x_i$  represents the  $i$  index variable, and  $y$  is the actual observation value, which is assigned to 1, 2, 3, 4 or 5, respectively, representing the probable older adult individual's health status in each option. The potential implicit variable  $y^*$  is introduced into the ordered logistic model as a unidirectionally observable value to examine the health status of the older adult, where  $y^*$  satisfies the following form:

$$y^* = AX + \varepsilon_i \quad (11)$$

where  $X$  is the explanatory variable,  $A$  is the parameter vector to be estimated and  $\varepsilon_i$  is the model intercept.  $\gamma$  represents the critical demarcation point of the unknown results of the health status of the middle-aged and older adult people in this study; that is,  $\gamma_1, \gamma_2, \gamma_3$  and  $\gamma_4$ , representing four demarcation points. After obtaining the parameter estimates of  $\varepsilon_i$  and  $\varepsilon_b$ , the probability of each value of  $y$  can be obtained as follows:

$$P(y \leq j|X) = \frac{e^{-(\alpha + \beta x_i)}}{1 + e^{-(\alpha + \beta x_i)}} \quad (12)$$

## Measurement method

### Self-reported health evaluation (*sfe*)

This study references the CHARLS question: what do you think of your health? As the measure of self-reported health. The responses include very good, good, general, bad or very bad, and the specific assignments are presented in Table 1.

### Mental health (*meth*)

This study uses life satisfaction, cognitive ability and depression indices to measure the mental health of the rural older adult. To measure mental health, the life satisfaction index references the CHARLS questionnaire's DC028: are you satisfied with your life, which includes responses of extremely satisfied, very satisfied, relatively satisfied, not very satisfied and not satisfied at all. At the same time, according to the cognitive assessment scale and the cognitive portion of the CHARLS questionnaire's DC01–DC08 and

DC19–DC27 questions, measures the cognitive level of the rural older adult in terms of orientation, reaction and memory. We obtain continuous variables referencing these questions. A higher score indicates higher cognitive abilities. In addition, questions DC009–DC018 are used in combination with the depression level scale to quantify the data of mental health rating as a main variable to measure depression status in mental health to comprehensively reflect the degree of depression among the rural older adult.

This study references the research methods of Tao and Shen (26) regarding indicators of mental health. Through factor analysis, three principal components are extracted which represent first-level indicators. The proportion of each rotating squared sum load to the total load of the three principal components is obtained via maximum variance rotation, to setting the weights of these three dimensions to 34.3116%, 33.1109%, and 32.5775%. Since the proportions of the three dimensions of mental health in the 2018 CHALRS questionnaire are equally important, this study directly applies one-third weight to the secondary indicators of mental health. Applying the entropy weight method to the three indicators to ensure rationality and accuracy, the objective assignment comprehensively considers errors and distortions, finally determining the entropy weight of the mental health dimension according to the distribution method presented in Table 2, which divides the mental health dimension in more detail.

### Physical health (*psh*)

In this study, residents' daily living self-care ability (ADL) represents rural older adult residents' objective physiological health status. Seven indicators of ADL are used, including whether respondents can run or jog for 1 km, bend and bend their knees or squat, dress independently, bathe independently, eat independently, go to the toilet independently and control physiological excretion. According to the internationally accepted definition, if one or more of the above seven activities of daily living require assistance from others

TABLE 1 Variable definition and descriptive statistics.

Variable name	Index selection	Variable definition	Maximum value	Minimum value	Mean value
Explanatory variable	<i>nrspi</i>	Participation = 1; not participated = 0	1	0	0.761
Explained variable	<i>sfe</i>	Very bad = 1; bad = 2; general = 3; good = 4; very good = 5	5	1	3.092
	<i>meth</i>	Very bad = 1; bad = 2; general = 3; good = 4; very good = 5	5	1	3.587
	<i>psh</i>	Very bad = 1; bad = 2; general = 3; good = 4; very good = 5	5	1	3.255
Control variable	<i>age</i>	The actual age of the older adult	108	60	68.786
	<i>sex</i>	Male = 1; female = 2	2	1	1.531
	<i>mst</i>	With spouse = 1; without spouse = 0	1	0	0.782
	<i>icl</i>	Gross annual income	8922.369	0	6545.492
	<i>sst</i>	1 represents the lowest level; 10 represents the highest level	10	1	4.055
Mediator variable	<i>msv</i>	Sufficient = 1; insufficient = 0	1	0	0.858
	<i>fas</i>	Sufficient = 1; insufficient = 0	1	0	0.446
	<i>rac</i>	Participation = 1; not participate = 0	1	0	0.253

The three digits after the decimal point are rounded.

TABLE 2 Mental health right weight table.

First grade indexes	Second index	Weight	Third grade indexes	Weight
Mental health	Life self-evaluation satisfaction	1/3	Overall, are you satisfied with your life	0.3333
			MMS Memory 1 (10 questions)	0.0192
			MMS Memory 2 (10 questions)	0.0152
			MMS Memory 3 (10 questions)	0.015
	Cognitive scale	1/3	MMS Directional force 1	0.0557
			MMS Directional force 2	0.0047
			MMS Directional force 3	0.0513
			MMS Basic cognition 1	0.0539
			MMS Basic cognition 2	0.0560
			MMS Basic cognition 3	0.0156
			MMS Basic cognition 4	0.0467
	Depression scale	1/3	I'm troubled by some small things	0.0323
			It is difficult for me to concentrate when doing things.	0.0297
			I'm feeling down.	0.0293
			I find it hard to do anything.	0.0278
			I am full of hope for the future	0.0214
			I feel afraid	0.0579
			My sleep is not good	0.0278
			I am very happy	0.0140
			I feel lonely.	0.0436
			I feel like I can't go on with my life	0.0496

to complete, respondents are considered to have daily living ability limitations, and the ADL health index is assigned to 0. Conversely, if the seven activities of daily living can be completed independently, the ADL health index is assigned to 1. The specific assignments are presented in [Table 1](#).

### Control variables

Referencing Grossman's health demand theory (25) and Liu and Liu (43), this study uses three groups of control variables. The first is individual characteristics, including age (*age*), sex (*sex*) and marital status (*mst*). The second includes the economic characteristic of income level (*icl*), and the third is social characteristics, covering social stratum (*sst*).

### Mediating variables

To further explore the impact of the NRSPI on the physical and mental health of the rural older adult, this study references Wu et al. (52), introducing mediating variables of social, life and spiritual levels and setting medical services (*msv*), food acquisition (*fas*) and recreational activities (*rac*) as mediating variables to examine how the NRSPI affects health status based on these variables.

### Data sources

This study takes the rural older adult in China as the research sample, and micro-data employed are from the 2015 and 2018 CHARLS conducted by the National Development Research Institute

of Peking University and implemented by the China Social Science Survey Centre. The main reason for choosing this database is its alignment with international experience, including the United States Health and Retirement Survey, the British Longitudinal Ageing Survey and the European Health, Ageing and Retirement Survey (SHARE) and pioneering electronic mapping software (CHARLS-GIS) technology, using a mapping method which produces village-level sampling frames. The samples cover more than 150 county-level units and 450 community-(village) level units in 28 provinces (autonomous regions and municipalities) across China, representing 19,000 respondents and 12,400 households. These data are high-quality and provide micro-level information on households and individuals of middle-age and older adult people aged 45 and above. In order to obtain the net effect of NRSPI, this study separates NRSPI from other types of pension or pension insurance, and further screens the samples, excluding individuals who had participated in the Old rural social pension insurance before 2009 and had retired and enjoyed pension or pension in 2009. In addition, in order to study the impact of NRSPI on the health status of the rural older adult, this paper only selects the rural older adult aged 60 and over in the sample, and the age distribution between the samples is relatively concentrated. The effect of age segmentation on the regression results is not significant, so the urban-rural distribution and age segmentation are eliminated from the individual characteristics. The final analysis data contains 1,660 samples. At the same time, according to the needs of the robustness test part, this paper synthesizes the CHARLS 2015 and 2018 survey data into panel data for the PSM-DID test.

## Descriptive statistics

Table 1 presents the descriptive statistical analysis results of the main variables. The explanatory variable used examines whether the respondent participated in the NRSPI, with an average of 0.761. The purchase rate, implementation and participation effect of the NRSPI can be directly quantified using the CHARLS (2018) survey data. The explained variables include self-reported health evaluation, mental health and physical health, which are all ordered categorical variables with values of 1–5, and the mean values are 3.092, 3.587 and 3.255, respectively.

## Empirical results and additional tests

### Benchmark regression results

This study adopts a step-wise regression analysis method. Columns (2) and (3) of Table 3 present the regression results using self-reported health evaluation as the explained variable, columns (4) and (5) present the regression results using mental health as the explained variable and columns (6) and (7) present the regression results using physical health as the explained variable. Columns (2) and (6) of Table 3 reveal that the NRSPI has a significant positive impact on the self-reported health evaluation and physical health of the rural older adult at the 1% level. The rural older adult who benefit from the NRSPI exhibit improved self-reported health evaluation and physical health compared with those who do not participate in the NRSPI. The impact coefficient of the NRSPI on the self-reported health evaluation and physical health of the rural older adult decreases after introducing control variables but remains significantly positive. This demonstrates that the NRSPI improves the economic circumstances of the rural older adult and increases the variety of food acquisition and medical service expenditure, which improves physical health. Individuals in similar physical condition with more income channels have sufficient social support and more optimistic self-reported health evaluation due to higher overall income, which has a positive impact on self-reported health evaluation and physical health (3, 8, 26). Notably, the regression results show that although the influence coefficient of the NRSPI on mental health is positive, it is not significant, indicating that the

NRSPI exerts a minimal positive impact on the mental health of the rural older adult. The relatively stable pension can mitigate financial worries and increase leisure and entertainment activities to elicit optimistic attitudes and alleviate the depression of the rural older adult. It also reduces the inter-generational support and spiritual comfort of children, which is cited as the primary reason the mental health problems of the insured rural older adult remain prominent. The regression results also verify the conclusions of the existing literature (43–45). Hypothesis 1 is verified.

### Heterogeneity analyses

Influenced by historical factors, traditional concepts and physical characteristics, considerable differences are evident in the social and economic status of rural older adult groups of different genders, which affect health status. This study examines the impact of the NRSPI on the physical and mental health of rural older adult men and women. The regression results in Table 4 indicate that the impact of the NRSPI on the health of the rural older adult of different genders is simultaneously consistent and diverse. The NRSPI has a significant impact on the self-reported health evaluation of older adult rural males and females at the 1% level, revealing that older adult males and females who participate in the NRSPI have higher self-reported health evaluation than those who do not participate. In addition, the NRSPI has a significant impact on the physical health of rural older adult females, but the impact on males is not significant. The rationale for this difference may be the considerable differences in the social economy between older adult males and females in rural areas and notable differences in the timeliness and feasibility of older adult care and medical treatment for older adult males and females. The above heterogeneity analysis results also prove the reliability of the previous analysis (27, 32). In addition, as with previous findings, the impact of the NRSPI on the mental health of rural older adult men and women is not significant.

### Mediating effect test

To explore whether the NRSPI can promote the health status of the rural older adult population through mediating variables, this

TABLE 3 Logistic regression results.

Variable name	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	<i>sfe</i>	<i>sfe</i>	<i>mth</i>	<i>mth</i>	<i>psh</i>	<i>psh</i>
<i>nrspi</i>	0.126*** (3.17)	0.017*** (3.21)	0.149 (1.44)	0.004 (0.06)	0.119*** (4.13)	0.012** (2.07)
<i>age</i>		−0.024** (−2.23)		−0.043 (−0.04)		−0.027*** (−3.92)
<i>sex</i>		0.326** (2.42)		0.217** (2.31)		0.362*** (3.98)
<i>mst</i>		0.122 (1.14)		0.096** (2.36)		0.117 (1.19)
<i>icl</i>		0.118*** (3.42)		0.144*** (3.16)		0.209*** (4.07)
<i>sst</i>		0.091*** (3.26)		0.116*** (3.98)		0.094*** (3.37)
<i>N</i>	1,660	1,660	1,660	1,660	1,660	1,660
Pseudo R2	0.0108	0.0367	0.0112	0.0574	0.0116	0.0397

\*, \*\*, \*\*\* are significant at the levels of 10%, 5%, and 1%, respectively, and the corresponding *t* values are in parentheses.

TABLE 4 Heterogeneity regression results.

Variable name	Male older adult			Female older adult		
	Model 7a	Model 7b	Model 7c	Model 8a	Model 8b	Model 8c
	<i>sfe</i>	<i>mth</i>	<i>psh</i>	<i>sfe</i>	<i>mth</i>	<i>psh</i>
<i>nrspi</i>	0.059*** (3.46)	0.097 (0.62)	0.154 (0.93)	0.015*** (3.12)	0.098 (0.67)	0.056*** (3.34)
<i>age</i>	−0.025*** (−3.61)	−0.006 (−0.68)	−0.018** (−2.21)	−0.017** (−2.12)	0.037** (2.43)	0.037*** (3.64)
<i>mst</i>	−0.237 (−1.44)	−0.078 (0.41)	−0.336** (−2.03)	0.037* (1.76)	0.094*** (4.63)	0.013 (0.17)
<i>icl</i>	0.542*** (3.97)	0.106*** (3.63)	0.157*** (4.54)	0.244*** (2.73)	0.278*** (2.61)	0.343*** (3.68)
<i>sst</i>	0.126*** (2.94)	0.122*** (2.78)	0.096*** (3.14)	0.068*** (3.67)	0.124*** (2.84)	0.113*** (2.76)
<i>N</i>	800	800	800	860	860	860
Pseudo R2	0.0423	0.0567	0.0368	0.0304	0.0565	0.0391

\*, \*\*, \*\*\* are significant at the levels of 10%, 5%, and 1%, respectively, and the corresponding *t* values are in parentheses.

TABLE 5 The mediating effect test of medical services.

Variable name	Model 4	Model 5	Model 6	Model 7
	<i>msv</i>	<i>sfe</i>	<i>mth</i>	<i>psh</i>
<i>nrspi</i>	0.227*** (3.19)	0.014*** (3.17)	0.011 (1.06)	0.008** (2.13)
<i>msv</i>		0.089** (2.14)	0.757*** (3.56)	0.365** (2.43)
<i>age</i>	−0.032* (−1.73)	−0.022** (−2.21)	−0.143 (−0.16)	−0.019*** (−3.74)
<i>sex</i>	0.169*** (3.62)	0.372** (2.16)	0.231** (2.42)	0.372*** (2.97)
<i>mst</i>	0.132 (1.43)	0.171 (1.19)	0.092** (2.36)	0.126 (1.05)
<i>icl</i>	0.162*** (2.83)	0.117*** (3.53)	0.146*** (2.97)	0.201*** (4.12)
<i>sst</i>	0.167*** (2.68)	0.093*** (4.19)	0.119*** (3.94)	0.097*** (3.32)
<i>N</i>	1,660	1,660	1,660	1,660
Pseudo R2	0.0147	0.0428	0.0602	0.0413

\*, \*\*, \*\*\* are significant at the levels of 10%, 5%, and 1%, respectively, and the corresponding *t* values are in parentheses.

paper empirically tests the role of medical services, food acquisition and recreational activities applying a step-wise regression method. Column (2) of [Tables 5–7](#) presents the respective regression results for medical services, food acquisition and recreational activities as mediating variables in Eq. 4. The results reveal that the coefficients of the NRSPI are significantly positive at the 1% level, indicating that medical services, food acquisition and recreational activities have mediating effects on the NRSPI.

This paper further regresses the Eqs 5–7, presenting the results in columns (2–4) of [Tables 5–7](#). After introducing the three mediating variables, the coefficient of the NRSPI on self-reported health evaluation and physical health remain significantly positive, and the coefficient of mental health is positive but not significant. The regression results demonstrate that the NRSPI has improved rural older adult population health by strengthening medical services, enriching the types of food acquisition and increasing the amount of leisure and recreational activities enjoyed. A possible rationale is that the NRSPI provides stable pension income for the insured rural older adult and encourages them to use this income to increase the variety of food intake and medical services in daily life, which improves dietary balance and nutritional intake, reducing the probability of illness, improving self-care ability and promoting the improvement of physical health. In addition, pension income also reduces the labour participation time of the insured older adult, increases participation

in social recreational activities, reduces the concerns about old age, improves life satisfaction and improves mental health, resulting in more optimistic self-reported health evaluations. Hypotheses 2 and 3 are confirmed.

### Moderating effect test

Older adult health is a complex and evolving challenge. Compared with the urban older adult, the health risks of the rural older adult are affected by multiple factors with mutual influences between the related dimensions. For example, the older adult with good mental health are capable of improving physical health, while those with poor physical health are more likely to have low psychological dispositions or pessimistic attitudes towards life. Therefore, when the health status of the older adult in a single dimension is problematic, the probability that in other dimensions falling into risk will inevitably increase. To control the NRSPI, control variables and mediating variables, this study empirically tests the moderating effect of the NRSPI on the physical and mental health of the rural older adult as shown in [Table 8](#).

The results of the regression model indicate that the physical health of the rural older adult has a significant positive effect on mental health, which was verified in the three regression models. In the model progressively introducing the NRSPI, control variables and



TABLE 6 The mediating effect test of food acquisition.

Variable name	Model 4	Model 5	Model 6	Model 7
	<i>fas</i>	<i>sfe</i>	<i>mth</i>	<i>psh</i>
<i>nrspi</i>	0.427*** (3.42)	0.015*** (3.05)	0.003 (0.05)	0.010** (2.05)
<i>fas</i>		0.017** (2.06)	0.004** (2.13)	0.174*** (3.91)
<i>age</i>	−0.026 (−0.12)	−0.031 (−0.69)	−0.043 (−1.13)	−0.036*** (−3.64)
<i>sex</i>	0.401** (2.33)	0.317** (2.12)	0.382** (2.41)	0.268*** (2.85)
<i>mst</i>	0.069** (2.14)	0.073** (2.17)	0.046** (2.48)	0.132 (1.49)
<i>icl</i>	0.127*** (3.13)	0.133*** (2.82)	0.188*** (2.69)	0.214*** (3.94)
<i>sst</i>	0.182*** (3.56)	0.134*** (3.17)	0.163*** (3.64)	0.089*** (3.89)
<i>N</i>	1,660	1,660	1,660	1,660
Pseudo R2	0.0153	0.0504	0.0618	0.0407

\*, \*\*, \*\*\* are significant at the levels of 10%, 5%, and 1%, respectively, and the corresponding *t* values are in parentheses.

TABLE 7 Test of the mediating effect of entertainment activities.

Variable name	Model 4	Model 5	Model 6	Model 7
	<i>rac</i>	<i>sfe</i>	<i>mth</i>	<i>psh</i>
<i>nrspi</i>	0.531*** (4.02)	0.008** (2.09)	0.001 (0.17)	0.013*** (3.64)
<i>rac</i>		0.211*** (2.83)	0.136** (2.49)	0.053*** (4.17)
<i>age</i>	−0.031*** (−3.42)	−0.016*** (−3.73)	−0.049 (−0.78)	−0.027*** (−3.44)
<i>sex</i>	0.273*** (3.87)	0.326*** (3.46)	0.253** (2.38)	0.349*** (3.98)
<i>mst</i>	0.121 (1.32)	0.104 (1.13)	0.078** (2.41)	0.128 (1.17)
<i>icl</i>	0.236*** (4.07)	0.283*** (3.92)	0.152*** (2.87)	0.214*** (3.73)
<i>sst</i>	0.112*** (3.21)	0.081*** (2.87)	0.103*** (3.46)	0.069*** (3.74)
<i>N</i>	1,660	1,660	1,660	1,660
Pseudo R2	0.0141	0.0473	0.0602	0.0414

\*, \*\*, \*\*\* are significant at the levels of 10%, 5%, and 1%, respectively, and the corresponding *t* values are in parentheses.

TABLE 8 Regulating effect test.

Variable name	Model 9a	Model 9b	Model 9c	Model 10a	Model 10b	Model 10c
	<i>mth</i>	<i>mth</i>	<i>mth</i>	<i>psh</i>	<i>psh</i>	<i>psh</i>
<i>nrspi</i>	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled
Control variable		Controlled	Controlled		Controlled	Controlled
Mediator variable			Controlled			Controlled
<i>mth</i>				1.113*** (3.64)	1.062*** (3.56)	1.006*** (3.37)
<i>psh</i>	1.238*** (2.83)	1.216*** (2.94)	1.157*** (2.62)			
<i>mth</i> × <i>psh</i>	3.086*** (2.84)	3.094*** (2.97)	3.103*** (2.59)	3.526*** (3.03)	3.504*** (2.92)	3.481*** (2.87)
<i>N</i>	1,660	1,660	1,660	1,660	1,660	1,660
Pseudo R2	0.8452	0.8469	0.8487	0.9034	0.9041	0.9058

\*, \*\*, \*\*\* are significant at the levels of 10%, 5%, and 1%, respectively, and the corresponding *t* values are in parentheses.

mediating variables, the correlation of mental health with physical health for the older adult in rural areas is 1.237 times, 1.219 times and 1.159 times that of the older adult with physical health challenges, and the NRSPI has a 7.8% moderating effect. In addition, the mental health of the rural older adult also exhibits a positive impact on

physical health. In the full variable model, the correlation of physical health challenges with mental health is 1.004 times that of the rural older adult with mental health challenges, demonstrating that mental health has a certain transformative effect on physical health, where the NRSPI has a 10.7% adjustment effect.

TABLE 9 *T* test.

Item	Before				After			
	Control	Treated	Diff	<i>t</i>	Control	Treated	Diff	<i>t</i>
<i>sfe</i>	0.021	0.032	0.011	1.06	0.018	0.041	0.023	3.43
<i>meth</i>	0.008	0.012	0.004	1.12	0.003	0.009	0.006	1.98
<i>psh</i>	0.028	0.036	0.008	1.33	0.022	0.046	0.024	2.11
Control variable	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled	Controlled

TABLE 10 Robustness test.

Variable name	Model 1	Model 2	Model 3	Model 4	Model 5
Treatment group $\times$ Year	0.032* (1.78)	0.028* (1.92)	0.027** (2.32)	0.026* (1.87)	0.024* (1.77)
Year	0.132*** (4.66)	−0.116*** (3.26)	0.083*** (3.05)	0.067*** (3.54)	0.065*** (2.98)
<i>msv</i>			0.041*** (3.43)	0.046*** (4.21)	0.043*** (2.87)
<i>rac</i>				0.014*** (2.98)	0.016*** (3.12)
<i>fas</i>					0.008* (1.84)
Control variable	Uncontrolled	Controlled	Controlled	Controlled	Controlled
R2	0.05	0.07	0.14	0.17	0.17

\*, \*\*, \*\*\* are significant at the levels of 10%, 5%, and 1%, respectively, and the corresponding *t* values are in parentheses.

## Robustness test

In this study, the use of multivariate ordinal logistic regression can largely control the endogenous bias caused by observable and unobservable variables, but it cannot effectively avoid the estimation bias caused by heterogeneity over time. Therefore, robustness tests are conducted to further confirm the reliability of the research results. First, before performing the difference-in-differences estimation (PSM-DID), it is usually necessary to perform a balanced trend test. The test methods include *t*-test method, graphical method, interaction term regression method and F-statistic method. In this paper, the *t* test method is used. Table 9 shows the parallel trend test of *t* test method, that is, when dealing with the data before the experiment, the processing variables and the research variables are tested. Because there is no significant difference, it shows that the parallel trend test is satisfied. At the same time, Table 9 also shows the results of the *t*-test between the post-processing variables and the explained variables. The *t* value shows a significant difference, indicating that there is a significant difference between the control group and the experimental group after the experiment. Second, this study uses the PSM-DID model to test the health impact of the NRSPI on the rural older adult by using the panel data from different years. The CHARLS 2015 and 2018 survey data are used to reconstruct the panel data for robustness testing. If the impact of NRSPI policy on the health of the rural older adult remains valid, this indicates that the benchmark empirical results are robust. Table 10 reveals that among the five models, the DID interaction coefficient and the regression coefficients of the three mediating variables remain significant, confirming that the benchmark results regarding the impact of NRSPI on the health of the rural older adult and the impact mechanisms are robust. In addition, this study uses the *diff* command in STATA software to test the previous results, revealing that the regression coefficient of the NRSPI on the health

of the rural older adult remains significant at the 10% level, once again verifying that the benchmark results are robust.

## Conclusions and recommendations

Based on 2015 and 2018 CHARLS survey data, this study applies the multivariate ordered logistic regression model to empirically analyse the impact of the NRSPI on the health of the rural older adult population, drawing four relevant conclusions.

- (1) The benchmark regression results demonstrate that the NRSPI has a positive impact on the health of China's rural older adult. The NRSPI is significant at the 1% level and has a positive impact on the self-reported and physical health of the rural older adult. The impact of NRSPI on the mental health of the rural older adult is not significant but the coefficient is still positive.
- (2) The heterogeneity analysis results show that the NRSPI has a significant impact on the self-reported health of rural male and female older adult at the 1% level. In addition, the NRSPI has a significant impact on the physical health of rural female older adult respondents, while the impact on males is not significant. In addition, the impact of the NRSPI on the mental health of rural male and female older adult is not significant.
- (3) The mediating effect test results reveal that medical services, food access and entertainment activities have a mediating effect on the NRSPI. After introducing the three mediating variables, the coefficients of self-reported and physical health and the NRSPI remain significantly positive, and that of mental health is not significant but still positive.
- (4) The moderating effect test results indicate that the mental health and physical health of the rural older adult have a

certain transformative effect. In the model progressively introducing the NRSPI, control variables and mediating variables, the NRSPI adjusted 7.8% of the effect of physical health on mental health and 10.7% of the effect of mental health on physical health.

Under the background of Healthy China strategy implementation, this study proposes the following three suggestions to advance the system of healthy old-age care for the rural older adult population based on the empirical results.

- (1) Improve the coverage of the NRSPI. Although the NRSPI has achieved the goal of wide coverage, the implementation of the family-bundled insurance policy and personal payments for the NRSPI increasing annually results in a considerable number of rural older adult people being omitted by the system, some of whom have even given up and are unable to obtain the protection of healthy old-age care. Accordingly, the government should gradually phase out the family bundling policy and reasonably optimise the personal payments required by the NRSPI. A social pension service system with government support and diversified development should be strategically targeted in relation to the unique economic incomes and personal pension needs of the rural older adult, continuing to expand the coverage of the NRSPI and solidly promoting the full participation of the rural older adult population.
- (2) Moderately improve the level of NRSPI benefits and improve the dynamic adjustment system. China established the NRSPI system to cover the whole country, which has an important role in ensuring the lives and health of the older adult in rural areas. However, the basic pension of the NRSPI implemented in 2009 was 55 yuan per month, while the basic pension of the new rural insurance after its merger in 2015 was only raised to 70 yuan per month. Overall, the financial support provided by the NRSPI remains relatively low, restricting the potential effects of the NRSPI system on improving the lives and health of the rural older adult. Consequently, the government should continue to improve the dynamic adjustment mechanism of the NRSPI on the basis of government expenditure, establish a rational growth mechanism between the basic old-age insurance fund and the consumer index, improve the level of pension treatment and gradually narrow the gap between the treatment of urban and rural residents so that NRSPI can effectively protect the basic lives and health of the rural older adult. The positive role of the NRSPI will further expand the beneficiaries of this new insurance programme and increase the benefits for the rural older adult.
- (3) Prioritise guiding the rural older adult to participate in the NRSPI and strengthen the publicity and guidance towards healthy lifestyles. By increasing social activities such as medical services, leisure and entertainment and improving the variety of food access and dietary balance, public leaders can improve rural older adult population health and enrich and improve the rural older adult's sense of belonging and achievement to maintain their positive and optimistic attitudes and health status and maximise the role of the NRSPI in advancing healthy lifestyles among the rural older adult.

- (4) Initiate the development of emotional support systems in rural old-age services. With the gradual improvement of China's socialised old-age care system, social subjects can be stimulated to support and care for the older adult in rural areas through publicity and education, establishing a social atmosphere that respects and helps the older adult in rural areas and mitigates loneliness, tension and a lack of belonging, forming a society that values and cares for the older adult in rural areas, improving their well-being and sense of security and improving their physical and mental health.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## Author contributions

YS: Conceptualization, Formal analysis, Funding acquisition, Writing – original draft. CS: Data curation, Writing – original draft, Formal analysis. ZW: Conceptualization, Data curation, Writing – original draft. GH: Conceptualization, Project administration, Writing – original draft.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## References

- Niu WT, Jiang RG. 70 years of rural old-age security reform in China: historical evolution and realistic dilemma. *Issues Agric Econ.* (2020) 2:54–64. doi: 10.132/j.cnki.iae.2020.02.006
- Yang HM. Dynamic trend of China's population ageing and new characteristics of the elderly. *Popul Res.* (2022) 46:104–16. doi: cnki:sun:rkyz.0.2022.05.008
- Qian WR, Li MH. Impact of China's new rural social endowment insurance program on the rural Elderly's health behavior and its mechanism. *J Zhejiang Univ.* (2020) 50:29–46. doi: 10.3785/j.issn.1008-942x.cn33-600/c.2020.05.143
- Zheng XD, Shangguan S, Fang XM. A literature review of research on the effect of new rural pension scheme. *Issues Agric Econ.* (2020) 5:79–91. doi: 10.13246/j.cnki.iae.2020.05.007
- Sun WJ, Sun JK. Investigation and reflection on the new rural social pension insurance system in Jiangsu Province. *Issues Agric Econ.* (2012) 33:98–103. doi: 10.13246/j.cnki.iae.2012.04.016
- Mu HZ, Yan LL. Factors affecting farmers' participation in the new rural pension insurance. *Popul Res.* (2012) 36:73–82. doi: cnki:sun:rkyz.0.2012.01.009
- Mu SH. Research on the new rural social pension insurance in poverty-stricken areas: taking Dongchuan District of Kunming as an example. *Truth Seek.* (2014) 51:177–80. doi: 10.3969/j.issn.1007-8487.2014.z1.067
- Xu M, Liu L. Could the new rural society endowment insurance affect the health improvement of the elderly: evidence from Chinese longitudinal healthy longevity survey. *J Stat Inf.* (2016) 31:87–94. doi: 10.3969/j.issn.1007-3116.2016.11.015
- Xue XD, Ge KX. The effect of socioeconomic status on the health of the elderly in China: evidence from the Chinese longitudinal healthy longevity survey. *Popul Dev.* (2017) 23:61–9. doi: 10.3969/j.issn.1674-1668.2017.02.007
- Zhu HY. Assessing the poverty reduction effect of urban and rural residents pension: from the perspective of multidimensional poverty. *Soc Sci Beijing.* (2017) 9:112–9. doi: 10.13262/j.bjsshkxy.bjsh.kx170912
- Liu YW. Do social to ease the poverty of the rural elderly? On the vicious circle of poverty. *Sci Decis Mak.* (2017) 2:26–43. doi: 10.3773/j.issn.1006-4885
- Liu QR, Liu SN. Poverty alleviation effect of rural pension system: empirical analysis based on PSM-DID model. *Popul Dev.* (2019) 25:38–46. doi: cnki:sun:scrk.0.2019-03.004
- Zheng C, Wang XJ. The impact of China's new rural pension scheme on the rural elderly poverty. *J Financ Econ.* (2020) 46:124–38. doi: 10.16538/j.cnki.jfe.2020.03.009
- Huang W, Zhang CC. The power of social pensions: evidence from China's new rural pension scheme. *Am Econ J Appl Econ.* (2021) 2:179–205. doi: 10.1257/APR.20170789
- Ning MX. Who benefits from the “family-bundled” new rural social pension insurance system: empirical analysis from CHARLS data. *Chinese Rural Econ.* (2015) 7:31-45+96. doi: cnki:sun:znjji.0.2015.07.005
- Jiao N. Does public pension affect intergenerational support in rural China? *Popul Res.* (2016) 40:88–102. doi: cnki:sun:rkyz.0.2016.04.008
- Zhang ZH, Wang L, Luo YX. Can the new rural old-age pension substitute rural family support for the elderly: evidence from regression discontinuity based on gender difference of children. *Econ Surv.* (2018) 35:23–9. doi: 10.1593/j.cnki.1006-1096.2018.04.002
- Jin WD, Wang PF, He L. A research on the security role of new rural pension scheme: theoretical mechanisms and empirical evidence. *J Financ Econ.* (2018) 44:125–38. doi: 10.16538/j.cnki.jfe.2018.11.00
- Hao CH, Zhao XD, Zhang HM. Can “social pooling elderly care” crowds out “family intergenerational elderly care” and “individual self-care”: a revalidation of the effect of the new rural social pension insurance. *Nankai Econ Stud.* (2021) 6:144–61. doi: 10.14116/j.nkes.2021.06.009
- Yang RL, Ren YZ, Wang ZN. New rural pension Scheme, Inter-generational support, and grandparenting: evidence based on the regression discontinuity design. *Popul Res.* (2022) 46:44–59. doi: cnki:sun:rkyz.0.2022.03.004
- Zhang CC, Giles J, Zhao YH. Policy evaluation of China's new rural pension program: income, poverty, expenditure, subjective well-being and labor supply. *China Econ Q.* (2015) 14:203–30. doi: 10.13821/j.cnki.ceq.2015.01.012
- Lv J, Lin YJ. The study of asymmetric impact of new rural insurance on family labor supply: based on the McElroy-Horney Nash game model. *Manag Rev.* (2019) 31:258–66. doi: 10.14120/j.cnki.cn115057/f.2019.06.024
- Huang HW, Hu HY. The substitution effect of new rural pension insurance on the self-pension security of rural residents: based on the perspective of household land operating area change. *Soc Secur Stud.* (2019) 6:65–72. doi: 10.3969/j.issn.1674-4802.2019.06.007
- Zheng C, Sun Q, Lv H. The new rural pension scheme, labor supply, and the eldercare patterns in rural China. *J Shandong Univ.* (2023) 2:61–76. doi: 10.19836/j.cnki.37-1100/c.2023.02.006
- Grossman M. On the concept of health capital and demand for health. *J Polit Econ.* (1972) 80:223–55. doi: 10.1086/259880
- Tao YC, Shen Y. The influence of social support on the physical and mental health of the rural elderly. *Popul Econ.* (2014) 3:3–14. doi: 10.3969/j.issn.1000-4149.2014.03.001
- Xue XD, Ge KX. The effect of socioeconomic status on the health of the elderly in China: evidence from the Chinese longitudinal health longevity survey. *Popul Dev.* (2017) 23:61–9. doi: cnki:sun:scrk.0.2017.02.007
- Kant SS, Ashish R. The effect of income, family and socio-religious affiliations on self-rated health of the aged in India. *J Public Aff.* (2020) 21:01–8. doi: 10.1002/pa.2589
- Guo LM, Zhang WK. Knowledge mapping of population health: a bibliometric analysis. *Heliyon.* (2022) 8:e12181. doi: 10.1016/j.heliyon.2022.e12181
- Huang BS, Li SS, Tong GQ, Liu Y. Spatial difference and influencing factors of self-rated health level of old people in China. *Hum Geogr.* (2020) 35:37–47. doi: 10.13959/j.issn.1003-2398.2020.03.005
- Lin XR, Zheng C, Du ML, Sun JH, Liu YQ, Zhao Z, et al. Analysis of the health status and influencing factors in Chinese elderly: based on the 8th round of CLHS data. *Acad J Nav Medi Univ.* (2022) 43:1022–8. doi: 10.16781/j.cn31-2187/r.20220149
- Wu XY, Chao JQ, Bao M, Liu YT, Zhang BW. Gender differences in health status of the Chinese elderly and related influencing factors. *Chin Prev Med.* (2022) 23:13–9. doi: 10.16506/j.1009-6639.2022.01
- Dong HY, Wu XL. Status, hot topics and inspiration of the research on the influencing factors in health among elderly people: analysis based on visual knowledge mapping. *Lanzhou Acad J.* (2022) 2:135–46. doi: cnki:sun:lxzk.0.2022.02.012
- Fleurbaey M, Schokkaert E. Unfair inequalities in health and health care. *J Health Econ.* (2009) 28:73–90. doi: 10.1016/j.jhealeco.2009.07.016
- Fleurbaey M, Schokkaert E. Equity in health and health care. *CORE Dis Papers.* (2011) 2:1003–92. doi: 10.1016/B978-0-444-53592-4.00016-5
- Gu HJ, Liu YP. Income-related health inequalities of the elderly and its decomposition: an empirical research in the urban and the rural of China. *South China Popul.* (2011) 26:1–9. doi: cnki:sun:lfrk.0.2011.04.001
- Ren Q, Huang J. Empirical analysis of the impact of social pension on old people's health from the perspective of urban and rural differences. *Finance Econ.* (2015) 3:109–20. doi: cnki:sun:cjkk.0.2015.03.011
- Tan T, Zhang Q, Liu HR. Decomposition of health inequality among elderly people in rural China: an empirical research based on the survey of eastern, central and western China. *South China Popul.* (2015) 30:57–68. doi: cnki:sun:lfrk.0.2015.03.006
- Pu XH, Wang YL, Zhang WK, Zeng M. Can basic medical insurance reduce elderly family income inequality in China? *Front Public Health.* (2022) 10:838733. doi: 10.3389/fpubh.2022.838733
- Yu CT, Lu WB, Li L. A study on the opportunity inequality in complete health of old people: based on intergenerational economic support. *Reform Econ Syst.* (2020) 1:188–95. doi: cnki:sun:jtg.0.2020.01.027
- Yang J, Li LY, Pan CJ, Zhou XF. Influencing factors of health inequality among urban elderly in China: a RIF-I-OLS decomposition analysis. *Chin J Public Health.* (2022) 38:404–9. doi: 10.11847/zgggws1132884
- Ai B. Study on the development trend of health inequality among the elderly. *Popul Econ.* (2022) 4:42–60. doi: 10.3969/j.issn.1000-4149.2022.00.016
- Liu W, Liu CP. Social insurance and rural old-age health: will participation in social insurance improve the health of the elderly: empirical study based on multiple order logistic model. *Soc Secur Stud.* (2018) 2:47–53. doi: cnki:sun:shby.0.2018.02.006
- Zhou Q, Jiang WG, Guo X. The effect of social insurance on mental health among rural residence: an empirical analysis based on CHARLS data. *China Econ Stud.* (2018) 5:125–36. doi: 10.19365/j.issn1000-4181.2018.05.10
- Zheng XD, Fang XM. The social pension scheme and subjective well-being of the elderly in rural China. *J Financ Econ.* (2018) 44:80–94. doi: 10.16538/j.cnki.jfe.2018.09.005
- Chen F, Liu JY, Liu XX. The influencing mechanism of new rural social pension policy on subjective well-being of the elderly in rural China. *Res Financ Econ Issues.* (2020) 1:111–20. doi: 10.19654/j.cnki.cjwtyj.2020.01.013
- Wang Z, Liu TQ. The effect of social on the subjective well-being of the rural elderly: a study from CHARLS data. *Finance Econ.* (2021) 4:105–17. doi: cnki:sun:cjkk.0.2021.04.010
- Zhang FF, Chen XD, Lin XH, Zhou LC. The influence of new rural pension scheme on rural households' consumption expenditures: evidence from Zhejiang Province. *Issues Agric Econ.* (2017) 38:17-24+110. doi: 10.13246/j.cnki.iae.2017.08.003
- Zhou YB, Cao RR. The effect of China's new rural pension program on the labor supply of middle aged and elderly people in rural areas of China: based on the PSM-DID. *Popul Econ.* (2017) 5:95–107. doi: 10.3969/j.issn.1000-4149.2017.05.009
- Zhang YH, Wang YX. The influence of new rural social pension insurance on poverty-stricken population: based on an analysis of CHARLS 2011-2015 panel data. *Insur Stud.* (2019) 5:69–80. doi: 10.13497/j.cnki.is.2019.05.005



51. He H, Li XQ. Evaluation of the impact of the new rural pension insurance policy on rural residents' consumption. *J Jiangxi Univ Finance Econ.* (2020) 3:61–72. doi: 10.13676/j.cnki.cn36-1224/f.2020.03.00
52. Wu YF, Hu JB, Nie JL. Study on the impact mechanism of the basic pension insurance for urban and rural residents on the health performance of the rural elderly. *Soc Secur Stud.* (2021) 6:10–22. doi: 10.3969/j.issn.1674-4802.2021.06.002
53. Huang Q, Li K, Xiong DP. Family socioeconomic status and residents' health: research based on dual perspectives of lifestyle and social support. *J Yunnan Univ Finance Econ.* (2020) 36:66–80. doi: 10.16537/j.cnki.jynufe.000608
54. Modigliani F. The life cycle hypothesis of saving and inter-country differences in the saving ratio In: WA Eltis, MF Scott and JN Wolfe, editors. *Induction, growth and trade: essays in honour of Sir Roy Harrod.* Oxford: Clarendon Press (1970). 197–225.
55. Fan CC, Li W. How new rural pension system affect consumption of rural residents: a case of Shandong Province. *J Jiangxi Univ Finance Econ.* (2015) 1:55–65 +130. doi: 10.13676/j.cnki.cn36-1224/f.2015.01.006
56. Zhang Y, Cheng LG, Liu ZB. Does China's new rural pension scheme improve the life quality of the rural elderly? *China Econ Q.* (2016) 15:817–44. doi: 10.13821/j.cnki.ceq.2016.01.17
57. Bai P, Tang YX, Zhang WK, Zeng M. Does economic policy uncertainty matter for healthcare expenditure in China? A spatial econometric analysis. *Front Public Health.* (2021) 9:673778. doi: 10.3389/fpubh.2021.673778
58. Huang HG, Hu HY. The impact of new rural society endowment insurance on the survival consumption of rural households. *Issues Agric Econ.* (2018) 5:18–26. doi: 10.13246/j.cnki.iae.2018.05.003
59. Ding ZH. The influence of social participation on the rural oldest-old on their health. *Lanzhou Acad J.* (2018) 12:179–95. doi: 10.3969/j.issn.1005-3492.2018.12.019
60. Werner V, Cornelia A, Sandra P. Analyzing coarsened categorical data with or without probabilistic information. *Stata J.* (2022) 22:158–94. doi: 10.1177/1536867x221083902
61. Wen ZL, Fang J, Xie JY, Ouyang JY. Methodological research on mediating effects in China's mainland. *Adv Psychol Sci.* (2022) 30:1692–702. doi: 10.3724/sp.j.1042.2022.01692
62. Jiang T. Mediating effect and moderating effect in causal inference. *China Indus Econ.* (2022) 5:100–20. doi: 10.19581/j.cnki.ciejournal.2022.05.005
63. Haan P, Uhlenborff A. Estimation of multinomial logit models with unobserved heterogeneity using maximum simulated likelihood. *Stata J.* (2006) 6:229–45. doi: 10.1177/1536867X0600600205



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# New rural pension scheme, intergenerational interaction and rural family human capital investments

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**Introduction:** The new rural pension scheme (NRPS) can improve the quality of life for rural older adult individuals; however, can it have a spillover effect on rural household human capital investments through intergenerational interactions?

**Methods:** Based on data from the China Family Panel Studies (CFPS) in 2010, 2012, 2014, 2016, and 2018 and from the perspective of intergenerational interactions, the spillover effect and influencing mechanism of the new rural insurance policy on rural household human capital investments are empirically tested.

**Results:** The results show that the participation of families in the new rural insurance policy can significantly promote the human capital investments of rural families, and they are robust. Moreover, the spillover effect of this new policy is significantly different due to the gender, insurance phase, and family income of the insured. Through intergenerational interactions, the new rural insurance policy has an impact on the human capital investments of rural families from the material level of intergenerational economic support, housework and childcare for children and the nonmaterial level of old-age care cognition.

**Discussion:** Therefore, continuing to promote the coverage of the new rural insurance policy and scientifically improving rural social security through publicity and education to promote benign intergenerational family interactions can improve the accumulation of human capital in rural areas.

## KEYWORDS

new rural pension scheme, spillover effect, intergenerational interaction, rural family, human capital investment

## 1. Introduction

Human capital is an important driver of rural revitalization, among which education is the most important channel for human capital formation and accumulation (1). Education is of great significance for improving individuals' abilities, increasing family welfare and promoting rural economic growth. The 20th report of the Communist Party of China also clearly proposed building a high-quality education system, accelerating the high-quality development of compulsory education and optimizing the allocation of regional educational resources. Faced with the current disparity between urban and rural public education investments and resource allocations in China, optimizing rural family human capital investments is said to be an important issue for some time to come. At the same time, given the transformation of China's demographic structure, the life expectancy of older adult individuals has been extended, and the modern family structure of three or even four generations exists generally, aggravating the burden on family pensions. In this context, to ensure the

basic livelihood of older adult rural residents, the State Council issued the Guiding Opinions on Carrying out the Pilot Project of the new rural social pension insurance policy in 2009 and started its pilot implementation. The pilot covers rural residents who do not participate in urban employee endowment insurance. The new rural pension scheme was officially implemented nationwide in 2012 (2). On the one hand, the implementation of a new rural pension insurance program can increase the disposable income of older adult individuals, reduce future uncertainty, and improve living conditions. On the other hand, as the basic unit of individual life, the family has an obvious two-way feedback and intergenerational relationship. New rural pension insurance programs have a certain spillover effect on the family and even society while satisfying the needs of older adult individuals themselves. In addition, due to the dual influence of traditional Chinese family ethics and the reality of childcare security, family intergenerational interaction behaviour and intergenerational caregiving have become common phenomena in Chinese society, especially in poor areas. Such caregiving implies two-way intergenerational economic support, caregiving support and emotional support, which contribute to the formation of adhesive intergenerational relationships among family members (3, 4). Then, due to intergenerational reciprocity behaviour and altruistic motivations, rural older adult individuals tend to choose the reciprocal family equilibrium relationship of give-and-reward to encourage their children to take care of them. In this way, while improving the welfare of older adult individuals, will the new rural pension insurance program have a spillover effect and thus impact family intergenerational interaction behaviour? We explore the impact of the implementation of a new rural pension scheme on the human capital investments of rural households from the perspective of intergenerational interactions, verify the spillover effect of this scheme at the empirical level using data from China Family Panel Studies (CFPS) in 2010, 2012, 2014, 2016, and 2018, and engage in an in-depth examination of the long-term impact of this scheme on households' human capital investments. We explore the impact mechanism of intergenerational interaction at the material and immaterial levels to better understand the relationship between the new rural pension scheme and the human capital investments of rural households, improve the old-age security system under demographic changes, and make better use of intergenerational family interactions to optimize the allocation of family resources.

## 2. Literature review

Human capital is an important driving force for high-quality economic development, and the factors affecting the level of human capital investments have been the focus of scholars at home and abroad. In previous studies, the factors affecting household human capital investments mainly include household input from a micro perspective and government public input from a macro perspective (5). At the household level, household wealth, such as household income level, housing wealth and land endowment, and household personality characteristics household characteristics, such as education expectations, family size, parents' education level and household demographic structure, are the main influencing factors of household human capital investments.

At the microhousehold level, the probability and intensity of household human capital investments are closely related to family wealth status (6, 7). It has basically become a social consensus that income inequality leads to educational inequality (8). Housing wealth has a significantly positive impact on family investments in education (9). Land transfers can increase families' attention to children's education and the nonagricultural employment of rural residents, thus increasing family investments in human capital and ultimately promoting the accumulation of the human capital of rural teenagers (10). In addition to family wealth, factors such as increased educational expectations, family size, and parents' educational level affect the level and probability of family education expenditures (11). Mothers' ambitions and education level are related to children's education expenditures to a certain extent, and ambition is a channel for intergenerational mobility (12, 13). Family size is associated with family human capital (14). Regarding the family demographic structure, grandparents affect the educational process of offspring through the specific role they assume in the family (15). There is a crowding-out effect of both the burden of old-age care and the burden of child support on household human capital investments (16). At the macro social level, government support for education is also a major determinant of household investments in human capital (17). But there are three forms of correlations – substitution, complementarity, and no statistical correlation – between public education financial investments and household education expenditures, and the findings of the current study are still controversial (18).

Among the above factors affecting household human capital investments, household wealth is a major influencing factor, and pension insurance is currently an important source of income for older adult individuals in households (19). The new rural insurance, as the main endowment insurance in rural areas, has been implemented since the pilot implementation of the new rural pension scheme in 2009. Some scholars have started to study the effect of the policy. The existing policy evaluation has not only focused on older adult individuals who receive the new rural pension scheme but has also extensively studied the spillover effect of the policy. On the one hand, improvements in the welfare of older adult individuals by the new rural pension scheme is mainly reflected in health status, economic income, mental health and other aspects (20). In the context of universal health insurance, pensions can encourage low-income people to use outpatient and inpatient services and older adult individuals to use preventive health care to obtain timely treatment and promote public health (21, 22). Regarding socioeconomic status, improvements in social welfare is conducive to enhancing the financial satisfaction and quality of life of older adult individuals (23). From the perspective of mental health, increasing the pension can improve the mental health problems caused by depressive symptoms and depression by improving confidence in the future (24). On the other hand, there are also certain spillover effects of the new rural pension scheme in the areas of labour supply, land, and children's health. The scheme can increase the labour supply of offspring, accelerate the transformation of the rural labour population structure, push more efficient production factors into the market (2), promote the increase in labour supply of groups with high labour supply, and inhibit the labour supply of groups with low labour supply (25). Moreover, while improving the welfare of older adult individuals and reducing their demand for agricultural labour, the scheme weakens the function of land security and accelerates land circulation (26). In this process, the

Abbreviations: CFPS, China family panel studies; NRPS, new rural pension scheme.

new rural pension scheme plays the role of a catalyst for transforming the rural economic development model (27). In addition, the Chinese family, as a basic living unit, redistributes resources within the family, which can increase the transfer payments and care of older adult individuals to their grandchildren and improve children's health through the influence of intergenerational interactions (28). Social security payments as a source of exogenous changes in family income have an impact on children's enrolment (29, 30).

In summary, scholars at home and abroad have studied the influencing factors of household human capital investments and the multidimensional effects of new rural pension schemes. However, most of the literature has focused on the impact of the policy on land, the health of older adult individuals, labour supply, children's health and other family aspects, while studies related to the microwelfare of household human capital with education as the main feature are still limited. In long-term interdependent family systems, older adult individuals and grandchildren of many families live together. In this context, the relationship between the new rural pension scheme and family human capital investments is an important research topic for current family and even social development. There is a lack of research in the literature on the human capital investments of rural households under the new rural pension scheme, and the underlying mechanisms of intergenerational interactions have not been explored in depth. Compared with the literature, the main contributions of this paper are as follows. (1) Combined with the particularity of China's family culture and the ageing of society, we set control variables from different dimensions, such as household head and family characteristics, study the impact of the new rural pension scheme on rural family human capital investments, and deeply analyse the spillover effect of the policy. (2) We provide a comprehensive analysis of the differential impact of the policy on household educational inputs in terms of gender of the household head, stage of participation and economic status. (3) From the innovative perspective of intergenerational interactions, we analyse at a deeper level the impact mechanism of the new rural pension scheme on family human capital investments from the material level of care inputs and intergenerational economic support and the nonmaterial level of old age and education cognition to provide a reference for making decisions that promote human capital investments of rural families in China.

### 3. Research hypothesis and analytical framework

The problems of an ageing population and a shortage of young labourers in rural areas are becoming increasingly prominent. In the context of China's comprehensive implementation of rural revitalization, human capital accumulation is increasingly important. Investments in education, as an effective means of human capital appreciation, is of great significance to the future economic growth of rural areas. At present, rural education resources are relatively scarce compared to those of urban areas; therefore, in addition to focusing on the impact of public education investments on human capital, we can also pay attention to the spillover effect of noneducation policies on human capital investments. It has been shown that the new rural pension scheme not only enhances the well-being of the rural older adult themselves but also has an impact on household education

expenditures, children's health, land transfers, children's labour time and so on.

In many developing countries, pensions, as fiscal transfer payments with the nature of welfare expenditures, are often independent of people's incomes. Pensions undoubtedly provide stable, exogenous incomes for many families (31), which helps enhance households' wealth levels. In rural areas, pensions are important incomes of households, especially for older individuals with limited sources of income. A higher income level is conducive to improving living conditions, enriching spiritual life and promoting physical and mental health (32). In addition, the economic level is an important dimension to measure the family's socioeconomic status, and the extra income from a pension improves the family's economic level. The higher the socioeconomic status of the family is, the more it invests in the education of the next generation, and the more it is conducive to the accumulation of human capital for family education. Therefore, the new rural pension scheme not only contributes to the direct improvement of individual welfare status but also changes the family's educational decision and enhances the total family investment in children's education in terms of indirect effects (33). Based on the above analysis, the following hypothesis is proposed:

*H1: The new rural pension scheme has a significant positive impact on the human capital investment of rural households.*

According to relevant studies, intergenerational interaction is a collective term for positive behaviours, such as communication, resource sharing, and mutual support among multiple generations possessing kinship, including intergenerational mutual assistance and exchange of economic, goods, and labour services, as well as the comprehension of different generations regarding lifestyle and values (34). We divide intergenerational interaction behaviour into two parts: intergenerational economic support and life care at the material level and old-age cognition and education cognition at the nonmaterial level.

Intergenerational interactions at the material level, such as family financial support and life care, have become normal in rural areas of China. Family pensions through intergenerational economic support originally represented the traditional filial piety ethics in rural areas. However, with the ageing of China's population, intergenerational transfer payments to support parents have become a serious economic burden for only children. Given the continuous improvements in the social security system, the burden, risk and uncertainty of family pensions are gradually weakening, and the underwriting protection of pension insurance is an important substitute for family pensions. The social pension security mechanism represented by the new rural pension scheme has become an important alternative resource for rural family pensions and allows parents to receive public transfer payments and improve their living economic situations, thus reducing the burden of children's pensions and family economic burden (35). To a certain extent, this mechanism can also increase the care of older adult individuals for their children's families and children and ease the pressure on young adults' lives. In addition, when the wealth level of older adult individuals increases, due to the reciprocity of family members, more intergenerational support of children comes from life care, irregular visits and spiritual comfort, alleviating older adult individuals' anxiety caused by emotional losses and pension problems. Given the reduction in family pension transfer payments, family decision makers make rational decisions to support older adult



individuals and invest in education under certain budget constraints. Moreover, benign intergenerational interactions are conducive to the internal flow of resources so that the spillover effect can be brought into play. These interactions alleviate a certain percentage of household pension expenditures and increase the share of investments in education for the care of young children (36). Based on this, the following hypothesis is proposed:

*H2: New rural pension schemes facilitate the internal flow of resources through benign intergenerational economic support and care inputs at the material level, which benefit families' investments in children's education.*

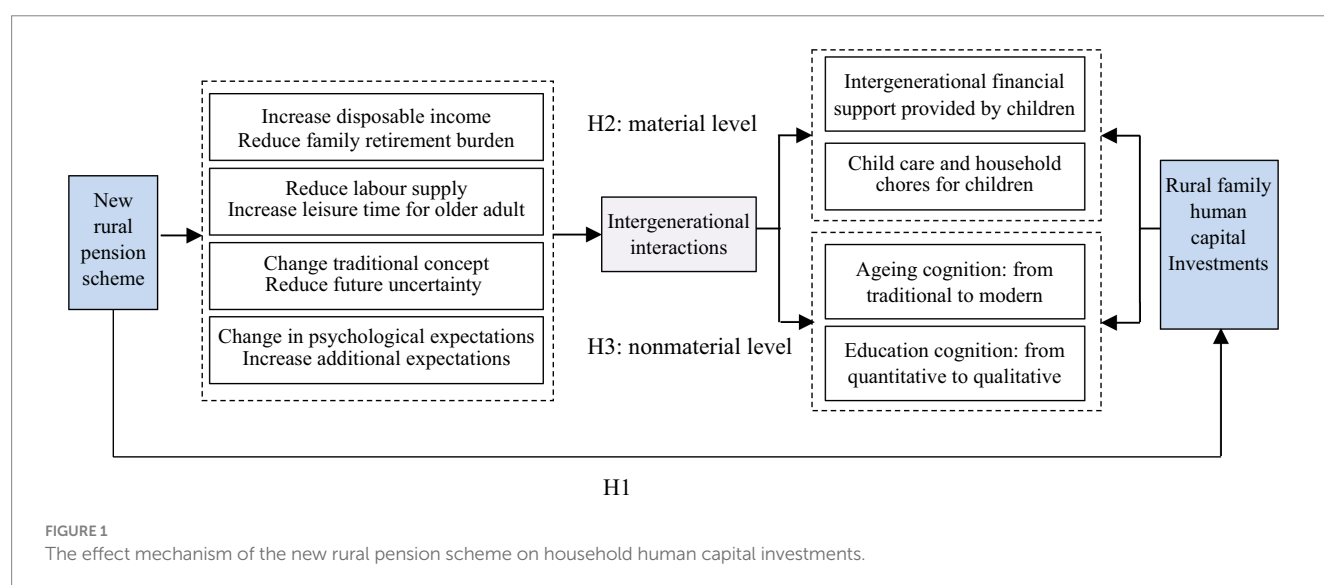
In rural China, the idea of passing on the family line and raising children for old age is deeply rooted; therefore, the intergenerational interaction of family care is common in the family unit. In recent years, the establishment of and improvements in the social security system have been continuously deepened, and some direct or indirect economic incentives have had a certain impact on intergenerational interactions and traditional concepts. Not only does it have a substitute effect on family pensions but also it is a change in the concept of raising children and passing on the family. The implementation of the new rural pension scheme has alleviated the worries of older adult individuals in terms of pensions and has a better vision of their pension expectations. Therefore, Given the basic satisfaction of material conditions, older adult individuals are more likely to pursue nonmaterial emotional needs, which may generate additional expectations for the next generation, such as expectations for the future development of their children (37). Compared with the current pursuit of the number of children in rural areas, many families have started to pay more attention to the quality of their offspring given an increase in social public welfare. Based on the above analysis, we propose the following hypothesis (see Figure 1):

*H3: New rural pension schemes change traditional pension cognition, raise the importance of education, and further improve the family human capital investment level.*

## 4. Methods

### 4.1. Data sources

In this paper, data from the China Family Panel Studies (CFPS) organized and implemented by the China Social Science Survey Center of Peking University are used as the dataset for the empirical research, covering the basic information of 16,000 households and individuals in 25 provinces/municipalities/autonomous regions. This dataset reflects social, economic, demographic, educational, and health changes in China. The database provides comprehensive and detailed data for the empirical study. In order to safeguard the basic livelihood of the older adult, ease the pressure on families to support them, and solve the problem of “providing for the older adult,” China issued the Guiding Opinions on the Pilot Project of New Rural Pension Scheme on 1 September 2009, exploring the establishment of a New Rural Pension Insurance system that combines individual contributions, collective subsidies and government subsidies. The policy was piloted in 10 percent of the country's counties in 2009, expanded to 23 percent of the counties in 2010, and fully rolled out in 2012. Within the scope of the pilot programme, people aged 60 and over who are not covered by urban basic pension insurance and who have a rural household registration do not have to pay and can receive a monthly pension. Rural residents between the ages of 16 and 59 (excluding schoolchildren) who are not covered by urban basic pension insurance can participate in the NRPS by making contributions for a cumulative total of 15 years, and receive a monthly pension when they reach the age of 60. Those who have less than 15 years away from pensionable age can also receive pension by making annual contributions or supplementary contributions. Pensions consist of a basic pension and a personal account pension. The nationally determined basic pension rate was 55 yuan per person per month in 2009, increasing to 70 yuan in 2012, 88 yuan in 2014, and 93 yuan in 2020. Individual account pensions are paid on a monthly basis, at a rate of 139 per person, divided by the total amount stored in the individual account.



We use panel data synthesised from 2010, 2012, 2014, 2016, and 2018. To accurately measure the impact of the new rural pension scheme on family human capital investments, we first exclude individuals and families who receive a pension and have old rural insurance, supplementary endowment insurance and other endowment insurance in the data. After that, according to the participation rules of the new rural pension insurance program, samples with an urban household registration are eliminated. And to study the spillover effects of the full coverage of the new rural pension insurance program in 2012, the sample that had participated in the insurance in 2010 was excluded. Next, the study sample was restricted to rural households with three or more generations to ensure that these households had both older adult individuals who might receive new rural pension insurance and children who were in school. Finally, the database was matched to remove missing values and abnormal data, resulting in a valid sample of 10,540. In addition, due to the missing intermediate mechanism variables required in the three years of data from 2012, 2014, and 2016, the paper uses two periods of data from CFPS 2010 and 2018 to discuss the intrinsic mechanism of action between the new rural pension insurance program and rural family human capital investments (see Figure 2).

## 4.2. Variable selection and descriptive statistics

### 4.2.1. Explained variable

In this paper, we use total family education expenditures to measure the explained variable family human capital investment. This is captured by the household question, “How much did your family spend on education in the past 12 months?” (38).

### 4.2.2. Core explanatory variables

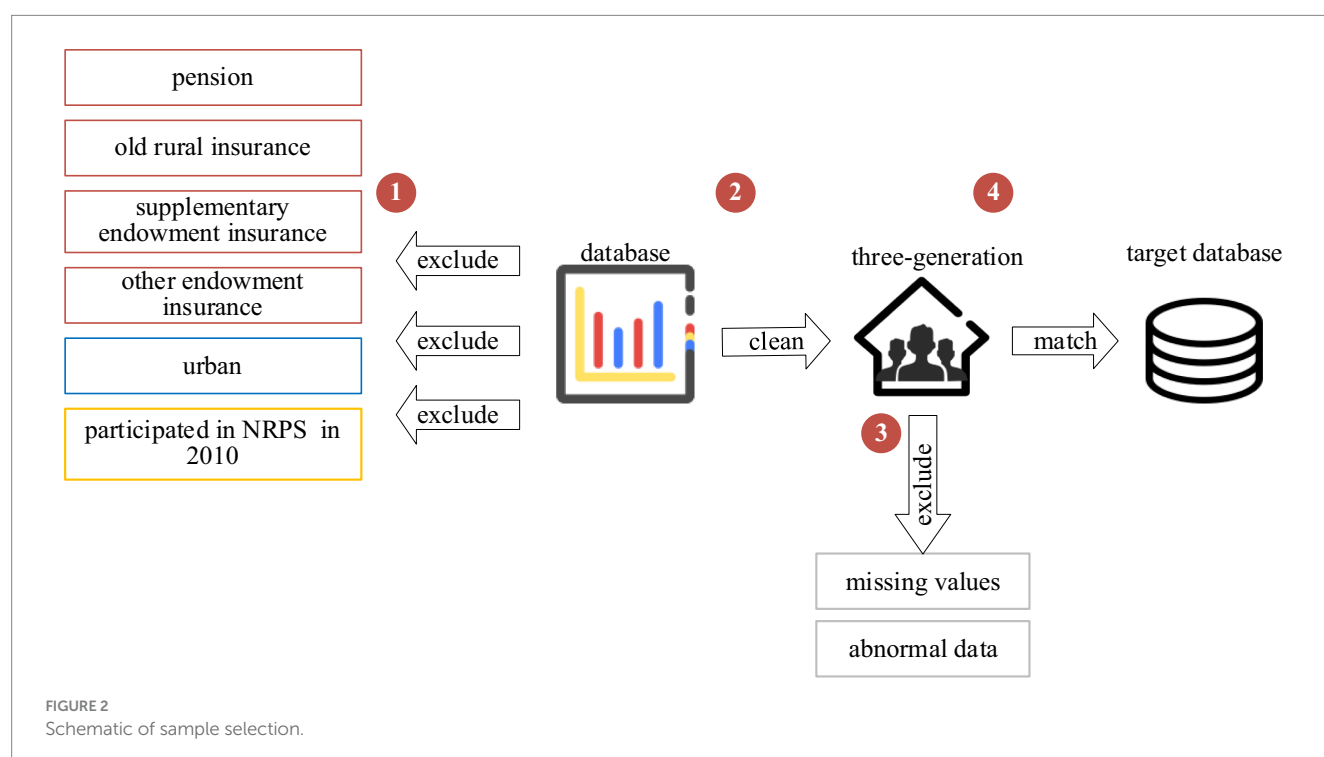
In this paper, the core explanatory variable is the insurance participation behaviour of rural households. Specifically, households with individuals participating in or receiving a new rural pension scheme are regarded as the individual's family to participate in pension insurance. The responses to the question of “participation items” were selected, the number of households choosing the new rural pension scheme was set to 1, and the rest of the choices were set to 0. To prevent the sample results from being influenced by other insurance items, we only take the sample of farmers who have participated in new rural pension insurance programs and those who have not participated in any pension insurance program. It should be noted that in the CFPS questionnaire in 2010, there is no option for a new rural pension scheme as an endowment insurance project. Therefore, we use the response to “when did you join new rural pension scheme” in the 2012 personal database to judge whether the 2010 sample participated in the program (39).

### 4.2.3. Intermediate mechanism variables

To test the mechanism of the impact of the new rural pension scheme on the human capital investments of rural households from the perspective of intergenerational interactions, based on the previous analysis and combined with data availability, we use intergenerational interaction as an intermediate mechanism variable. Specifically, care input and intergenerational economic support at the material level, as well as old-age cognition and education cognition at the nonmaterial level, are selected as intergenerational interactions for the mechanism test.

### 4.2.4. Control variables

Combining data availability and following the principle of exogeneity, control variables were selected at the individual and family



levels, including household size, household *per capita* income, and household savings rate at the household level and gender, years of education, marriage, and health status of the participants at the individual level.

The descriptive statistical results of the main variables are shown in Table 1.

Table 1 shows that the current participation rate in the new rural pension scheme is relatively low, and there is room for the further release of the popularity of pension insurance. Family expenditure on education is rising year by year, which shows that families are attaching greater importance to it. Regarding household demographic

structure, most rural families have five or six members and there are relatively more families living with the older adult and children. Regarding family background, the majority of the household heads in rural areas are male, and the health status of the household heads is generally good and job opportunities are also increasing. However, their educational background is generally poor, indicating that the existing educational level of residents in rural areas is still low and that it is necessary to study human capital investments in rural households to facilitate the understanding of the importance of families, government and society to children's education and improve such education.

TABLE 1 Description of main variables and descriptive statistical analysis.

Year		2010		2012		2014		2016		2018	
Variable	Variable description	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Explained variable											
Total education expenditure	Total family educational expenses (in Chinese yuan), logarithmically	4.673	3.759	4.695	3.827	4.933	3.903	5.543	3.849	5.744	3.841
<i>Per capita</i> education expenditure	Average educational expenses per child (in Chinese yuan), logarithmically	4.288	3.493	4.398	3.617	4.629	3.691	5.203	3.646	5.378	3.626
Explanatory variable											
Household participation	Household participating in new rural pension scheme is set to 1 and 0 otherwise	0	0	0.658	0.474	0.816	0.388	0.632	0.482	0.611	0.488
Head of household participation	Household head participating in the new rural pension scheme is set to 1 and 0 otherwise	0	0	0.532	0.499	0.691	0.462	0.478	0.5	0.459	0.498
Household head characteristics											
Gender	Household head is set to 1 for male and 0 for female	0.836	0.370	0.626	0.484	0.570	0.495	0.555	0.497	0.540	0.499
Marriage	Household head has a spouse set to 1 and no spouse set to 0	1	0	0.929	0.257	0.924	0.265	0.913	0.282	0.904	0.294
Education level	Household head years of education	6.566	3.814	5.805	4.417	6.077	4.073	6.277	4.087	6.636	4.072

(Continued)

TABLE 1 (Continued)

Year		2010		2012		2014		2016		2018	
Variable	Variable description	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Health	Physical condition of household head, 1 → 5 unhealthy → healthy	4.178	1.029	2.797	1.227	2.974	1.269	2.886	1.253	2.869	1.262
Work	Set to 1 if household head is employed, set to 0 if no employment or retirement	0.673	0.469	0.864	0.343	0.856	0.351	0.831	0.375	0.829	0.376
Household characteristics											
Filial piety	Whether children are responsible for caring for their parents when they are sick	0.127	0.332	0.123	0.328	0.137	0.344	0.167	0.373	0.144	0.351
Family Size	Total number of family members	5.495	0.948	5.177	0.912	5.215	0.929	5.190	0.944	5.251	0.929
Household <i>per capita</i> income	Household's income <i>per capita</i> (in Chinese yuan)	4575.925	4393.318	7999.669	7890.458	8898.464	7774.319	11354.676	9185.234	12720.736	9971.503
Household savings rate	Total household savings as a proportion of income	0.183	0.967	1.973	15.595	1.028	16.694	0.607	9.338	0.476	2.014
Household health care expenditure	Household expenditures on health care (in Chinese yuan) taken as a logarithm	6.324	2.509	7.043	2.036	7.088	2.383	7.218	2.413	7.232	2.484
Intergenerational interaction											
Care inputs	Older adult person helps with household chores or childcare	0.056	0.229	0.086	0.281	—	—	0.196	0.397	0.201	0.401
Intergenerational financial support	Children provide financial support to older adult individuals	0.033	0.178	0.070	0.255	—	—	0.174	0.379	0.202	0.402
Perceptions of Ageing	Household head's perception of heirlooms	4.168	1.064	—	—	3.759	1.410	—	—	4.305	1.013
Education awareness	Household head's perception of future children's success	4.639	0.675	—	—	4.122	1.060	—	—	4.594	0.756



### 4.3. Model setting

The paper focuses on the impact of the new rural pension scheme on the human capital investments of rural households. To validate H1, we use a two-way fixed effects model for time and individuals as follows:

$$\ln edu_{it} = \beta_0 + \beta_1 Nrps_{it} + \beta_2 X_{it} + u_i + v_t + \varepsilon_{it} \quad (1)$$

In Equation (1),  $\ln edu_{it}$  represents the logarithmic value of household education expenditures, and  $Nrps_{it}$  represents whether rural households participate in the new rural pension scheme. The variable is a dummy variable and takes the value of 1 if participating and 0 otherwise.  $X_{it}$  and  $\beta_2$  represent a series of control variables, such as household level, head of household level and their corresponding regression coefficients.  $\beta_0$  and  $\beta_1$  are parameters to be estimated, and  $\beta_1$  is the coefficient of focus in this paper, reflecting the impact of the new rural pension scheme on the human capital investment of rural households.  $\beta_0$  is the constant term,  $u_i$  and  $v_t$  represent household individual fixed effects and time fixed effects.  $\varepsilon_{it}$  is the random error incorporating both individual and time dimensions. This model is used in the basic regression and heterogeneity analysis sections.

According to the previous analysis, the new rural pension scheme mainly affects family human capital investments through the paths of care inputs, intergenerational economic support, education cognition and pension cognition. Referring to the practice of Chen et al. (40) and Peng et al. (41), we further explore the impact mechanism of the new rural pension insurance program on the human capital of rural households, and the specific model is as follows:

$$M_{it} = \gamma_0 + \gamma_1 Nrps_{it} + \mu X_{it} + \varepsilon_{it} \quad (2)$$

In the formula,  $M_{it}$  is the intergenerational interaction of the intermediate mechanism variable,  $Nrps_{it}$  is the core explanatory variable of the new rural pension scheme,  $X_{it}$  represents a series of control variables that affect household human capital investments and insurance participation behaviour, and  $\varepsilon_{it}$  is a random disturbance term. To test the mechanism of care input, intergenerational economic support at the material level and education cognition and old-age cognition at the nonmaterial level, we adopt the logit and ordered probit models for the estimation, respectively.

## 5. Empirical analysis

### 5.1. The effect of the NRPS on the human capital investment of rural households

#### 5.1.1. Baseline regression

To explore the impact of the new rural pension scheme on household human capital investments, we use total education expenditure of rural households as the explanatory variable. The fixed-effects regression results of the panel data are detailed in Table 2. Models (1–1), (1–2), and (1–3) successively add a series of control variables. In all regression results, the coefficients of the new rural pension scheme participation variable are positive and significant at the 1% level, indicating that participation in the

TABLE 2 Influence of the new rural pension scheme on rural family human capital investment.

Explained variable	Education		
	(1–1)	(1–2)	(1–3)
Explanatory variable			
Household participation	0.434*** (0.131)	0.431*** (0.131)	0.399*** (0.129)
Household head characteristics			
Gender	—	−6.788 (4.289)	−5.813 (4.225)
Marriage	—	−0.303 (0.454)	−0.881* (0.451)
Education level	—	0.0002 (0.060)	0.008 (0.060)
Health	—	0.081 (0.054)	0.086 (0.053)
Work	—	0.496*** (0.166)	0.529*** (0.163)
Household characteristics			
Filial piety	—	—	0.063 (0.165)
Family size	—	—	0.915*** (0.086)
Household <i>per capita</i> income	—	—	0.0000125 (0.0000076)
Household savings rate	—	—	−0.002 (0.007)
Household health care expenditure	—	—	0.055** (0.024)
_cons	4.501*** (0.099)	8.445*** (2.786)	2.876 (2.791)
Family fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
R <sup>2</sup>	0.0479	0.0516	0.0816
Number of Obs.	10,540	10,540	10,540

\*\*\*, \*\*, and \* indicate significance at the 1%, 5%, and 10% levels, respectively; standard deviations are in parentheses (same below).

new rural pension scheme helps improve human capital investments of rural households. Hypothesis 1 is verified. Models (1–3) show that household participation in the new rural pension scheme increases household human capital investments at a rate of 39.9%. Therefore, it can be concluded that the participation of rural households in the new rural pension scheme has a significantly positive effect on total household education expenditures, which also indicates that this new scheme has a spillover effect. In the regression results of the control variables, the work of the household head variable is significant at the 1% level, and the coefficient is positive, indicating that household education expenditure is higher when the head of household has a job, probably because the household head has a higher family income if he has a job, and has a certain status in social life, so he will pay more attention to the welfare of the family and pay more attention to the quality of education. A larger

TABLE 3 Robustness test results.

	Education		
	(2–1)	(2–2)	(2–3)
Household participation	0.393*** (0.123)	—	0.380*** (0.120)
Head of household participation	—	0.261** (0.123)	—
Household head characteristics	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes
_cons	4.016 (2.663)	3.032 (2.794)	3.094 (2.858)
Family fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
R <sup>2</sup>	0.0700	0.0803	0.0805
Number of Obs.	10,540	10,540	11,190

TABLE 4 Endogeneity tests: treatment effects.

Variable	Education		
	(3–1) CSDID	(3–2) DID <sub>M</sub>	(3–3) PSM-DID <sub>M</sub>
ATT	1.244*** (0.361)	—	—
Household participation	—	0.407** (0.185)	0.539** (0.200)
Household head characteristics	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes
Family fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Number of Obs.	2,620	2,683	2022

household size increases household education expenditures, probably because there are more children in the family, so the education expenditure is larger.

### 5.1.2. Robustness test

In this section, we replace the explanatory variables, change the explanatory variables, and increase the study sample to conduct the robustness test. The regression results are shown in Table 3.

Considering that the number of children in different families will have an impact on the overall education expenditure, this part of the total education expenditure of the explanatory variables will be replaced by the “average education expenditure of the child” for the robustness test. The results are shown in Model (2–1) in Table 3. The new rural pension scheme has a significantly positive impact on the human capital investment of rural households, and the regression results obtained do not shift substantially and the previous results remain robust.

Considering the differences between the insurance participation behaviour of households and individuals, to further test the robustness of the above results, we use the insurance participation behaviour of

household heads as the core explanatory variable to verify the basic regression results according to the literature. The results for Model (2–2) are presented in Table 3 and show that the participation behaviour of household heads is still significantly and positively related to household education expenditures, indicating that the receipt of pensions by household heads can significantly promote household human capital investments. These results are similar to the benchmark regression results, further indicating their robustness.

Because of the existence of pilot areas in 2010, this paper uses the panel data synthesised by excluding households participating in NRPS in 2010. This part extends to all insured households by re-adding the excluded samples in the regression. Models (2–3) show that the implementation of the NRPS has a significantly positive impact on household human capital investment at the 1 percent level, consistent with the results of the benchmark regression.

### 5.1.3. Endogeneity problem

To better address the endogenous problems caused by missing variables and possible reverse causality between the new rural pension scheme and household human capital investments, we refer to Zheng et al. (42) and Zhou et al. (43), whether the local county was a NRPS pilot at the survey year is defined as an instrumental variable to eliminate the estimation errors caused by self-selection bias. However, since the new rural pension program was implemented nationwide at the end of 2012, and the policy has achieved full coverage, and the survey areas after 2012 are all pilot counties for the new rural pension program. Given the data reasons, the instrumental variables in this paper for 2014, 2016, and 2018 are invariant and the time fixed effects cannot be controlled, so the instrumental variable method is not used in this paper to test the endogeneity problem. We use a multi-temporal policy effect estimation methodology.

Although the two-way fixed effects model controls for the variables that affect household human capital investments at the household and individual levels, on the one hand, there may be other unobservable variables may simultaneously affect participation in the new rural pension scheme and household education expenditures, resulting in missing variable bias. On the other hand, two-way fixed effects models usually contain only two groups (treatment and control) and two periods (before and after policy treatment), but with heterogeneous treatment effects, many studies have more than two treatment time points, where earlier treated samples become the control group for the later treated samples and the negative weighting problem may make the estimated coefficients biased, and so it leads to implausible empirical estimates. To alleviate the problem of estimation bias, we first refer to the idea of Callaway and Sant’Anna (44). Estimation is carried out using the CSDID model, which basically consists of avoiding the use of individuals who have already been treated as the “bad control group” and selecting only the “good control group” to estimate the group-period average treatment effect, and then weighted average on both group and period dimensions to obtain the average treatment effect of the policy. At the same time, the use of two-way fixed effects models to estimate the dynamic effects of policies may also lead to the coefficients for each period becoming difficult to interpret because of cross-contamination across periods. Based on this consideration, the DID<sub>M</sub> estimator proposed by de Chaisemartin and D’Haultfoeuille is used to deal with the problem (45).

CSDID is used to mitigate the problem of estimation bias, while the average treatment effect of the new rural pension scheme and the average effect of all groups in different years are examined, and the results are shown in Table 4. The policy effects in model (3–1) are all

significantly positive at the 1% level, which indicates that the policy has a facilitating effect on the human capital investment of rural households. The results of model (3–2) show a slight increase in the  $DID_M$  estimates compared to the base regression results, but the change is relatively small. This suggests that the base model bias issue may be present, but does not materially affect the results. And PSM- $DID_M$  is used to avoid potential selectivity bias. It obtained the propensity score value by logit regression of the control variables through the dummy variable of whether or not to participate in the new rural pension scheme, and used k-nearest neighbour matching to determine the weights. The mean value of the matched treatment group is 5.38 and the mean value of the control group is 5.00, which is closer. ATT after matching was 0.372, which suggests that the NRPS does significantly increase the level of investment in the human capital of rural households. To ensure that the PSM results meet the “conditional independence assumption,” it is necessary to test the balance of matching variables between the treatment group and the control group, requiring that there is no significant systematic difference between the samples. The absolute values of the standardised deviations of the matched covariates are less than 10% and most of the t-test results do not reject the original hypothesis that there is no difference between the treatment group and the control group, which passes the balance test, thus justifying the use of PSM- $DID_M$ . Meanwhile, it draws the density function plot of the propensity score value to test the matching effect of the treatment and control groups. As shown in Figure 3, the probability densities of the propensity score values are close to each other after matching, indicating that the matching effect is better. So the feasibility and reasonableness of the PSM- $DID_M$  are further proved on the basis of the common support domain. Table 4 models (3–3) reveal the  $DID_M$  regression results after using propensity score for k-nearest neighbour matching. Their coefficient is higher than those of the estimated results of the benchmark regression and is still positive at the 5% significance. This finding shows that the positive impact of the new rural pension scheme on the human capital investment of rural households is still verified after controlling for the endogeneity problem of sample selection bias. So the conclusions all suggest that the heterogeneity treatment effect has a more limited impact on the estimation results in this paper.

Due to space constraints, the logit regression results during PSM matching, the diagram of the common support domain and the

balance test results of PSM are not shown in the paper, as shown in the [Supplementary material](#).

#### 5.1.4. Heterogeneity analysis

The paper further divides the samples into groups according to age, gender and household income to explore the differences in the spillover effect of insurance participation on household human capital investments among different groups.

To examine the heterogeneity of the impact of the policy on family education expenditures in different stages of insurance participation, this section classifies the family samples according to the age required by the policy and discusses the impact of the new rural pension insurance program on the human capital investments of households in the insured but uncollected and collected segments. The regression results are detailed in Table 5 and show that the new rural pension scheme significantly increases household human capital investments in receiving stages but has no significant effect on participants under 60 years of age who have not yet received the NRPS. The reason is that the insured under 60 years old can only expect stable pension security in the future, whereas for aged 60 and above, they have been able to directly obtain the pension, which can increase their welfare, satisfy their basic needs, and even improve their sense of well-being and confidence in the future, so they are willing to use it for other purposes. Thus, compared with the group that is insured but does not receive it, the group in the stage of receiving insurance that receives it promotes investment in the human capital of the household. Thus, compared with the group that is insured but does not receive it, the group in the stage of receiving insurance that receives it promotes investment in the human capital of the household.

Gender difference is one of the factors that affects the human capital investments of rural households. New rural pension schemes to increase the level of human capital investments in households may also differ among household heads of different genders. We divide the total sample into female and male subsamples according to the gender of the household head, and the results are shown in Table 6. Female household heads pay more attention to children's education than do male household heads, and the new rural pension scheme can significantly improve the level of human capital investments of female-headed households. The reason for the above results may be that

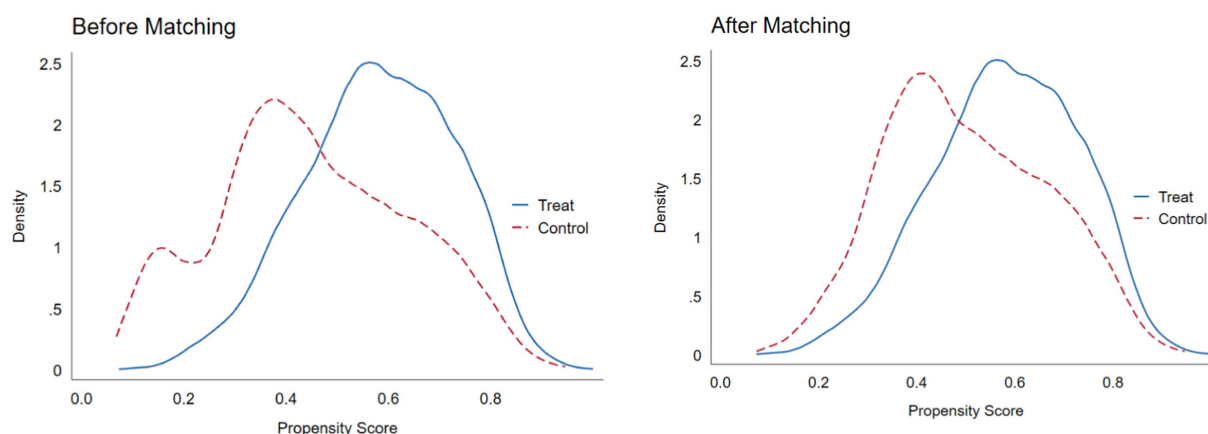


FIGURE 3  
Nuclear density map of PSM matching.

TABLE 5 Regression results for different ages of enrollees.

	Education			
	(4–1)	(4–2)	(4–3)	(4–4)
	Over 60	Below 60	Over 60	Below 60
Household participation	0.795*** (0.265)	0.276 (0.198)	0.758*** (0.265)	0.204 (0.195)
Household head characteristics	No	No	Yes	Yes
Household characteristics	No	No	Yes	Yes
_cons	4.635*** (0.327)	4.700*** (0.119)	0.957 (1.482)	−2.341* (1.202)
Family fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
R <sup>2</sup>	0.0260	0.0630	0.0467	0.1142
Number of Obs.	3,185	7,355	3,185	7,355

TABLE 6 Regression results for different participants' genders.

	Education			
	(5–1)	(5–2)	(5–3)	(5–4)
	Female	Male	Female	Male
Household participation	0.669 *** (0.206)	0.289* (0.169)	0.602*** (0.204)	0.271 (0.167)
Household head characteristics	No	No	Yes	Yes
Household characteristics	No	No	Yes	Yes
_cons	4.647*** (0.284)	4.497*** (0.102)	0.759 (1.474)	−1.128 (0.950)
Family fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
R <sup>2</sup>	0.0712	0.0393	0.1037	0.0752
Number of Obs.	3,879	6,661	3,879	6,661

women are in a weak position in the household under the long-term historical influence of “men farming and women weaving” and “men taking the lead outside the household and women taking the lead inside the household,” and male household heads are predominant. However, with the progressive emphasis on education in society and as the main group of people who take care of children, women are the heads of the family and are more willing than men to invest more of their stable incomes from pension insurance in their children's education. Doing so represents better nurturing and care for children, gives them access to more educational resources, increases the family's resistance to future risks, and exchanges human capital accumulation for life security in old age.

To explore the impact of the new rural pension scheme on family human capital investments in different income classes, family income

is divided into low income, middle income and high income according to the quantile of the mean household net income. The regression results are shown in Table 7. The results indicate that for low-income households, participation in the NRPS leads to an increase in household expenditure on education, while for middle-income and high-income households, there is no significant effect. Compared to families with higher income, families with low income usually have a low socio-economic status. The additional income from the pension is likely to improve the overall income level of the family and play a relatively more important role in family expenditures, helping the older adult and the education of their children to a certain extent. Families with higher income may attach relatively higher importance to education itself and spend more on education. This additional income received by the family accounts for a small proportion of the total family income and the likelihood of investing it in childcare costs is relatively low. In general, the difference in income leads to a gap in human capital investments among different families, which further intensifies the differences in human capital endowments among different classes and thus causes larger gaps among families and their incomes.

## 5.2. Mechanisms of the impact of the new rural pension scheme on human capital investments in rural households

The family, as an individual living unit, has innate unity and trust. Two-way feedback intergenerational relationships are obvious in traditional society. Under the long-term influence of traditional concepts, most of rural older adult care is based on intergenerational economic support as a means of “family pension.” As an exogenous shock to rural family wealth (46), the new rural pension scheme not only reduces the financial burden of children supporting the older adult to a certain extent, but may even improve the sense of well-being of the older adult, and in turn, the older adult provide their children with livelihood and even financial assistance. And among them, the flow of family resources, the power and status of the older adult in the family, as well as the support of children for older adult individuals are mainly affected by the intergenerational interaction pattern of the family (47). A balanced and orderly benign intergenerational interaction is conducive to the distribution and flow of family resources. Therefore, we analyse the mechanism from both material and immaterial levels to examine whether intergenerational interactions play a role in the impact of the policy on household human capital investments.

Considering the situation of grandparents taking care of children's household chores and children providing economic support to their parents, the behavioural changes of individuals in the family under the influence of the NRPS are explored at a deeper level to analyse whether intergenerational interactions at the material level play a role in the influence of the policy on the investment in human capital of rural families. The first variable is that grandparents look after children or help with household chores. The current combination of inadequate childcare services, the increase in the number of dual-income families, traditional cultural concepts of succession, and intergenerational family reciprocity has made intergenerational care common in three-generation families. Therefore, after the older adult have secured their basic livelihood, we presume that they may use their leisure time to help their children, so



TABLE 7 Regression results of income disparity.

	Education					
	(6–1)	(6–2)	(6–3)	(6–4)	(6–5)	(6–6)
	Low income	Moderate income	High income	Low income	Moderate income	High income
Household participation	0.661** (0.284)	0.417 (0.348)	0.040 (0.278)	0.616** (0.286)	0.355 (0.348)	0.075 (0.271)
Household head characteristics	No	No	No	Yes	Yes	Yes
Household characteristics	No	No	No	Yes	Yes	Yes
_cons	3.978*** (0.158)	4.009*** (0.261)	4.251*** (0.416)	−0.179 (1.716)	−1.508 (2.140)	−3.173 (1.931)
Family fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R <sup>2</sup>	0.0461	0.0703	0.0855	0.0658	0.1080	0.1477
Number of Obs.	3,512	3,340	3,688	3,512	3,340	3,688

TABLE 8 Mechanisms of the effect of the new rural pension scheme on family human capital in-vestments.

Intergenerational interaction	Material level		Nonmaterial level	
	(7–1)	(7–2)	(7–3)	(7–4)
	Care inputs	Intergenerational financial support	Perceptions of ageing	Education awareness
Household participation	−0.209* (0.125)	−0.248* (0.135)	0.156*** (0.044)	−0.033 (0.048)
Household head characteristics	Yes	Yes	Yes	Yes
Household characteristics	Yes	Yes	Yes	Yes
_cons	−1.463*** (0.385)	−0.037 (0.399)	—	—
R <sup>2</sup>	0.1166	0.1656	0.0104	0.0036
Number of Obs.	4,547	4,547	4,547	4,547

as to fulfill the value of positive family security. The second variable is the financial support provided by children to their parents. As an important part of the social security system for the older adult, the new rural pension scheme will have a substitution effect on supporting for the older adult in the family to a certain extent, which can alleviate the financial burden, reduce some of the upward intergenerational economic support, and improve the distribution of income.

Models (7–1) and (7–2) in Table 8 report the effects of participation in the NRPS on the above mechanism variables at the material level. Model (7–1) shows that participating in the new rural pension scheme reduces the frequency of older adult individuals helping their children do housework and take care of their children. It is possible that the withdrawal of older adult individuals from the labour market to age at home under the impact of the new rural pension scheme. Although a large amount of human capital of the older adult has been accumulated, due to the improvement of their own welfare status and a certain degree of economic independence, the need for their children's life care and economic help is reduced. As a result, many older adult individuals live more apart from their children, causing them to lack

environmental conditions and opportunities to help their children look after their children and do housework. Therefore, it is likely that in the context of the relaxation of the family's budget constraint, some help is provided to children through intergenerational economic support, giving them more resources to invest in family human capital. As shown in Model (7–2), under the influence of the new rural pension scheme, the financial support provided by the children to their grandparents has decreased. This suggests that the implementation of the policy has improved the wealth level and income expectations of older adult individuals. Thus, children in rural households provide less financial help to their grandparents to some extent, leading to a relative increase in household wealth. Subsequently, the implementation of the policy has not only directly alleviated the pressures of living on older adult individuals themselves but also has indirectly reduced the burden of family care and pensions and has resulted in higher investments of the family income in children's education.

The next step is to examine how intergenerational interactions at the non-material level play a role in the process of the impact of the NRPS on household human capital investments by considering perceptions of

ageing and education awareness. The first variable is household head's perception of heirlooms. Considering the cultural traditions of succession and family continuity in rural areas, there may be a trade-off between the number and quality of children. Under the influence of a strong idea of succession, it is likely to emphasise the number of children at the expense of investing in the education of each child. The second variable is the importance that the head of the household perception of future children's success. If household head believes that it is important for children to be successful and attaches importance to the future development, then education, as a key way to improve human capital, is likely to be the choice of the members of the household to invest more resources in their children, so that if their children's level of wealth increases in the future, they will be more benefited.

As shown in Model (7–3), there is a significant effect of participation in the new rural pension scheme on the perception of family retirement. From the results, it can be seen that participation in the NRPS at the 1 per cent level of significance will increase the importance of the family's succession, and there is an impact on perceptions of retirement. May be due to the long-term impact of history, the traditional concept of raising children to prevent old age in rural areas still has a deep impact, the policy of "social pension" on the children of "family pension" replacement role is relatively limited, so the participation of the NRPS has not reduced but rather increased its weakening function. In the model (7–4), there is no significant effect on the importance of children's success. Overall, the new rural pension insurance program has a positive impact on household human capital investments through three paths: increased awareness of grandparents taking care of children's household chores, children providing financial support, and perceptions of ageing.

## 6. Conclusion

We focus on the human capital investments of rural households in China and discuss the spillover effect of the new rural pension scheme on rural household education investments. Based on data from the China Family Panel Studies (CFPS) in 2010, 2012, 2014, 2016, and 2018, we use a two-way fixed effect model to study the impact of the new rural pension insurance program on household human capital investments and adopts the treatment effect to solve the endogeneity problem.

We find that (1) rural households participating in the new rural pension scheme can significantly increase the level of household human capital investments. (2) The treatment effect model is used to conduct the endogeneity test, it is found that the policy has a positive contribution to household human capital investments, and the results are robust. (3) The spillover effect of the new rural pension insurance program is different depending on the family's stage of participation, family income and gender of the household head. The spillover effect of the policy is more significant for participants who are female, are in the recipient stage, and are in low-income households. (4) The new rural pension scheme affects household human capital investments mainly through intergenerational interactions in terms of intergenerational financial support for children at the material level, taking care of their children's household chores, and the cognitive aspects of retirement at the immaterial level. According to the above research conclusions, we propose the following countermeasures.

First, the new rural pension scheme has a positive externality on the education expenditures of rural households in China. We should continue to promote the breadth and depth of the new rural pension scheme, ensure the stable development of the rural social security system, and deepen the pension insurance policy and transfer payment policies such as tax reform in rural areas. Doing so is important to improve the quality of life of rural older adult individuals and investments in the human capital of families. The level of social security in many rural areas is still low, making it necessary to scientifically and reasonably increase the proportion of low-income groups participating in insurance, focus on improving the level of social security for women, strengthen the old-age security function of insurance, improve the psychological expectations of rural residents, and enhance the ability to resist future risks, which are all conducive to promoting family human capital investments and high-quality economic development in rural areas. Second, we can promote benign intergenerational family interactions through publicity and education. We should not only strengthen children's responsibility of caring for older adult individuals and focus on the intergenerational support of families in noneconomic aspects such as living companionship, psychological health and care for older adult individuals but also help rural households liberate their mindsets, weaken traditional concepts such as passing down the family line and raising children for old age, and strengthen the importance of education to the family. In addition, we can enhance family human capital accumulation through high-quality education investments, improve confidence in children's future incomes, and reduce future uncertainty. Third, we should accelerate the construction of a high-quality education system, promote the high-quality and balanced development of education, increase public education investments in rural areas, especially remote rural areas and poor mountainous areas, and ensure the equity of education resources. Meanwhile, we should broaden the income channels of rural families and increase family investments in education to promote the healthy development of rural education.

## Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding author.

## Author contributions

LF: Data curation, Formal analysis, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. JH: Conceptualization, Formal analysis, Funding acquisition, Methodology, Project administration, Resources, Supervision, Visualization, Writing – original draft, Writing – review & editing.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## References

1. Becker GS, Chiswick BR. Education and the distribution of earnings. *Am Econ Rev.* (1966) 56:358–69.
2. Hao CH, Zhao XD, Zhang HM, Chen FJ. Does the new rural pension program increase offspring labor supply? An examination from the perspective of family intergenerational division. *Stud Labor Econ.* (2022) 10:81–110.
3. Manzoni A, Gebel M. Young adults' labour market transitions and intergenerational support in Germany. *Eur Sociol Rev.* (2023). jcad006. doi: 10.1093/esr/jcad006
4. Zhao M, Wang X. A study on elderly labor supply in multigenerational households from the perspective of the embeddedness theory. *J Renmin Univ China.* (2023) 37:116–30. doi: 10.3969/j.issn.1000-5420.2023.01.010
5. Liu W, Song H, Chen S. Effects of education finance on household human capital investment: facts, mechanisms, and policy implications. *J Financ Res.* (2022) 507:93–110.
6. Zhang AC, Fan SD. Labor mobility, household income and rural human capital inputs: an empirical study based on CFPS microdata. *Mod Econ Res.* (2018) 435:19–26. doi: 10.13891/j.cnki.mer.2018.03.003
7. Sirisankaran A. Household risks and household human capital investment: longitudinal evidence from Thailand. *Eur J Dev Res.* (2017) 29:493–511. doi: 10.1057/s41287-016-0012-0
8. Blankenau W, Youderian X. Early childhood education expenditures and the intergenerational persistence of income. *Rev Econ Dyn.* (2015) 18:334–49. doi: 10.1016/j.red.2014.06.001
9. Wang L, Ji Y, Wang Y. Housing wealth, family income and educational expenditure: a case study of Tianjin. *Urban Dev Stud.* (2019) 26:116–24. doi: 10.3969/j.issn.1006-3862.2019.05.024
10. Wang CL, Xu GQ, Yang Z. Influence of land transfer on rural human capital accumulation: from the perspective of intergenerational educational investment. *Reformation.* (2020) 10:128–40.
11. Wu Q. A study on the influence of income and characteristic of family education expenditure. *J Cent China Norm Univ (Hum Soc Sci).* (2020) 59:175–86. doi: 10.3969/j.issn.1000-2456.2020.05.020
12. Serneels P, Dercon S. Aspirations, poverty, and education. Evidence from India. *J Dev Stud.* (2021) 57:163–83. doi: 10.1080/00220388.2020.1806242
13. Yao S, Chen J-J. How does mothers' education affect their children's schooling years —an empirical study based on CLDS2016. *J Huazhong Univ Sci Technol (Soc Sci Ed).* (2020) 30:87–96. doi: 10.19648/j.cnki.jhustss1980.2020.03.10
14. Hai-Anh HD, Rogers FH. The decision to invest in child quality over quantity: household size and household investment in education in Vietnam. *World Bank Econ Rev.* (2016) 30:104–42. doi: 10.1093/wber/lhv048
15. Arenas E. Abuelos at home: differential impact on children's education by family structure. *Res Soc Stratif Mobil.* (2017) 52:36–48. doi: 10.1016/j.rssm.2017.09.001
16. Li HR, Shi YT. The influence of the double burden of pension and child care on family human capital investment: empirical evidence from the Chinese family tracking survey (CFPS). *Chongqing Soc Sci.* (2022) 3:56–69. doi: 10.19631/j.cnki.css.2022.003.004
17. Yuan C, Zhang L. Public education spending and private substitution in urban China. *J Dev Econ.* (2015) 115:124–39. doi: 10.1016/j.jdevco.2015.02.006
18. Fang C, Huang B. Crowd-in or crowd-out: how financial investment in public education produces an effect on a family's education expenditure. *Educ Res.* (2022) 43:150–9.
19. Sung Y-A. Importance of pension income of elderly households in Korea and related factors. *Asia Pac J Soc Work Dev.* (2016) 26:29–45. doi: 10.1080/02185385.2016.1150875
20. Jin W, Wang P, He L. A research on the security role of new rural pension scheme: theoretical mechanisms and empirical evidence. *J Financ Econ.* (2018) 44:125–38. doi: 10.16538/j.cnki.jfe.2018.11.009
21. Li Y, Liu JX, Li L. The impact and its heterogeneity of new rural pension program on health service utilization of the rural elderly. *Aust J Agric Econ.* (2022) 8:112–24. doi: 10.13246/j.cnki.jae.20211014.002
22. Herl CR, Kabudula C, Kahn K, Tollman S, Canning D. Pension exposure and health: evidence from a longitudinal study in South Africa. *J Econ Ageing.* (2022) 23:100411. doi: 10.1016/j.jea.2022.100411
23. Pak T-Y. Social protection for happiness? The impact of social pension reform on subjective well-being of the Korean elderly. *J Policy Model.* (2020) 42:349–66. doi: 10.1016/j.jpolmod.2019.12.001
24. Zhou M, Sun X, Huang L. Does social pension expansion relieve depression and decrease medical costs? Evidence from the rural elderly in China. *Int J Public Health.* (2022) 67:1604296. doi: 10.3389/IJPH.2022.1604296
25. Zhang ZY, Cao SI. Does "new rural pension insurance" promote or suppress labor supply? --from the perspective of policy benefit ratio. *Stat Res.* (2021) 38:89–100. doi: 10.19343/j.cnki.11-1302/c.2021.09.007
26. Guo YX, Dai RX, Zhang LQ. Whether the new rural pension insurance can promote the land transfer of part-time farmers or not—by fuzzy regression discontinuity design. *China Agric Resour Zoning.* (2020) 41:186–94.
27. Zhang CC, Giles J, Zhao YH. Policy evaluation of China's new rural pension program: income, poverty, expenditure, subjective wellbeing and labor supply. *China Econ Q.* (2014) 14:203–30. doi: 10.13821/j.cnki.ceq.2015.01.012
28. Yu XL, Shangguan YW, Liu HM. New rural social endowment insurance, intergenerational care and children's health. *China Rural Econ.* (2019) 7:125–44.
29. de Carvalho IEF. Household income as a determinant of child labor and school enrollment in Brazil: evidence from a social security reform. *Econ Dev Cult Change.* (2012) 60:399–435. doi: 10.1086/662576
30. Gutierrez E, Juarez L, Rubli A. The effect of a transfer program for the elderly in Mexico city on co-residing children's school enrollment. *World Bank Econ Rev.* (2017) 31:809–28. doi: 10.1596/31479
31. Li Q, Zhou XB. Study on the impact of new rural social pension insurance on child care time of rural elderly and its mechanism. *World Econ Lit.* (2018) 246:31–52.
32. Pak T-Y. What are the effects of expanding social pension on health? Evidence from the basic pension in South Korea. *J Econ Ageing.* (2021) 18:100287. doi: 10.1016/j.jea.2020.100287
33. Herrmann T, Leckcivile A, Zenker J. The impact of cash transfers on child outcomes in rural Thailand: evidence from a social pension reform. *J Econ Ageing.* (2021) 19:100311. doi: 10.1016/j.jea.2021.100311
34. Lai H, Fu BC. Intergenerational interaction behavior patterns and environmental support in public spaces of urban settlements. *Urban Iss.* (2021) 5:73–83. doi: 10.13239/j.bjsshkxy.cswt.210508
35. López-Ortega M, Aguila E. Non-contributory pensions, functional limitations, and unpaid family care for older adults in Mexico. *J Aging Health.* (2022) 34:1213–27. doi: 10.1177/08982643221110093
36. Li YH. Aging population, child support burden and family human capital investment. *J Xi'an Jiao Tong Univ (Soc Sci).* (2019) 39:84–97. doi: 10.15896/j.xjtuskxb.201906011

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## Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2023.1272069/full#supplementary-material>

37. Zhang S, Li PN. Can new rural insurance policy promote household education expenditures--empirical evidence from the Chinese household tracking survey. *J Shanxi Univ Finance Econ.* (2022) 44:34–56. doi: 10.13781/j.cnki.1007-9556.2022.12.003
38. Acar EÖ, Günalp B, Cilasun SM. An empirical analysis of household education expenditures in Turkey. *Int J Educ Dev.* (2016) 51:23–35. doi: 10.1016/j.ijedudev.2016.03.007
39. Jing J, Rui KE. Whether the new rural insurance policy is conducive to the human capital investment of rural families? Empirical data from China family panel studies. *J Jiangxi Univ Finance Econ.* (2019) 6:158. doi: 10.13676/j.cnki.cn36-1224/f.2019.06.007
40. Chen Y, Fan Z, Gu X, Zhou L-A. Arrival of young talent: the send-down movement and rural education in China. *Am Econ Rev.* (2020) 110:3393–430. doi: 10.1257/aer.20191414
41. Peng XH, Fu YC, Shi QH. The impact and mechanism of migrant workers' remittances on educational performance of left-behind children in rural areas: an empirical analysis based on CFPS data. *China Rural Obs.* (2022) 5:168–84.
42. Zheng X, Shangguan S, Shen Z, Yang H. Social pensions and Children's educational outcomes: the case of new rural pension scheme in China. *J Fam Econ Iss.* (2023) 44:502–21. doi: 10.1007/s10834-022-09850-3
43. Zhou GS, Zhang XY, Jia S, Zhang CC. The impact of new rural pension program on expenditure inequality. *China Econ Quart.* (2020) 19:1467–90. doi: 10.13821/j.cnki.ceq.2020.03.15
44. Callaway B, Sant'Anna PHC. Difference-in-differences with multiple time periods. *J Econ.* (2021) 225:200–30. doi: 10.1016/j.jeconom.2020.12.001
45. De Chaisemartin C, d'Haultfoeuille X. Two-way fixed effects estimators with heterogeneous treatment effects. *Am Econ Rev.* (2020) 110:2964–96. doi: 10.1257/aer.20181169
46. Chen X, Wang T, Busch SH. Does money relieve depression? Evidence from social pension expansions in China. *Soc Sci Med.* (2018) 220:411–20. doi: 10.1016/j.socscimed.2018.12.004
47. Liu L. Low-balanced intergenerational relationships and rural family pension order--a field study based on village W in northern Hunan. *J Party Sch Fujian Prov Comm Comm Party China (Fujian Adm Coll).* (2020) 472:139–47. doi: 10.15993/j.cnki.cn35-1198/c.2020.02.017





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# Digital economy: an effective path for promoting residents' health in China

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The primary prerequisite for socioeconomic growth is good health, hence promoting residents' health is a vital objective of public policies. It is yet up for debate whether or not the digital economy (DE), which will be crucial to future economic growth, will eventually result in improvements in residents' health. Utilizing the China Family Panel Studies (CFPS) data in 2020, we explore how the DE affects residents' health. The findings reveal that residents' health is greatly enhanced by the DE. The eastern region sees a more dramatic improvement in residents' health as a result of the DE. Additionally, the DE can improve residents' health through the promotion of regional green development. The study's findings add to our knowledge of how the DE impacts residents' health while also offering recommendations for achieving universal health.

## KEYWORDS

digital economy, residents' health, green development, CFPS2020, China

## 1 Introduction

Health is an important human capital and a major support for socioeconomic development. In spite of the country's continued progress in economic development and social living standards, the residents' health remains not optimistic (1). According to the Report on Nutrition and Chronic Diseases of Chinese Residents (2020), chronic diseases were responsible for 88.5% of Chinese deaths in 2019, and hypertension, hypercholesterolemia, chronic obstructive pulmonary disease, diabetes, and cancer incidence rates increased compared to the statistics recorded in 2015. The Chinese government successively introduced multiple policies aimed at improving residents' health. The "Healthy China 2030" Plan Outline, released in December 2016 by the State Council and the Central Committee of the Communist Party of China, set the target year of 2030 for a considerable improvement in health service capacities. The Healthy China Action (2019–2030), issued in July 2019 by the Healthy China Promotion Committee, advocates for residents to develop a healthy and civilized lifestyle and achieve a healthy life with less illness. In its report to the 20th National Congress of the Communist Party of China, the party stressed the need of "placing the health of individuals in a position of strategic importance of prioritized development and improving policies to promote people's health". Through the joint efforts of all sectors of society, the level of health literacy among residents across the country steadily improved, from 8.8% before 2011 to 25.4% in 2021.

The DE has recently undergone a period of rapid expansion and has emerged as a new engine of China's growing economy. China's DE ranked second in the world in 2022, with a scale of 50.2 trillion yuan and its proportion of GDP increasing to 41.5%, according to the Internet Information Office's Digital China Development Report (2022). Through

constantly upgraded network infrastructure and information tools like smartphones, the DE promotes the penetration of digital technology into deeper areas, with far-reaching implications for economic sustainability and low-carbon growth. Specifically, the DE will be deeply integrated with producing and living activities, promoting the shaping of green consumption concepts, patterns, and production methods, and the creation and growth of smart energy, IoT platforms, and green factories will be encouraged by the DE, which will also greatly empower traditional industries to undertake digital and environmentally friendly transformations. As population health challenges become a more prominent research area in academia (2), can inclusive health dividends result from the DE? Answers to this question are still pending. China is confronted with issues like an aging population and a declining demographic dividend, so it is urgent to develop a talent dividend by enhancing population health in order to capitalize on human resources and support the healthy development of the economy and society. Therefore, scientifically assessing the DE's impact on residents' health is not merely an objective need to comprehensively accelerate digital economic development but also an inevitable requirement to solidly promote the health of all individuals. This study explores the effects of the DE on residents' health and examines its internal mechanisms in an effort to serve as a guide for advancing and improving policies.

## 2 Literature review

The first category of research that has a close connection to this subject is the study of the DE, which mostly researched the DE's influence from two perspectives: macro and micro, covering many fields such as economy, society, and ecology. The DE benefits regional green development, industrial structure upgrading, and green innovation, as has been confirmed by the existing macro-level research (3–5). The analysis of the influence of the DE on enterprise development has been the primary topic of micro-level studies. Implementing digital economic strategies could significantly increase listed Chinese firms' cash holdings, claimed Zhang and Liu (6). Li et al. provided evidence that by easing the constraints of financing, the DE effectively promoted innovation in firms (7). Another type of research is based on a more micro perspective, focusing on the DE's social welfare. Research by Zou et al. found that the DE hampered the sociocultural and psychological integration of migrant workers while facilitating their economic integration (8). Lu et al. argued that digital economics significantly boosted women's employment but failed to enhance women's employment quality in all respects (9). In addition, some studies have focused on DE-relevant issues such as enterprise digitization, automation, information technology, the digital divide, and digital finance (10–14).

The second category of relevant research is the study of residents' health. The majority of currently conducted research has examined how residents' health and medical costs are affected by both macroeconomic issues and personal characteristics. In terms of macroeconomic conditions, Bai et al. pointed out that EPU had a positive spatial spillover effect on China's healthcare expenditure (15). McInerney et al. found that for most of the period from 1994 to 2008, the mortality rate of the older adults was countercyclical,

and as the unemployment rate rose, the mental health status of the older adults became worse (16). Ruhm's research suggested that as the economy grew, smoking and obesity increased, while physical activity decreased and diets became less healthy (17). Atalay et al. used Australian residents as a sample and confirmed that rising property prices had a beneficial influence on homeowners' physical health but had an adverse impact on renters' physical and mental health (18). Regarding personal factors, Xu et al. believed that purchasing commercial insurance could improve residents' health (19). Von Dem Knesebeck et al. used data from the 2003 European Social Survey and found that people with a low level of education (middle school or lower) often self-rated their health as poor (20).

Direct studies on how the DE influences residents' health are still lacking. The research that is most pertinent to our study examines how internet development affects residents' health, and it has not yet formed a consensus. One type of research held a positive perspective. Wu et al. discovered that internet development greatly enhanced residents' health (1). Shapira et al. also pointed out that internet use was beneficial for improving the health of older adults (21). Another type of research held the opposite view. According to Zhou et al., internet addiction could reduce children's sleep and exercise time, ultimately damaging their physical and mental health (22). Allcott et al. believed that the intensive use of social media can have an adverse effect on mental health (23).

The impact of the DE and the factors that affect residents' health have generally been thoroughly examined in existing studies from both theoretical and empirical perspectives, and it is generally accepted that the DE plays an advantageous role in promoting regional green development. There are three main aspects of the existing research that need to be further developed and improved: first, the existing literature mostly portrays the development of the DE from the perspective of internet application and development, which is insufficient to accurately reflect the connotation of the DE; second, the existing literature primarily uses inductive reasoning to explore the impact of the DE on residents' health and lacks the support of empirical evidence; and third, additional study is required because the existing literature on the mechanism of the DE on residents' health is not conclusive. Consequently, this study explores the effect and mechanism of the DE on residents' health, aiming to provide directions for China to promote residents' health through digital economic development. The marginal contribution of this study is primarily reflected in three areas: first, it creatively assesses the impact of the DE from the perspective of residents' health, reveals its impact mechanism, and expands and enriches the research in the area of DE and health. Second, the endogenous issues in the research are successfully avoided through instrumental variable regression and other robustness tests. Third, the research findings of this work can serve as recommendations for improving DE policy.

## 3 Research hypotheses

From a realistic standpoint, the construction of China's ecological civilization is fundamentally centered on ecological priority and green development (24), but environmental pollution is posing a growing threat to this development. Environmental pollution is one of the main health risks; thus, improving



FIGURE 1  
Influence mechanism diagram.

environmental quality and promoting regional green development is a feasible path to improving residents' health. Theoretically, the DE may help traditional industries make intelligent and sustainable shifts, which will support green production and industries' development (25). Additionally, the DE aids in enhancing energy efficiency (26), lowering resource waste and unneeded environmental emissions, and considerably encouraging the growth of clean energy (27). Overall, the DE successfully promotes regional green development. According to related studies, increases in per capita sulfur dioxide and smoke emissions significantly increased the medical expenses of Chinese residents (28), and carbon emissions had detrimental long-term consequences for residents' health (29). By enhancing environmental quality and improving ecological services, regional green development can address the health demands of the residents. So we speculate that DE may promote green development, thereby enhancing the residents' health. Figure 1 illustrates the fundamental logic behind enhancing residents' health through the DE. Two research hypotheses are put forth in our research.

Hypothesis 1: The DE helps improve residents' health.

Hypothesis 2: The DE may improve residents' health by promoting regional green development.

## 4 Data sources and variables information

### 4.1 Data sources

Data from the CFPS in 2020 is used in this study. The China Social Science Survey Center at Peking University is responsible for carrying out the CFPS, a comprehensive, extensive, and multidisciplinary social tracking survey project. The database created by this project has a wealth of data at the individual, family, and community levels, comprising a wide range of research areas like economic activity, educational accomplishments, family relationships and dynamics, health, and so on. It serves as a reliable source of data samples for this study and is commonly utilized in the field of health economics. In addition, the provincial digital financial inclusion index data as well as the China Statistical Yearbook data, the National Bureau of Statistics data, and the provincial statistical yearbook data are all used in this study. Among these is the provincial digital financial inclusion index, which Ant Financial Group and the Digital Finance Research Center of Peking University jointly established. This index comprises numerous secondary variables in addition to three basic indicators of the coverage, intensity, and level of digital finance. It has been widely used in pertinent studies (30).

### 4.2 Variables information

The level of residents' health, as determined by their self-rated health (19), functions as the dependent variable in this study. Five categories: "unhealthy", "average", "relatively healthy", "very healthy", and "extremely healthy" are included in the residents' self-assessment of their health condition, given values of 1, 2, 3, 4, and 5, respectively. Self-rated health refers to an extensive assessment of respondents' health that takes into account a number of variables, such as disease severity and health stability. It can accurately depict the residents' health and satisfy the statistical requirements for validity and reliability. The higher the value, the healthier the residents.

The development degree of the DE serves as the study's independent variable. This research assesses the degree of development of the DE from the perspectives of the internet and digital inclusive finance, since the development of the DE relies on the growth of the internet and the promotion of digital finance (31). Specifically, it includes five indicators, namely, the number of internet users per 100 individuals, the proportion of people working in computer services and software, the overall amount of telecommunication services per capita, the number of people using mobile phones per 100 individuals, and the digital financial inclusion index. The entropy value method is used in this study to standardize and shrink the dimensions of the data for the five indicators shown above and build core independent variable DE indicators (9). The primary advantage of the entropy value method is that it is an objective empowerment method that establishes the index weights in accordance with the degree of variation of the index values of various indicators. This effectively avoids the deviation brought on by human factors, strengthens the objectivity of the indicators, and more accurately reflects the degree of the DE's development.

In this paper, the control variables are chosen from three dimensions: individual, family, and province. According to research that has already been conducted, a number of economic and social factors, including education level, per capita income, regional medical investment, and regional economic level, can have a significant impact on residents' health (29, 32). Existing research has also demonstrated that residents' individual characteristics, such as age, gender, marital status, and lifestyle choices like smoking, drinking, and family size, have a considerable impact on health (33). Therefore, in this study, the aforementioned aspects are controlled. To avoid interference from extreme samples, this paper excludes samples with family sizes greater than 10. Continuous variables are then put through a two-tailed 1% level winsorization procedure.

The detailed variable definition methods are presented in Table 1.

Statistics for the primary variables are listed in Table 2. The average for residents' health is 3.09, with a median of 3, indicating that the majority of residents are at the "relatively healthy" level. The DE still has some space for development, since the DE's average only stands at 0.2363, and the difference between the two values, 0.12 for the lowest and 0.91 for the highest, is quite large. Other variables' ranges of values remain within appropriate bounds.

TABLE 1 Variable definition and assignment.

Variable	Variable assignment
health	From 1 to 5, get better
dig	The development level of the DE
age	Age (years)
age_2	The square of age
gender	Male = 1, Female = 0
eduyear	Completed years of education
marriage	Married or not, Yes = 1, No = 0
smoke	Smoking or not, Yes = 1, No = 0
drink	Drinking or not, Yes = 1, No = 0
familysize	Number of people living together currently
lnfincomeper	Ln(per capita household income)
lngdp	Ln(provincial GDP)
lnmediexp	Ln(provincial financial expenditure on healthcare)

Married includes four states: being married, cohabiting, divorced, and widowed. Smoking is classified based on whether the respondents have smoked in the past month, and alcohol consumption is classified based on whether the respondents have consumed alcohol more than three times a week in the past month.

TABLE 2 Descriptive statistics of variables.

Variable	Observation	Mean	Standard deviation	Median	Minimum	Maximum
health	20101	3.09	1.20	3	1	5
dig	20101	0.24	0.14	0.17	0.12	0.91
age	20101	45.71	16.68	47	16	95
age_2	20101	2367.31	1570.81	2209	256	9025
gender	20101	0.50	0.50	1	0	1
eduyear	20101	8.87	4.70	9	0	24
marriage	20101	0.83	0.37	1	0	1
smoke	20101	0.27	0.44	0	0	1
drink	20101	0.13	0.33	0	0	1
familysize	20101	4.09	1.85	4	1	10
lnfincomeper	20101	9.86	0.93	9.88	7.31	12.21
lngdp	20101	10.36	0.75	10.49	9.10	11.62
lnmediexp	20101	6.52	0.50	6.57	5.70	7.48

## 5 Model design and baseline regression

### 5.1 Model design

This research creates the following econometric model for analyzing how the DE affects residents' health:

$$health_{ip} = \alpha + \beta dig_p + \gamma X_{ip} + \varepsilon_{ip} \quad (1)$$

The variables *health* and *dig* stand for residents' health and the provincial DE's level of development, respectively. Individuals and provinces are indicated by the subscripts *i* and *p*, respectively. The control variables are denoted by  $X_{ip}$ , and the random error term is indicated by  $\varepsilon_{ip}$ . This paper focuses primarily on the coefficient  $\beta$  to reveal how the DE influences residents' health.

### 5.2 Baseline regression

The findings of the baseline regression on how the DE affects residents' health are displayed in Table 3. Only the independent variable is introduced in Column (1), and the independent variable's significant positive regression coefficient shows that the DE greatly promotes residents' health. This conclusion is still confirmed by the estimation findings of the introduction of control variables in Column (2). Based on the aforementioned results, which show the health dividend of the DE, the government can take into account increasing the development of the DE by expanding the application of digital technology and establishing DE policies to encourage the improvement of residents' health.

This is evident from the control variables' regression results, where the regression coefficients for the variable *age* and its square term, *gender*, *drink*, *familysize*, *lnfincomeper*, *lngdp*, and *lnmediexp*, are found to pass the relevant significance test. The



TABLE 3 Baseline regression.

Variable	(1)	(2)
dig	0.2742***	0.4673***
	(0.0536)	(0.0646)
age		0.0450***
		(0.0035)
age_2		−0.0002***
		(0.0000)
gender		−0.1640***
		(0.0200)
eduyear		−0.0026
		(0.0022)
marriage		−0.0129
		(0.0310)
smoke		−0.0324
		(0.0222)
drink		−0.1671***
		(0.0262)
familysize		−0.0316***
		(0.0048)
lnfincomeper		−0.0477***
		(0.0104)
lngdp		−0.1530***
		(0.0315)
lnmediexp		0.2108***
		(0.0451)
N	20,101	20,101
R <sup>2</sup>	0.0011	0.1157

The \*\*\*, \*\*, and \* in the table, respectively, show the significance under the significance level of 1, 5, and 10%, and the robust standard errors are shown in the brackets. The same as in the following tables.

age of residents has a positive influence, but its square term has a negative impact, demonstrating that as people age, their self-rated health level exhibits a reversed “U” trend, originally rising and then gradually falling. The adverse effect of gender shows that men’s health level is relatively low, which may be due to men being under greater financial strain than women. Drinking frequently and a large household size worsen residents’ health. People who live in households with greater per capita incomes tend to be in worse health, which may be because these families generally have higher living standards and are more likely to have issues like obesity, work pressure, irregular work and rest. The provincial GDP level has an adverse influence, pointing to the fact that residents’ health level in economically developed areas is lower. This may be considered because rapid economic development has an adverse effect on the environment by increasing environmental pollution, and the number of diseases brought on by occupational diseases and sub-health is gradually rising. The provincial financial investment in healthcare has a beneficial effect, showing that the more the regional health investment, the healthier the residents are.

TABLE 4 Robustness test 1.

Variable	Order probit	Order logit	Tobit
	(1)	(2)	(3)
dig	0.4567***	0.7800***	0.4673***
	(0.0611)	(0.1017)	(0.0646)
age	0.0424***	0.0710***	0.0450***
	(0.0033)	(0.0057)	(0.0035)
age_2	−0.0002***	−0.0004***	−0.0002***
	(0.0000)	(0.0001)	(0.0000)
gender	−0.1583***	−0.2731***	−0.1640***
	(0.0190)	(0.0324)	(0.0199)
eduyear	−0.0012	−0.0056	−0.0026
	(0.0021)	(0.0037)	(0.0022)
marriage	−0.0006	0.0028	−0.0129
	(0.0297)	(0.0496)	(0.0310)
smoke	−0.0288	−0.0517	−0.0324
	(0.0211)	(0.0363)	(0.0222)
drink	−0.1546***	−0.2624***	−0.1671***
	(0.0248)	(0.0433)	(0.0262)
familysize	−0.0302***	−0.0513***	−0.0316***
	(0.0046)	(0.0079)	(0.0048)
lnfincomeper	−0.0435***	−0.0752***	−0.0477***
	(0.0099)	(0.0172)	(0.0104)
lngdp	−0.1514***	−0.2458***	−0.1530***
	(0.0299)	(0.0510)	(0.0315)
lnmediexp	0.2106***	0.3739***	0.2108***
	(0.0428)	(0.0731)	(0.0450)
N	20,101	20,101	20,101
R <sup>2</sup>	0.0414	0.0429	0.0385

### 5.3 Robustness test

This study undertakes robustness testing from three aspects: regression methods, indicator measures, and endogeneity issues, to guarantee the reliability of the study’s conclusions.

#### 5.3.1 Change the regression method

Given that the variable *health* in this study has a value of 1–5, which is an ordered categorical variable, order probit and order logit models are used for regression to reduce the estimate error from the OLS method. In addition, the tobit model is further utilized for regression because the dependent variable’s range of values is constrained. Table 4’s regression results show that the choice of regression methods had no impact on the paper’s findings.

### 5.3.2 Replace the variable measure

This paper also considers that differences in the measurement of core variables may affect research conclusions, so we change the measurement method of core variables. The variable *health2* is defined. Give *health2* a value of 1 for “unhealthy” or “average” self-rated health, a value of 2 for “relatively healthy” and a value of 3 for

“very healthy” or “extremely healthy” self-rated health. The binary categorical variable *health3* is also defined, and a value of 1 is given when the self-rated health status is “very healthy” or “extremely healthy”, and a value of 0 otherwise. The relevant regression findings are listed in Table 5’s Columns (1) and (2). The major component approach is additionally applied to create another DE

TABLE 5 Robustness test 2.

Variable	(1) Health2	(2) Health3	(3) Health	(4) Dig	(5) Health
dig	0.3378*** (0.0412)	0.3665*** (0.0875)			4.0164** (1.6913)
dig2			1.3972*** (0.2143)		
officenum1984				0.0002*** (0.0000)	
age	0.0301*** (0.0022)	0.0719*** (0.0049)	0.0449*** (0.0035)	−0.0006 (0.0004)	0.0472*** (0.0039)
age_2	−0.0002*** (0.0000)	−0.0005*** (0.0000)	−0.0002*** (0.0000)	0.0000*** (0.0000)	−0.0003*** (0.0000)
gender	−0.0918*** (0.0123)	−0.1015*** (0.0266)	−0.1629*** (0.0200)	0.0072*** (0.0021)	−0.1902*** (0.0247)
eduyear	−0.0039*** (0.0014)	−0.0325*** (0.0027)	−0.0028 (0.0022)	−0.0006*** (0.0002)	−0.0004 (0.0026)
marriage	0.0036 (0.0195)	−0.1304** (0.0513)	−0.0138 (0.0310)	−0.0180*** (0.0037)	0.0506 (0.0456)
smoke	−0.0181 (0.0138)	−0.0611** (0.0290)	−0.0329 (0.0222)	−0.0033 (0.0023)	−0.0213 (0.0242)
drink	−0.0823*** (0.0165)	−0.1415*** (0.0338)	−0.1685*** (0.0262)	−0.0148*** (0.0028)	−0.1126*** (0.0379)
familysize	−0.0181*** (0.0030)	−0.0214*** (0.0060)	−0.0310*** (0.0048)	0.0040*** (0.0004)	−0.0460*** (0.0085)
lnfincomeper	−0.0259*** (0.0065)	−0.0836*** (0.0129)	−0.0455*** (0.0104)	0.0331*** (0.0010)	−0.1651*** (0.0570)
lnngdp	−0.0797*** (0.0195)	−0.0332 (0.0409)	−0.1334*** (0.0308)	0.2230*** (0.0032)	−0.9501** (0.3819)
lnmediexp	0.1294*** (0.0279)	0.0987* (0.0585)	0.1981*** (0.0450)	−0.2615*** (0.0052)	1.1570** (0.4545)
Kleibergen-Paap rk Wald F statistic					37.252 [16.38]
Kleibergen-Paap rk LM statistic					64.996 [0.0000]
N	20,101	20,101	20,101	20,098	20,098
R <sup>2</sup>	0.1261	0.1252	0.1153	0.3437	−0.0045

For Kleibergen-Paap rk Wald *F*-test, the value in the square bracket is the critical value of 10% level of Stock-Yogo test, and for Kleibergen-Paap rk LM test, the value in the square bracket is the corresponding probability of accepting the original hypothesis.

TABLE 6 Heterogeneity test—region differences.

Variable	Eastern region	Central region	Western region
	(1)	(2)	(3)
dig	0.4855*** (0.0755)	−0.1030 (0.7754)	−1.6318** (0.6532)
age	0.0460*** (0.0051)	0.0413*** (0.0071)	0.0468*** (0.0064)
age_2	−0.0003*** (0.0001)	−0.0002*** (0.0001)	−0.0002*** (0.0001)
gender	−0.1993*** (0.0292)	−0.1143*** (0.0380)	−0.1693*** (0.0393)
eduyear	0.0027 (0.0036)	−0.0088** (0.0043)	−0.0009 (0.0039)
marriage	−0.0379 (0.0461)	−0.0321 (0.0639)	0.0364 (0.0557)
smoke	−0.0140 (0.0332)	−0.0594 (0.0423)	−0.0288 (0.0425)
drink	−0.1886*** (0.0376)	−0.0861* (0.0484)	−0.2432*** (0.0571)
familysize	−0.0277*** (0.0074)	−0.0521*** (0.0089)	−0.0182** (0.0090)
lnincomeper	−0.0741*** (0.0160)	−0.0360* (0.0202)	−0.0310 (0.0189)
lngdp	−0.0534 (0.0581)	−0.1284 (0.1552)	0.1630 (0.1328)
lnmediexp	0.0999 (0.0665)	0.2348 (0.1980)	−0.1972 (0.1941)
N	8,753	5,873	5,475
R <sup>2</sup>	0.1135	0.1051	0.1387

indicator (*dig2*). Column (3) of Table 5 lists the corresponding findings. The aforementioned findings confirm that key variables' measure approach has no influence on the paper's results.

### 5.3.3 Addressing endogeneity issues

This study theoretically avoids potential reverse causality issues because the indicators of the DE and residents' health are defined at the provincial and individual levels, respectively. To further exclude interference from endogeneity issues, the instrumental variable in this paper's usage of the instrumental variable approach in regression is set to the historical amount of post offices per million persons (*officenum*1984). We specifically utilized provincial-level corresponding data in 1984 for analysis. The post offices per million persons number was chosen as the instrumental variable because the DE depends highly on regional internet development and earlier internet access depended on the post office system, so it

satisfies the requirement for relevance, and it is likely that the number of post offices historically does not have an impact on residents' health, therefore, so it meets the exclusivity requirements. The corresponding estimation results are displayed in Columns (4) and (5) of Table 5. The under identification test and the weak identification test both disprove the initial assumption and support the validity of the instrumental variable. The research conclusion is further confirmed by the fact that the independent variable's regression coefficient in the second stage is obviously positive.

## 6 Further discussion

### 6.1 Heterogeneity test

The sample is then divided into three groups in this study by geographic location: eastern, central, and western (34). The results of subsample regression are then performed, and they are presented in Table 6 as findings. The coefficient of *dig* in the eastern region is obviously positive, which shows that residents' health is greatly promoted by the DE. The central region's regression coefficient of *dig* is not significant, proving that residents' health is barely affected by the local DE. The western region's regression coefficient of *dig* is markedly negative, implying that the DE has a major adverse influence on residents' health. The aforementioned results show that there is regional variability in how the DE affects residents' health. The cause is that the eastern, central, and western regions exhibit substantial differences in the state of the development of the DE, the state of the health infrastructure, and the socioeconomic environment. In comparison to the central and western regions, the eastern region uses digital technology more widely, has a greater variety of digital goods and services, and typically has a higher income and educational level. It is also simpler to access high-quality digital goods and services. As a result, the residents are more significantly impacted by the DE in terms of their health in the eastern region.

### 6.2 Mediation effect test

The following econometric model is developed for the purpose of investigating the mechanism underlying how the DE affects residents' health:

$$health_{ip} = c_0 + cdig_p + e_{ip} \quad (2)$$

$$green_p = a_0 + adig_p + e_p \quad (3)$$

$$health_{ip} = b_0 + c' dig_p + bgreen_p + e_{ip} \quad (4)$$

In this model, the mediating variable is regional green development (*green*), which is quantified by the provincial pollution comprehensive index's opposite value. The total provincial wastewater discharge, general industrial solid waste, and sulfur dioxide releases in the waste gas are standardized and reduced in dimensions in this study through the entropy value method to calculate the provincial environmental pollution composite index, whose larger value denotes a more seriously polluted area. Therefore, this study uses the opposite of the

TABLE 7 The relationship between the DE and residents' health.

Health	Coef	Std.err	t	$p >  t $	[95% conf. interval]	
dig	0.2742429	0.0535821	5.12	0.000	0.1692176	0.3792682
_cons	2.845985	0.0158089	180.02	0.000	2.814998	2.876972

TABLE 8 The relationship between the DE and green development.

Green	Coef	Std.err	t	$p >  t $	[95% conf. interval]	
dig	0.2968942	0.0065145	45.57	0.000	0.2841253	0.3096632
_cons	-0.4312448	0.0019501	-221.14	0.000	-0.4350672	-0.4274224

TABLE 9 The relationship between the DE and green development and residents' health.

Health	Coef	Std.err	t	$p >  t $	[95% conf. interval]	
dig	0.1911995	0.0565738	3.38	0.001	0.0803101	0.3020888
green	0.2797069	0.0554032	5.05	0.000	0.1711112	0.3883018
_cons	2.966607	0.0289706	102.4	0.000	2.909822	3.023392

provincial environmental pollution composite index to measure regional green development. This study will investigate whether the DE will affect residents' health by influencing regional green development.

In general, there are three steps to testing for mediation effects. The first step focuses primarily on studying the effect of *dig* on *health*, and the major objective of it is to assess the significance of the estimated coefficient *c*. Table 7 displays the corresponding results.

In light of the results in Table 7, the coefficient *c* is equal to 0.2742 and significantly favorable, revealing that residents' health improves greatly as a consequence of the DE. So that the second step test may be taken out.

The coefficient *a* is what needs to be tested in the second step test, which examines the effect of *dig* on *green*. The pertinent findings are displayed in Table 8.

According to the results in Table 8, regional green development is greatly aided by the DE, with the coefficient *a* equal to 0.2969 and being significantly positive. We therefore get on with the third step test.

The third step test introduces the addition of the mediating variable green development (*green*), primarily testing *c'* and *b*, to explore the association between the DE, green development, and residents' health. Table 9 presents the findings from the regression.

As can be observed in Table 9, both the coefficients *c'* and *b* are positively significant and, respectively, equal to 0.1912 and 0.2797. After the introduction of the green development indicator, the benefits of the DE for residents' health do not change, and green development is conducive to enhancing residents' health. The aforementioned findings show that regional green development is an influential way for the DE to benefit residents' health. Overall, the argument is that DE efficiently encourages regional green development by lowering pollution, increasing energy efficiency, and encouraging green industrial transformation, which in turn improves the residents' health.

Based on the tests above, the overall and the direct effect of *dig* on *health* are both significantly positive, respectively, equal to 0.2742 and 0.1912, and that the mediating role of the DE in improving residents' health by encouraging regional green development is significantly positive, equal to 0.0830, accounting for 30.27% of the overall effect.

## 7 Conclusion and insights

This study explores how the DE impacts residents' health by utilizing CFPS data in 2020. According to the study, (1) The DE has a noticeable beneficial effect on residents' health. (2) The function that the DE plays for residents' health differs by region, with the eastern region having the greatest benefit. (3) By encouraging regional green development, the DE enhances residents' health effectively.

The study offers the following three policy insights after considering the results listed above: First, advance digital economic development, and adequate attention should be given to the DE's function in improving residents' health. Specifically, the government should put more emphasis on improving the construction of information infrastructure, enhancing residents' digital literacy, and strengthening the leadership position of the internet, as well as optimizing the regional business environment, supporting the rational allocation of production factors, and creating favorable conditions for the growth of the DE. Make use of the DE's beneficial functions in improving resource utilization efficiency, encouraging green shifts in industries, and promoting regional green development to promote the continual improvement of residents' health.

Second, enhance local environmental pollution inspection and control, assisting the DE in improving residents' health. The government should work to build environmentally friendly industries and support the green transformation of companies in regions with more environmental pressure. Reasonable

environmental management policies should be developed based on the carrying capacity of regional resources. In order to remove barriers that stand in the way of regional green development, it is also necessary to strengthen the oversight mechanism for the effectiveness of regional pollution control and the implementation of environmental protection policies, fully ensure the implementation of environmental policies, and impose harsh administrative and monetary penalties on enterprises that violate environmental restrictions. Additionally, to unlock the potential of the DE, we must continue to explore more channels where the DE may benefit residents' health and work with appropriate policies to reinforce the positive benefits of the DE.

Finally, make digital economic development plans that fit local characteristics to drive regional economic development. Considering the regional variations in the DE's function on residents' health, we should work to remove obstacles preventing digital economic development in economically underdeveloped areas and contribute to closing the economic development gap. Specifically, it is essential to integrate regional economic development features with industry comparative advantages, execute distinct regional DE development strategies, and support the growth of digital industries. During this process, full attention should be paid to the actual situation of regional development and people's livelihood issues. The central and western regions should be given fiscal assistance to achieve a steady improvement in the development level of the DE, committed to promoting the application of the DE while driving regional economic development.

These research directions can be explored in the future: First, consider how the DE affects residents' mental health; next, examine how the development of digital infrastructure, digital governance, and digital finance affect residents' health; Third, analyze how certain DE policies affect residents' health.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## References

1. Wu HT, Ba N, Ren SY, Xu L, Chai JX, Irfan M, et al. The impact of internet development on the health of Chinese residents: transmission mechanisms and empirical tests. *Socio Econ Plan Sci.* (2022) 81:101178. doi: 10.1016/j.seps.2021.101178
2. Guo LM, Zhang WK. Knowledge mapping of population health: a bibliometric analysis. *Heliyon.* (2022) 8:e12181. doi: 10.1016/j.heliyon.2022.e12181
3. Ma D, Zhu Q. Innovation in emerging economies: research on the digital economy driving high-quality green development. *J Bus Res.* (2022) 145:801–13. doi: 10.1016/j.jbusres.2022.03.041
4. Su JQ, Su K, Wang SB. Does the digital economy promote industrial structural upgrading?—A test of mediating effects based on heterogeneous technological innovation. *Sustainability.* (2021) 13:10105. doi: 10.3390/su131810105
5. Luo SY, Yimamu N, Li YR, Wu HT, Irfan M, Hao Y. Digitalization and sustainable development: how could digital economy development improve green innovation in China? *Bus Strat Environ.* (2023) 32:1847–71. doi: 10.1002/bse.3223
6. Zhang C, Liu LX. Corporate inventory and cash holdings in digital economy strategy: evidence from China. *Fin Res Lett.* (2023) 53:103607. doi: 10.1016/j.frl.2022.103607
7. Li Q, Chen HM, Chen Y, Xiao T, Wang L. Digital economy, financing constraints, and corporate innovation. *Pac Basin Fin J.* (2023) 80:102081. doi: 10.1016/j.pacfin.2023.102081
8. Zou J, Deng XJ. To inhibit or to promote: how does the digital economy affect urban migrant integration in China? *Technol Forecast Soc.* (2022) 179:121647. doi: 10.1016/j.techfore.2022.121647
9. Lu J, Xiao QL, Wang TX. Does the digital economy generate a gender dividend for female employment? Evidence from China. *Telecommun Policy.* (2023) 47:102545. doi: 10.1016/j.telpol.2023.102545
10. Fang MY, Nie HH, Shen XY. Can enterprise digitization improve ESG performance? *Econ Model.* (2023) 118:106101. doi: 10.1016/j.econmod.2022.106101

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XZ: Conceptualization, Methodology, Software, Writing – original draft. W-YY: Formal analysis, Resources, Validation, Writing – original draft. X-TL: Data curation, Project administration, Writing – original draft. HL: Supervision, Validation, Writing – original draft, Writing – review & editing. Y-ZW: Data curation, Funding acquisition, Methodology, Project administration, Resources, Writing – original draft. B-CX: Methodology, Resources, Supervision, Visualization, Writing – review & editing.

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## Conflict of interest

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11. Acemoglu D, Restrepo P. The race between man and machine: implications of technology for growth, factor shares, and employment. *Am Econ Rev.* (2018) 108:1488–542. doi: 10.1257/aer.20160696
12. Gaggl P, Wright GC. A short-run view of what computers do: evidence from a UK tax incentive. *Am Econ J Appl Econ.* (2017) 9:262–94. doi: 10.1257/app.20150411
13. Luan BJ, Zou H, Huang JB. Digital divide and household energy poverty in China. *Energ Econ.* (2023) 119:106543. doi: 10.1016/j.eneco.2023.106543
14. Hu DB, Zhai CZ, Zhao SB. Does digital finance promote household consumption upgrading? An analysis based on data from the China family panel studies. *Econ Model.* (2023) 125:106377. doi: 10.1016/j.econmod.2023.106377
15. Bai P, Tang YX, Zhang WK, Zeng M. Does economic policy uncertainty matter for healthcare expenditure in China? A spatial econometric analysis. *Front Public Health.* (2021) 9:673778. doi: 10.3389/fpubh.2021.673778
16. McInerney M, Mellor JM. Recessions and seniors' health, health behaviors, and healthcare use: analysis of the medicare current beneficiary survey. *J Health Econ.* (2012) 31:744–51. doi: 10.1016/j.jhealeco.2012.06.002
17. Ruhm CJ. Are recessions good for your health? *Q J Econ.* (2000) 115:617–50. doi: 10.1162/003355300554872
18. Atalay K, Edwards R, Liu BYJ. Effects of house prices on health: new evidence from Australia. *Soc Sci Med.* (2017) 192:36–48. doi: 10.1016/j.socscimed.2017.09.008
19. Xu BC, Li XJ, Gao MY. Influence of commercial insurance purchase on the health status of Chinese residents. *Front Public Health.* (2021) 9:752530. doi: 10.3389/fpubh.2021.752530
20. Von Dem Knesebeck O, Verde PE, Dragano N. Education and health in 22 European countries. *Soc Sci Med.* (2006) 63:1344–51. doi: 10.1016/j.socscimed.2006.03.043
21. Shapira N, Barak A, Gal I. Promoting older adults' well-being through Internet training and use. *Aging Ment Health.* (2007) 11:477–84. doi: 10.1080/13607860601086546
22. Zhou M, Zhu WM, Sun XT, Huang L. Internet addiction and child physical and mental health: evidence from panel dataset in China. *J Affect Disord.* (2022) 309:52–62. doi: 10.1016/j.jad.2022.04.115
23. Allcott H, Braghieri L, Eichmeyer S, Gentzkow M. The welfare effects of social media. *Am Econ Rev.* (2020) 110:629–76. doi: 10.1257/aer.20190658
24. Zhou X, Wang JP. Evaluation and differentiation analysis of China's construction of ecological civilization from the perspective of collaboration: using China's representative region as an example. *Sustainability.* (2023) 15:13403. doi: 10.3390/su151813403
25. Zhang JN, Lyu YW, Li YT, Geng Y. Digital economy: an innovation driving factor for low-carbon development. *Environ Impact Assess.* (2022) 96:106821. doi: 10.1016/j.eiar.2022.106821
26. Wang LH, Shao J. Digital economy, entrepreneurship and energy efficiency. *Energy.* (2023) 269:126801. doi: 10.1016/j.energy.2023.126801
27. Chen PY. Is the digital economy driving clean energy development? New evidence from 276 cities in China. *J Clean Prod.* (2022) 372:133783. doi: 10.1016/j.jclepro.2022.133783
28. Hao Y, Liu S, Lu ZN, Huang JB, Zhao MY. The impact of environmental pollution on public health expenditure: dynamic panel analysis based on Chinese provincial data. *Environ Sci Pollut Res Int.* (2018) 25:18853–65. doi: 10.1007/s11356-018-2095-y
29. Dong HM, Xue MG, Xiao YJ, Liu YS. Do carbon emissions impact the health of residents? Considering China's industrialization and urbanization. *Sci Tot Environ.* (2021) 758:143688. doi: 10.1016/j.scitotenv.2020.143688
30. Zhao H, Chen SW, Zhang WK. Does digital inclusive finance affect urban carbon emission intensity: evidence from 285 cities in China. *Cities.* (2023) 142:104552. doi: 10.1016/j.cities.2023.104552
31. Li ZG, Wang J. The dynamic impact of digital economy on carbon emission reduction: evidence city-level empirical data in China. *J Clean Prod.* (2022) 351:131570. doi: 10.1016/j.jclepro.2022.131570
32. Lu ZN, Chen HY, Hao Y, Wang JY, Song XJ, Mok TM. The dynamic relationship between environmental pollution, economic development and public health: evidence from China. *J Clean Prod.* (2017) 166:134–47. doi: 10.1016/j.jclepro.2017.08.010
33. Zheng WJ, Qi X, Yao HY, Liu JJ, Yu SC, Zhang T. Influence of built environment in hygienic city in China on self-rated health of residents. *Biomed Environ Sci.* (2022) 35:1126–32. doi: 10.3967/bes2022.142
34. Yang Z, Li QQ, Xue WH, Xu ZH. Impacts of nature reserves on local residents' income in China. *Ecol Econ.* (2022) 199:107494. doi: 10.1016/j.ecolecon.2022.107494



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# Impact of health insurance equity on poverty vulnerability: evidence from urban–rural health insurance integration in rural China

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**Background:** In 2016, the Chinese government introduced an integration reform of the health insurance system with the aim to enhance equity in healthcare coverage and reduce disparities between urban and rural sectors. The gradual introduction of the policy integrating urban and rural medical insurance in pilot cities provides an opportunity to evaluate the policy impact. This study attempts to assess the policy impact of urban–rural health insurance integration on the chronic poverty of rural residents and to analyze the mechanisms.

**Method:** Based on the four waves of data from the China Health and Retirement Longitudinal Study (CHARLS) conducted in 2011, 2013, 2015, and 2018, we employed a staggered difference-in-differences (staggered DID) model to assess the impact of integrating urban–rural health insurance on poverty vulnerability among rural inhabitants and a mediation model to analyze the mechanism channel of the policy impact.

**Results:** (1) Baseline regression analysis revealed that the urban–rural health insurance integration significantly reduced the poverty vulnerability of rural residents by 6.32% ( $p < 0.01$ ). The one health insurance system with one unified scheme of contributions and benefits package (OSOS, 6.27%,  $p < 0.01$ ) is more effective than the transitional one health insurance system with multiple schemes (OSMS, 3.25%,  $p < 0.01$ ). (2) The heterogeneity analysis results showed that the urban–rural health insurance integration had a more significant impact on vulnerable groups with relatively poor health (7.84%,  $p < 0.1$ ) than those with fairly good health (6.07%,  $p < 0.01$ ), and it also significantly reduced the poverty vulnerability of the group with chronic diseases by 9.59% ( $p < 0.01$ ). The integration policy can significantly reduce the poverty vulnerability of the low consumption and low medical expenditure groups by 8.6% ( $p < 0.01$ ) and 7.64% ( $p < 0.01$ ), respectively, compared to their counterparts. (3) The mechanism analysis results showed that the urban–rural health insurance integration can partially enhance labor supply (14.23%,  $p < 0.01$ ) and physical examinations (6.28%,  $p < 0.01$ ). The indirect effects of labor supply and physical examination in reducing poverty vulnerability are 0.14%, 0.13% respectively.

**Conclusion:** The urban–rural health insurance integration policy significantly reduced poverty vulnerability, and the OSOS is more effective than the OSMS. The urban–rural health insurance integration policy can significantly reduce poverty vulnerability for low consumption and poor health groups. Labor supply and physical examination are indirect channels of the impact. Both channels potentially increase rural household income and expectations of investment

in human health capital to achieve the policy objective of eliminating chronic poverty.

#### KEYWORDS

urban–rural health insurance integration, health insurance equity, poverty vulnerability, rural China, healthcare utilization, poverty due to illness

## 1 Introduction

China has achieved remarkable success in its anti-poverty strategies and social security policies. According to the international poverty standards set by the World Bank, China's efforts in reducing poverty accounted for over 70% of the global poverty reduction, significantly advancing the progress of global poverty alleviation (1). The financial risks of pursuing medical treatment for severe illnesses can still devastate low- and middle-income families. On the one hand, as of 2015, China has achieved an introductory medical insurance coverage rate exceeding 95% of its population of 1.336 billion (2), and the medical insurance coverage rate remained stable at more than 95% in 2022, with the number of participants reaching 1.346 billion (3). The basic medical security system for universal coverage has been essentially completed. On the other hand, according to official poverty statistics from 2018, over 42% of registered poor households in China experienced poverty due to illness (4), and the proportion of poverty due to illness remained at 40% in 2022 (5). This has resulted in the coexistence of “broad coverage” basic medical insurance and “high proportion” illness-induced poverty.

High medical expenses will transform uncertain health risks into economic risks affecting family welfare. The prepayment pooling mechanism established by health insurance can provide social protection. Health insurance with comprehensive coverage and sufficient safeguards is one of the most crucial measures to combat poverty (6). However, the varying arrangements of health insurance systems for different population groups may diminish the anti-poverty effect of health insurance and result in inequity. China has witnessed a remarkable expansion in social health insurance coverage, with the establishment of the New Rural Cooperative Medical System (NCMS) and Urban Residents' Basic Medical Insurance (URBMI) in 2003 and 2007, respectively, catering to rural residents and urban non-employed individuals.

The utilization of outpatient and inpatient services has increased under the NCMS (7) while the cost of deliveries has decreased (8). However, there has been no reduction in overall out-of-pocket payments, and the health status of rural residents enrolled in the NCMS remains the same (9). There are indications of moral hazards on the supply side that the program has increased ownership of expensive equipment among central township health centers (10) and had no impact on cost per case. Additionally, participants in the NCMS receive relatively lower reimbursement ratios than their counterparts in the URBMI due to constrained funding (11). Although designed to protect against economic risk from inpatient care costs, the limited protective effect of the NCMS on medical impoverishment is primarily due to expensive outpatient services for chronic conditions (12).

The health outcomes of individuals covered by URBMI were significantly superior to those without insurance. The availability and quality of inpatient care for enrollees have improved, both while avoiding additional costs (13). The URBMI is designed as an equitable financing policy, with premiums not varying based on income or education levels. Low-income families express higher satisfaction levels with the URBMI (14), although beneficiaries from higher-income groups tend to benefit more than those from lower-income groups. In other words, the health insurance fund (primarily composed of government subsidies) intended to support vulnerable populations has disproportionately benefited wealthier individuals (15).

Inequitable access to healthcare and financial protection for rural residents results from the fragmented social health insurance schemes between urban and rural regions (16). First, rural residents face lower actual reimbursement rates when seeking better quality medical services in advanced medical institutions in cities than their urban counterparts, resulting in heavier medical economic burdens. Second, the financing of the NCMS at the county level significantly weakens the portability of health insurance and the flow of rural residents seeking better job opportunities between counties and cities. Third, segmented health insurance systems have caused inefficiencies such as enrollee repeated participation that increase unnecessary operating costs and fiscal burden while distorting economic resource allocation and information sharing. To address healthcare inequality derived from the fragmentation of social health insurance between urban and rural areas, China implemented reforms to merge the NCMS with the URBMI, forming the Urban–Rural Resident Basic Medical Insurance (URRBMI). The URRBBI policy was officially implemented in 2016, but some provinces/cities began pilot policies around 2009.

The URRBBI significantly enhances inpatient care utilization among rural residents, particularly in the middle-aged and older adult groups, while demonstrating limited impact on improving health outcomes (17). The URRBBI notably increases consumption among vulnerable households with lower wealth or higher health risks by directly reducing medical expenses and indirectly influencing precautionary savings (18). The URRBBI expands the income group of rural residents, reduces out-of-pocket payments, improves the financial protection provided by basic medical insurance, benefits more low-income rural residents, and further enhances the overall health performance of rural communities. Implementing the URRBBI policy raises reimbursement rates and significantly improves financial protection and health performance. This is especially beneficial for low-income individuals within rural areas (19).

The research purpose of this study as follows. First, some pieces of literature have discussed the impact of the URRBBI on healthcare utilization and consumption. However, few studies have focused on the causal relationship between the URRBBI and persistent poverty.

Our study attempts to fill this literature gap by systematically evaluating the impact of the URRBMI on rural residents' poverty vulnerability. Second, we conducted an empirical study with a more rigorous research design, which will make the results of policy evaluation more reliable and robust. The urban and rural health insurance integration in China was gradually carried out in local provinces and cities from 2009 to 2020, which allowed us to employ a staggered difference-in-differences (staggered DID) mode to evaluate the policy effect of URRBMI through the empirical strategy of the quasi-natural experiment. We carefully checked the policy implementation time announced on local official websites and combined it with four waves of data from the China Health and Retirement Longitudinal Study (CHARLS) for 2011, 2013, 2015, and 2018. Third, we used the mediator effect model to explore the mechanism of the URRBMI in reducing the possibility of poverty in the future by promoting physical examinations and increasing labor supply.

## 2 Institutional background

China has been unswervingly committed to the public policy practice of universal healthcare coverage (UHC) to protect all citizens, especially the impoverished population, from being excluded from the healthcare system due to economic risk. Since the establishment of the Urban Employee Basic Medical Insurance (UEBMI) for urban workers in 1998, the Chinese central government has unveiled a long-term plan for establishing multiple social health insurance schemes. It has expanded the coverage of the overall population. The New Rural Cooperative Medical System (NCMS) for rural residents and Urban Residents' Basic Medical Insurance (URBMI) for urban non-employed residents were established in 2003 and 2007, respectively. The overall participation rate of basic medical insurance was only 22.1% in 2003 (49.4% in urban areas and 12.6% in rural areas). With the continuous

improvement of the basic medical insurance system, the overall coverage rate rose to 87.1% in 2008 (92.5% in urban areas and 71.9% in rural areas) (20).

China implemented a milestone healthcare reform in 2009 to provide affordable and equitable primary healthcare for all. This reform proposed a notable idea for integrating basic medical insurance to address health inequalities across urban–rural regions and operation inefficiencies. Since 2009, several provinces and cities, particularly those in the economically developed eastern coastal areas, have gradually initiated pilot policies for integrating urban–rural health insurance integration with the guiding principles of the healthcare reform policy document. In 2016, the State Council of China issued an official policy document on integrating the basic medical insurance system for the NCMS and URBMI, establishing six unified policy implementation principles (i.e., unified coverage, unified financing policy, unified benefits packages, unified catalog of health services and drugs, unified designated medical institutions, and unified fund management) to promote the integration process. The central government formulates the framework and policies uniformly for urban–rural health insurance integration, while local governments are responsible for implementing these policies. Before the State Council's document issuance, nine provinces, including Tianjin, Shanghai, Zhejiang, Shandong, Guangdong, Chongqing, Ningxia, Qinghai, and Xinjiang, had already promoted integration efforts by establishing a unified medical insurance system for both urban and rural residents.

Three crucial policy changes can enhance the policy effectiveness of health insurance poverty alleviation. First, the URBMI and NCMS are administered by the Chinese Ministry of Human Resources and Social Security (MoHRSS) and China's National Health Commission (NHC, previously China's Ministry of Health), respectively. After implementing the integration policy, the NCMS and URBMI were uniformly administered by the MoHRSS for the Urban and Rural Residents' Basic Medical Insurance (URRBMI). Table 1 provides concrete details about

TABLE 1 Introduction to the institutional background of basic social medical insurance systems for urban and rural residents in China (URBMI, NCMS, and URRBMI).

Scheme	URBMI	NCMS	URRBMI
Coverage eligibility	Urban non-working residents (including infants, children, and various types of students on campus)	Rural residents	Rural and urban residents not covered by the UEBMI
Benefits package	Mainly for inpatients and a unified reimbursement ratio of specific diseases for outpatients	Mainly for inpatients and a unified reimbursement ratio of specific diseases for outpatients	Mainly for inpatients and a unified reimbursement ratio of specific diseases for outpatients
The level of fund pooling	Municipal level	County level	Municipal level
Financing model	Individual contribution + Government subsidy	Individual contribution + Government subsidy	Individual contribution + Government subsidy
Reimbursable ratio and list of drugs and medical services	Higher and wider	Lower and narrower	Upgrade for URBMI standards
Implementation time	2007	2003	Gradually, pilot cities from 2009; official policy documents implemented in 2016
Administration	MoHRSS	NHC	MoHRSS from the integration, NHSA from 2018

Based on previous vital studies (19, 21, 22), we summarize the details of the institutional background for China's basic social medical insurance systems for urban and rural residents and supplement the reform of management institutions after 2018.

URBMI, Urban Residents' Basic Medical Insurance; NCMS, New Rural Cooperative Medical System; URRBMI, Urban and Rural Residents' Basic Medical Insurance; UEBMI, Urban Employee Basic Medical Insurance; MoHRSS, Chinese Ministry of Human Resources and Social Security; NHSA, National Healthcare Security Administration; NHC, National Health Commission.



the health insurance schemes of the URBMI, NCMS, and URRBMI. There are no rural or urban identity differences (i.e., the hukou requirement) for participating in the URRBMI. The unification of administration has relieved the waste of human resources and financial and economic burden, while information system sharing can effectively regulate duplicate health insurance participation problems. In 2018, China established the National Healthcare Security Administration (NHSA), which was in charge of the URRBMI (merged from the NCMS and URBMI) and UEBMI. Second, the financing levels of the URRBMI have been upgraded from the county to the municipal level. This dramatically improves health insurance portability and expands the list of drugs and healthcare services. When rural residents go from towns or counties to local cities for healthcare in high-level healthcare service institutions (i.e., tertiary hospitals in China), they gain higher reimbursement than with the NCMS. The expansion fund pooling of the URRBMI has strengthened the capacity to prevent economic risks. Third, a differential premium payment standards and benefits package could be adopted temporarily in areas where there is a significant difference in individual contributions standards between the URBMI and NCMS before implementing the integration policy. The central government allows local governments to gradually unify the scope of healthcare services and reimbursement standards, transitioning over 2–3 years. After urban–rural health insurance integration, the actual *per capita* contribution and benefits package should not be lower than the current level. In the policy process promoting urban–rural health insurance integration, there are differences in the policies adopted by local governments. Some cities adopt an approach of one system with one scheme of contribution and benefits package (i.e., the OSOS), which directly unifies the financing and security benefits of the NCMS and URBMI in one step. Some cities adopt another approach of one system with multiple schemes (i.e., the OSMS), which links premium payment standards with reimbursement standards. In general, the OSMS offers three choices of health insurance scheme (scheme I, II, and III). Scheme I corresponds to a lower contribution and benefits package, and is close to the original standard for the NCMS. Scheme II corresponds to a moderate contribution and benefits package, and is close to the initial standard for the URBMI. Compared to the formers, scheme III corresponds to a higher level of contribution and benefits package, and is lower than the standard for the UEBMI. We use Qiqihaer City in Heilongjiang province in China as an example to illustrate the details of health insurance schemes differences in the details of the three health insurance schemes offered by the OSMS ([Appendix Tables A1, A2 in Supplementary material](#)). Although there are no differences in the benefits package of the OSOS for urban and rural residents, the relatively high level of premium payment of funding contributions is likely to exclude the participation of low-income rural families from the health insurance system, which means there is a potential possibility to reduce the coverage rate of health insurance for rural residents. The OSMS provides multiple health insurance scheme selections for participants, who can choose corresponding health insurance schemes based on their economic capabilities, ensuring the accessibility of health insurance to low-income rural families. Moreover, the transition plan of the OSMS can alleviate the critical pressure on the finance funding of health insurance in the initial implementation stage of the urban–rural health insurance. The problem of the OSMS is that the NCMS and URBMI formally integrate a health insurance system. Still, it does not entirely change the substantive multi-layer policy institutional arrangement to promote health insurance equity. When the equity of health insurance is improved, what are the policy effect differences between the OSOS and

OSMS on long-term poverty? This question needs to be answered through rigorous empirical research. The gradual implementation of the pilot policy process for the urban–rural health insurance integration provides a pivotal opportunity to identify policy effects through the research design of quasi-natural experiments. To assess the impact of this integration on poverty vulnerability, we utilize the staggered DID econometric model and analyze potential impact mechanisms.

## 2.1 Data and method

We have compiled official policy regulations and documents released by the administration responsible for health insurance in local governments and collected the policy implementation time of urban–rural health insurance integration to form the city-level policy dataset (see [Figure 1](#)). There are 118 cities that implemented integration policies (103 cities for the OSOS and 15 cities for the OSMS) from 2011 to 2018, and we matched the city-level dataset information with individual-level microdata to form the available dataset for policy evaluation.

The China Health and Retirement Longitudinal Study (CHARLS) is a nationally comprehensive individual-level dataset, which is a large-scale interdisciplinary survey project led by the National Development Research Institute of Peking University, jointly executed by the China Social Sciences Survey Center of Peking University and the Youth League Committee of Peking University. The project aims to collect high-quality microdata representing Chinese residents aged 45 and older. The national baseline survey began in 2011, and follow-up surveys were conducted every two to three years, covering 28 provinces (municipalities, autonomous regions), 150 county-level units, and 450 community (village) units nationwide. As of the completion of the fourth wave nationwide follow-up survey in 2018, the sample covered a total of about 19,000 respondents from 12,400 households. The questionnaire included: demographic information, family structure, economic relations, health examination status, medical service utilization, medical insurance, work and labor supply, social security income, consumption, assets, and community information. The CHARLS has been widely recognized and applied in academic quantitative research due to its high-quality sample representation and data collection response rate. Our paper uses the four waves of the CHARLS (2011, 2013, 2015, and 2018) for the following considerations: first, the policy of urban–rural health insurance integration is implemented gradually in different provinces and cities. The CHARLS releases important geographical information about where the cities of individual household samples are located. Second, the respondents to the CHARLS are mainly aged 45 and older, with more demand for healthcare. The CHARLS includes comprehensive information on health insurance, healthcare services, and medical cost expenditures. Third, we can adopt a rigorous research design based on the data structure of four waves of the CHARLS for evaluating the dynamic results of urban–rural health insurance integration on poverty vulnerability and ensuring the robustness of the estimated impacts of policy effects. Our research aims to explore the integration policy effect for rural residents who participated in the URRBMI merged from the NCMS and URBMI. We removed samples with urban resident hukou registration, duplicate health insurance coverage, participating in the UEBMI or commercial health insurance, and being uninsured. The estimation bias errors caused by the staggered DID model have aroused extensive discussion in the academic community ([23–26](#)). We can



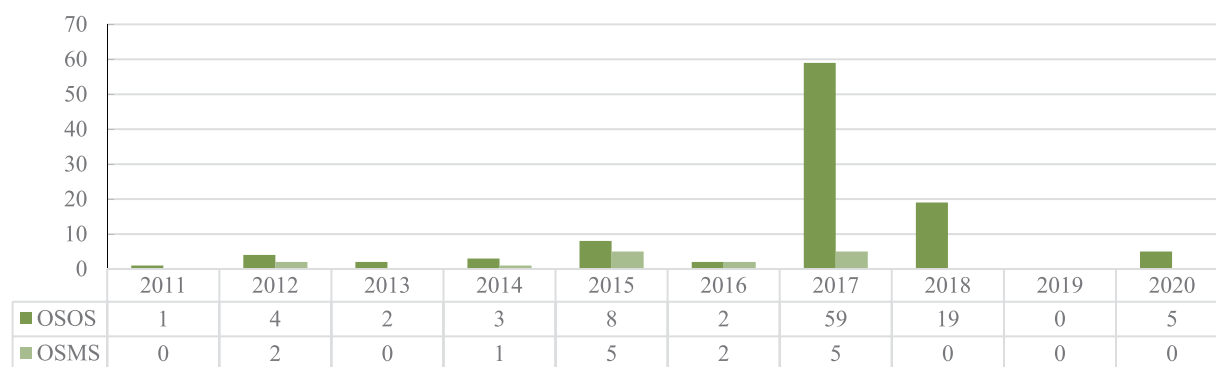


FIGURE 1

Accumulated number distribution of the Chinese cities implementing the policy of urban-rural health insurance integration for both the OSOS and OSMS. Based on the CHARLS sample, time information for the implementation of urban-rural medical insurance integration in cities is collated according to the official website document of the local government department responsible for administering the health insurance.

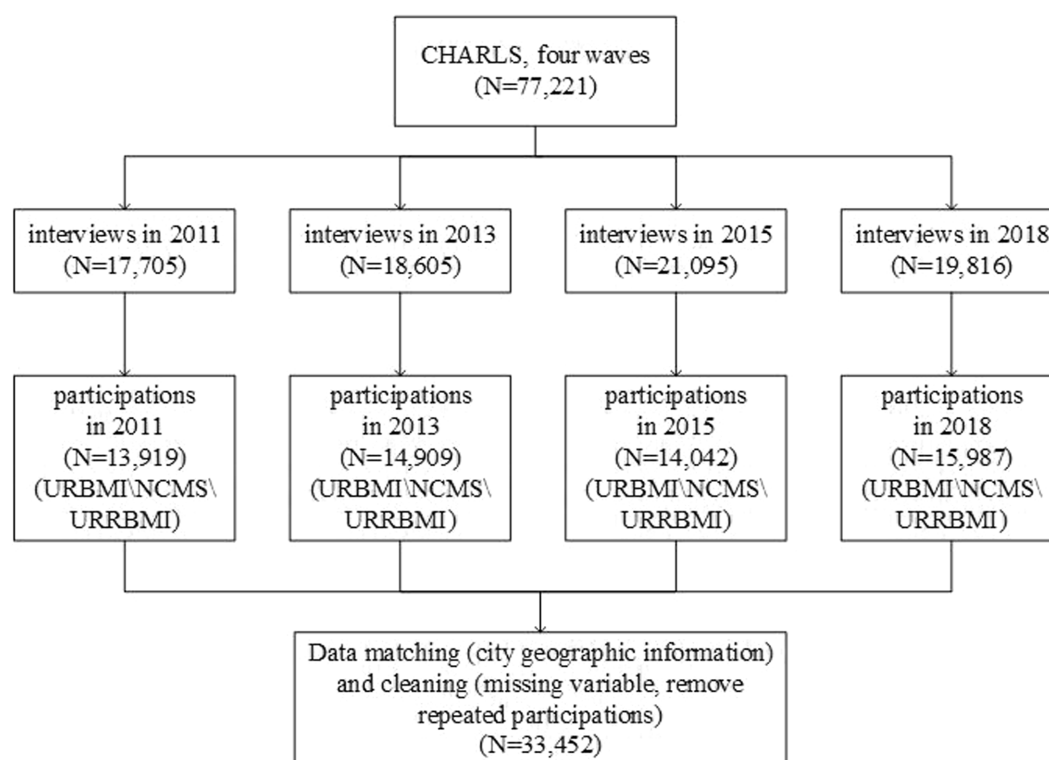


FIGURE 2

Flowchart of population selection.

relieve estimation bias errors through rigorous research design, including as many samples as possible that have always been in the control group during the sample period and minimizing the number of samples in the treatment group since the beginning of the sample period (25). We have removed samples of the policy implementation time before 2011, including Jiaxing (2003), Shenzhen (2004), Foshan (2007), Chongqing (2009), Chengdu (2009), Jiangmen (2010), and Tianjin (2010). After data processing, the final sample size for our research was 33,452 observations from 116 prefecture-level cities in 26 provinces for 4 years (see Figure 2). The control variable data at the city and provincial levels were collected from the China City Statistical

Yearbook and the National Bureau of Statistics. We matched macro data at the city and provincial levels with individual microdata from the CHARLS based on the year and city geographic information.

## 2.2 Description of variables

### 2.2.1 Dependent variable

To gain a comprehensive understanding of chronic poverty, we leverage the concept of poverty vulnerability. Within the framework of poverty alleviation, it is generally defined as the ex-ante

risk (i.e., adverse shocks, serious illness, lost job, bad harvest) that causes a household that is currently non-poor to fall below the poverty line or a household that is currently poor to remain in poverty (27–30). Poverty vulnerability could be formally defined as the probability that the welfare (i.e., income) of a household  $i$  at time  $t$  will be below the poverty line at time  $t + 1$ .

$$V_{i,t} = \Pr(\text{income}_{i,t+1} \leq z) \quad (1)$$

where  $\text{income}_{i,t+1}$  is *per capita* household income and  $z$  is the official income poverty line. The current poverty standard means that the living standard of rural residents is less than 2,300 yuan *per capita* per year at the 2010 price in China, corresponding to the CHARLS sample survey timings (2,536 yuan for 2011, 2,736 yuan for 2013, 2,855 yuan for 2015, and 2,995 yuan for 2018).

To estimate parameters and compute poverty vulnerability, we deploy a three-step feasible generalized least squares (FGLS) procedure (27, 31). An in-depth exploration of the estimation methodologies and calculations can be found in [Appendix A](#) in [Supplementary material](#).

### 2.2.2 The key independent variable

The policy treatment variable of urban–rural health insurance integration is the key independent variable. We introduce three types of policy variables to identify the integration policy effects. First, the policy treatment variable,  $Dpolicy_{ist}$ , is set to 1 as individual  $i$  located in city  $s$  which implemented the urban–rural health insurance integration policy in the year  $t$ , and 0 for otherwise. Second, the policy treatment variable of  $Dpolicy_{ist,OSOS}$  indicates that the city adopted a unified policy with one scheme. The policy treatment variable of  $Dpolicy_{ist,OSMS}$  indicates that the city adopted differentiated policies with multiple schemes. The control group refers to the samples that did not implement the urban–rural health insurance integration policy during the sample time, and is set to the baseline control group to avoid the dummy variable trap in the regression. Third, in order to estimate the dynamic policy effects of the urban–rural health insurance integration, multiple policy periods dummy variables are introduced in our study, corresponding to the seven periods consisting of the occurrence of integration policy, before three periods and after three periods. As an example, assume that the year of policy implementation in a certain city is 2013, the definition of  $Dpolicy_{is,t-b}$  “the integration policy implementation before one period,” is set to 1 in the first round of the CHARLS 2011 (national baseline survey) and 0 for otherwise. The definition of  $Dpolicy_{is,t+2}$  “the integration policy implementation after two period,” in the fourth round of the CHARLS 2018 survey (the third national follow-up survey) is 1, and 0 for otherwise.

### 2.2.3 Control variables

To obtain reliable and consistent estimation of the rural–urban healthcare integration policy effects, we controlled for a range of variables, including individual and household demographic characteristics, such as age, gender, marital status, education level, party membership, ethnic minority, self-assessed health, family size, household income, and eligibility for social assistance. We also controlled the variables as to whether sewer systems and asphalt roads have been built in a community or village, the *per capita* gross

domestic product (GDP) in a city, and the number of medical institution beds per 10,000 people in a province. These control variables, which may potentially affect the implementation of integration policies, represent the level of community infrastructure, the level of urban economic development, and the distribution of medical resources at the provincial level, respectively. We provide more details: the definition of the variables and the descriptive statistics of the sample in the baseline regression are provided in [Tables 2, 3](#), respectively.

## 2.3 Empirical strategy

The urban–rural health insurance integration policy pilot is gradually being implemented in various cities, which gives us the opportunity for a quasi-natural experiment. We employed a staggered DID model as an empirical strategy to identify the integration policy effect on poverty vulnerability of rural residents through the overlapping DID model, as shown in Eqs. (2, 3).

$$\text{Poverty\_vulnerability}_{ist} = \beta_0 + \beta_1 Dpolicy_{ist} + \gamma X_{ist} + \mu_i + \lambda_t + \varepsilon_{ist} \quad (2)$$

$$\text{Poverty\_vulnerability}_{ist} = \beta_0 + \beta_2 Dpolicy_{ist,OSOS} + \beta_3 Dpolicy_{ist,OSMS} + \gamma X_{ist} + \mu_i + \lambda_t + \varepsilon_{ist} \quad (3)$$

$$\begin{aligned} \text{Poverty\_vulnerability}_{ist} = & \beta_0 + \beta_{t-t_0=-3}^{pre} Dpolicy_{is,t-t_0 < -3} \\ & + \sum_{t-t_0=-1}^{-3} \beta_{t-t_0}^{pre} Dpolicy_{is,t-t_0} \\ & + \sum_{t-t_0=1}^3 \beta_{t-t_0}^{post} Dpolicy_{is,t-t_0} \\ & + \beta_{t-t_0=3}^{post} Dpolicy_{is,t-t_0 > 3} \\ & + \gamma X_{ist} + \mu_i + \lambda_t + \varepsilon_{ist} \end{aligned} \quad (4)$$

$\text{Poverty\_vulnerability}_{ist}$  represents the dependent variable of the probability of a household  $i$  falling below the poverty line in prefectural city  $s$  in  $t + 1$  year.  $Dpolicy_{ist}$  ( $Dpolicy_{ist,OSOS}$ ,  $Dpolicy_{ist,OSMS}$ ) is the key independent variable that the city  $s$  of household  $i$  has implemented an integration policy in year  $t$ .  $X_{ist}$  is a bundle of control variables.  $\alpha_i$  is the fixed effects at the individual level and  $\lambda_t$  is time-fixed effect.  $\varepsilon_{ist}$  is the error term. An important contribution of our study is to compare the differences in policy effects between the OSOS and OSMS. This also introduces the individual-level self-selection problem into the estimation model, where individuals can choose multiple health insurance schemes based on unobservable and time-varying characteristics. In order to deal with the potential bias error, we chose to control the fixed effects at the individual household level. To avoid the bias error potentially introduced by the self-selection problem and non-linear models (32), we opted for the linear probability model as the identification method. The linear probability model is easier to interpret and faster to run than other logistic models, which is especially important when dealing with large data sets or complex models (33). We use dynamic DID to achieve the dynamic effect of staggered DID and to test the critical parallel pre-trend hypothesis, as shown in [Eq. \(4\)](#). We set the event window

TABLE 2 Definition of variables.

Variable	Definition
<i>Dependent variables</i>	
poverty_vulnerability <sub>ist</sub>	The probability that <i>per capita</i> household income at time t will be below the poverty line at time t + 1. 1 for the probability of poverty vulnerability exceeds 0.5, 0 for otherwise.
Dpolicy <sub>ist</sub>	1 for the implementation of the policy of urban–rural health insurance integration, 0 for otherwise.
Dpolicy <sub>ist,OSOS</sub>	1 for the implementation of the policy of urban–rural health insurance integration with OSOS, 0 for otherwise.
Dpolicy <sub>ist,OSMS</sub>	1 for the implementation of the policy of urban–rural health insurance integration with OSMS, 0 for otherwise.
<i>Independent variables</i>	
Age	The age of respondents in the year of the data survey.
Gender	1 for female, 0 for male.
Marital status	1 for married or cohabiting, 0 for otherwise.
Education level	The years of education.
Party membership	1 for party membership, 0 for otherwise.
Ethnic minority	1 for ethnic minority, 0 for otherwise.
Self-assessed health	1 for self-assessed health level being above good, 0 for otherwise.
Family size	The number of people living together in a household.
ln(household income)	Total income earned by all family members (in logarithmic form).
Eligibility for social assistance	1 for the family being eligible for government subsidies for officially recognized low-income families, 0 for otherwise.
Asphalt roads	1 for asphalt roads having been built in a community or village, 0 for otherwise.
Sewer system	1 for sewer systems having been built in a community or village, 0 for otherwise.
ln( <i>per capita</i> GDP)	<i>Per capita</i> gross domestic product (GDP, unit: 100 million yuan) of a city (in logarithmic form).
Medical beds	The number of medical beds per 10,000 people in a province.

We set years of schooling for the variable of education level as follows: (1) No formal education (illiterate) for 1.5; (2) Did not finish primary school but capable of reading and/or writing for 3; (3) Elementary school (Sishu/home school) for 6; (4) Middle school for 9; (5) High school (vocational school) for 12; (6) Two-/Three-year college/Associate degree for 15; (7) Four-year college/Bachelor's degree for 16; (8) Master's degree for 18.5; and (9) Doctoral degree/Ph.D. for 22. The variable of self-assessed health is set to 1 for Excellent, Very good, and Good, and 0 for Fair, Poor, and Very poor.

TABLE 3 Summary statistics.

Variable	N	Mean	S.D.	Min	Max
<i>Dependent variables</i>					
poverty_vulnerability <sub>ist</sub>	33,452	0.298	0.457	0	1
Dpolicy <sub>ist</sub>	33,452	0.338	0.473	0	1
Dpolicy <sub>ist,OSOS</sub>	33,452	0.285	0.452	0	1
Dpolicy <sub>ist,OSMS</sub>	33,452	0.0427	0.202	0	1
<i>Independent variables</i>					
Age	33,452	60.31	9.747	35	97
Gender	33,452	0.52	0.5	0	1
Marital status	33,452	0.879	0.326	0	1
Education level	33,452	5.025	3.319	1.5	16
Party membership	33,452	0.075	0.263	0	1
Ethnic minority	33,452	0.066	0.247	0	1
Self-assessed health	33,452	0.288	0.453	0	1
Family size	33,452	2.965	1.597	1	16
ln(household income)	33,452	9.264	1.621	0	15.4
Eligibility for social assistance	33,452	0.113	0.316	0	1
Asphalt roads	33,452	0.598	0.49	0	1
Sewer system	33,452	0.186	0.389	0	1
ln( <i>per capita</i> GDP)	33,452	10.49	0.593	8.8	12.2
Medical beds	33,452	49.22	10.48	27.7	75.5

The summary statistics reported in Table 3 are based on the baseline regression sample.

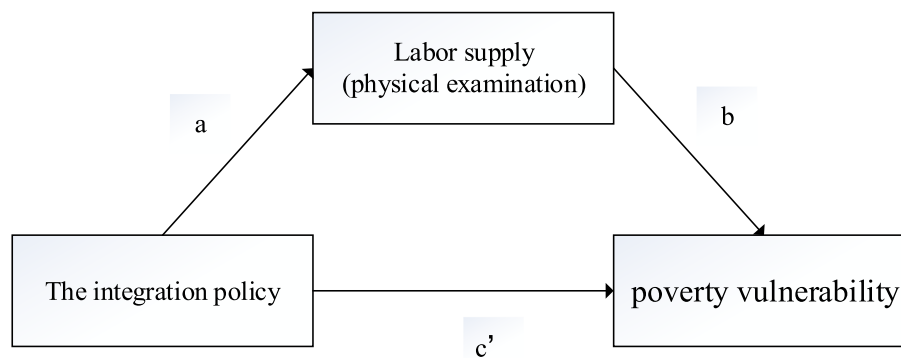


FIGURE 3  
Labor supply and physical examination as the mediator.

period of dynamic DID as three periods before and after the integration policy implementation. Since the CHARLS sample period is generally from July or August of the interview year to July or August of the previous year, many pilot cities implement the urban–rural health insurance integration policy at the end of the calendar year. It is likely that the policy will not work temporarily in the year of the integration policy implementation, but will work in the first period after the year. Therefore, we used the current period as the baseline control group in the dynamic test to avoid the dummy variable trap.

$$Labor\_supply_{ist} = \alpha_0 + \alpha_1 Dpolicy_{ist} + \gamma X_{ist} + \mu_i + \lambda_t + \varepsilon_{ist} \quad (5)$$

$$Poverty\_vulnerability_{ist} = \delta_0 + \delta_1 Dpolicy_{ist} + \delta_2 Labor\_supply_{ist} + \gamma X_{ist} + \mu_i + \lambda_t + \varepsilon_{ist} \quad (6)$$

$$Physical\_examination_{ist} = \eta_0 + \eta_1 Dpolicy_{ist} + \gamma X_{ist} + \mu_i + \lambda_t + \varepsilon_{ist} \quad (7)$$

$$Poverty\_vulnerability_{ist} = \kappa_0 + \kappa_1 Dpolicy_{ist} + \kappa_2 Physical\_examination_{ist} + \gamma X_{ist} + \mu_i + \lambda_t + \varepsilon_{ist} \quad (8)$$

As is shown in Figure 3, we used the mediation effect model to test that whether labor supply and physical examinations are important influencing mechanisms for the urban–rural health insurance integration policy to indirectly reduce the poverty vulnerability of rural residents, as shown in Eqs. (5–8) (34, 35).

## 3 Empirical results

### 3.1 Baseline regression results

We report the main estimation results regarding the impact of the urban–rural health integration policy on rural residents' poverty vulnerability in Table 4, based on Eq. (2). Considering that the CHARLS has only published party membership and ethnic minority data in two data waves (2013 and 2018) and community (or village) characteristics in one data wave (2011), we matched data information across years while assuming that these individual and community

characteristics remain stable in recent years. Controlling for these variables in Table 4 (column 2 in Table 4) does not affect the estimation of the integration policy effect. The estimated results show that the urban–rural health insurance integration policy significantly reduces the poverty vulnerability of rural residents by 6.32% ( $p < 0.01$ ). Both the OSOS and OSMS can greatly alleviate chronic poverty. However, the policy effect for alleviating chronic poverty of the OSOS (6.27%,  $p < 0.01$ ) is greater than that of the OSMS (3.25%,  $p < 0.01$ ).

### 3.2 Heterogeneity analysis

To understand the different policy effects on various populations in terms of health and expense across two dimensions, we conducted a heterogeneity analysis and explore the potential mechanism. We chose self-assessed health for subjective health and chronic disease for objective health as a health dimension to group the samples. Integration policies are more likely to reduce the poverty vulnerability of groups with relatively poor health (7.84%,  $p < 0.1$ ) than those with fairly good health (6.07%,  $p < 0.01$ ). They also significantly reduce the poverty vulnerability of the group with chronic diseases by 9.59% ( $p < 0.01$ ). We grouped the samples by household consumption and medical expenditure as expense dimensions. The integration policy can significantly reduce the poverty vulnerability of the low consumption and low medical expenditure groups by 8.6% ( $p < 0.01$ ) and 7.64% ( $p < 0.01$ ), respectively, compared to their counterparts. The heterogeneity analysis shows that the urban–rural health insurance integration policy has a greater effect on groups with poor health and low expense levels. We also conducted a preliminary exploration of the mechanism through heterogeneity analysis. The integration can significantly reduce household medical expenditure and has a greater effect on the low-consumption group (50.18%,  $p < 0.01$ ) (Table 5).

### 3.3 Mechanisms

We employed the mediation model to explore two important mechanism channels, labor supply and physical examination, which have not been paid attention to in previous literature. The mediation model was set according to Eqs. (2, 5, 6) for labor supply and Eqs. (2, 7, 8) for physical examination. We report the estimation results of

TABLE 4 The impact of urban–rural health insurance integration on poverty vulnerability.

Variable	Vulnerability	Vulnerability	Vulnerability
	(1)	(2)	(3)
<i>Dpolicy</i> <sub>1st</sub>	−0.0696*** (0.0141)	−0.0632*** (0.0137)	
<i>Dpolicy</i> <sub>1st, OSOS</sub>			−0.0627*** (0.0117)
<i>Dpolicy</i> <sub>1st, OSMS</sub>			−0.0325** (0.0149)
Age	−0.0058*** (0.0003)	−0.0054*** (0.0003)	−0.0054*** (0.0003)
Gender	−0.0870*** (0.0054)	−0.0838*** (0.0053)	−0.0838*** (0.0053)
Marital status	−0.2366*** (0.0092)	−0.2452*** (0.0088)	−0.2451*** (0.0088)
Education level	−0.0455*** (0.0008)	−0.0429*** (0.0008)	−0.0429*** (0.0008)
Party membership		−0.0289*** (0.0097)	−0.0287*** (0.0097)
Ethnic minority		−0.0939*** (0.0108)	−0.0927*** (0.0108)
Self-assessed health	−0.0828*** (0.0058)	−0.0726*** (0.0057)	−0.0725*** (0.0057)
Family size	0.0087*** (0.0019)	0.0109*** (0.0019)	0.0109*** (0.0019)
ln(household income)	−0.0366*** (0.0019)	−0.0305*** (0.0018)	−0.0306*** (0.0018)
Eligibility for social assistance	0.0499*** (0.0089)	0.0454*** (0.0086)	0.0455*** (0.0086)
Asphalt roads		−0.0793*** (0.0060)	−0.0788*** (0.0060)
Sewer system		−0.1928*** (0.0066)	−0.1940*** (0.0066)
ln( <i>per capita</i> GDP)	−0.1338*** (0.0050)	−0.0918*** (0.0051)	−0.0895*** (0.0052)
Medical beds	−0.0025*** (0.0005)	−0.0051*** (0.0005)	−0.0054*** (0.0005)
Observations	33,452	33,452	33,452
Adj. <i>R</i> <sup>2</sup>	0.6035	0.6268	0.6269

Standard errors are in parentheses. The statistical significance is as follows: \*\*\* denotes  $p < 0.01$ ; \*\* denotes  $p < 0.05$ ; and \* denotes  $p < 0.1$ . We controlled all estimation results for individual and year fixed effects.

mediation analyses in Table 6. For labor supply and physical examination, the total effect (path c) of integration policy is significantly negative according to the estimation for Eq. (2). The coefficient of path a ( $\alpha_1=14.34\%$ ,  $p < 0.01$ ,  $\eta_1=6.28\%$ ,  $p < 0.01$ ) is significantly positive in column (1, 3), and the coefficient of path b ( $\delta_2=0.95\%$ ,  $p < 0.01$ ,  $\kappa_2=2.09\%$ ,  $p < 0.01$ ) is significantly negative in

column (2, 4). The estimation of the mediation effect model showed that the indirect effects of labor supply and physical examination were 0.14%, 0.13% ( $\alpha_1 \times \delta_2, \eta_1 \times \kappa_2$ ), respectively. The proportion of

indirect effect to total effect is  $2.16, 2.05\% \left( \frac{\alpha_1 \times \delta_2}{\alpha_1 \times \delta_2 + \delta_1}, \frac{\eta_1 \times \kappa_2}{\eta_1 \times \kappa_2 + \kappa_1} \right)$ .



TABLE 5 Heterogeneous impact of urban–rural integration on poverty vulnerability.

Variable	Vulnerability	Vulnerability	Vulnerability	Vulnerability	Vulnerability
	Good health	Poor health	Chronic disease	No chronic disease	Low household consumption
	(1)	(2)	(3)	(4)	(5)
$Dpolicy_{it}$	−0.0607***	−0.0784*	−0.0959***	−0.0377	−0.0860***
	(0.0193)	(0.0419)	(0.0219)	(0.0305)	(0.0253)
Control	Y	Y	Y	Y	Y
Observations	19,768	3,873	14,957	6,954	12,374
Adj. $R^2$	0.6514	0.6178	0.6602	0.6714	0.7056

Variable	Vulnerability	Vulnerability	Vulnerability	ln(medical expenditure)	ln(medical expenditure)
	High household consumption	Low medical expenditure	High medical expenditure	Low household consumption	High household consumption
	(6)	(7)	(8)	(9)	(10)
$Dpolicy_{it}$	−0.0195	−0.0764***	−0.0529**	−0.5019***	−0.4148**
	(0.0205)	(0.0292)	(0.0227)	(0.1845)	(0.2097)
Control	Y	Y	Y	Y	Y
Observations	9,498	8,359	13,741	13,431	10,912
Adj. $R^2$	0.6111	0.682	0.6504	0.474	0.491

Standard errors are in parentheses. The statistical significance is shown as follow: \*\*\* denotes  $p < 0.001$ ; \*\* denotes  $p < 0.01$ ; and \* denotes  $p < 0.05$ . The grouping basis of the heterogeneity test is the median of household consumption and medical expenditure. The dependent variable for columns (9) and (10) is the logarithm of the family's medical expenditure.

### 3.4 The parallel trend assumption test and robustness check

We report the estimation results of dynamic DID and robustness tests in Table 7. The interview time of the CHARLS samples is mainly concentrated in summers, from July or August of the survey year to July or August of the previous year. However, most pilot cities implement the urban–rural health insurance integration at the end of the year, which has a potential possibility that the policy effect will not work immediately. There may be a policy lag effect on the model estimation results. Therefore, the current period was set to the baseline control group in the dynamic DID model to avoid the dummy variable problem in our study. The estimation of dynamic DID indicates that there is no significant policy effect three periods before the implementation of the integration policy, and the parallel trend test is satisfied. The effect of the integration policy has significantly reduced the poverty vulnerability of rural residents after the implementation of three periods, and the effect of the policy has begun to decline as time goes by. If staggered DID includes the treatment groups (early treatment groups) from the beginning of the sample period, this could raise potential bias issues (25). The Chinese government promoted the urban–rural health insurance integration in 2016, and most prefecture-level cities began implementing the integration policy after 2017. We adopted a more flexible research design by excluding the CHARLS data of 2018 to conduct the robustness test. The estimated regression results show that there is no serious bias issue in Table 7, column (2). We recalculated poverty vulnerability using the World Bank poverty standard of \$1.25 per person per day in Table 7, column (2), and the results remain robust with China's national poverty line

estimation result. We estimated the results of the placebo test by moving forward the policy implementation time for all prefecture-level cities by one period, and the estimation result in Table 7, column (4), indicates that the placebo test is satisfied.

## 4 Discussion

### 4.1 The policy implications of the baseline regression evaluation

We examined the impact of the urban–rural health insurance integration policy on the long-term poverty of rural residents. We found that the urban–rural health insurance integration policy significantly reduced poverty vulnerability, and the OSOS was more effective than the OSMS. This difference of the policy effect indicates very critical policy implications. The implementation of a comprehensive unified medical insurance scheme policy in the OSOS from the very beginning can fully meet the medical demand of rural residents. As previous studies have shown (15, 17), urban–rural health insurance integration policies promote the accessibility of healthcare services, which can repair the current health human capital of rural residents in a timely manner and reduce the probability of poverty in the future period. The OSOS treats all urban and rural residents equally for the same contribution and benefits. The OSOS is the integration of urban and rural health insurance systems in real practice. The OSMS stabilizes the coverage of health insurance by providing multiple schemes for rural residents, preventing the probability of low- and middle-income rural residents leaving the health insurance system. But the OSMS

TABLE 6 Mechanism analysis of the urban–rural health insurance integration.

Variable	Labor supply	Vulnerability	Physical examination	Vulnerability
	(1)	(2)	(3)	(4)
$Dpolicy_{it}$	0.1434*** (0.0251)	−0.0626*** (0.0139)	0.0628*** (0.0146)	−0.0627*** (0.0139)
Mediation variable		−0.0095*** (0.0036)		−0.0209*** (0.0060)
Age	−0.0139*** (0.0005)	−0.0053*** (0.0003)	0.0073*** (0.0003)	−0.0050*** (0.0003)
Gender	−0.1335*** (0.0093)	−0.0857*** (0.0054)	0.0290*** (0.0057)	−0.0837*** (0.0053)
Marital status	−0.0509*** (0.0130)	−0.2456*** (0.0090)	0.0035 (0.0094)	−0.2448*** (0.0089)
Education level	0.0196*** (0.0016)	−0.0428*** (0.0009)	0.0045*** (0.0010)	−0.0429*** (0.0009)
Party membership	0.1070*** (0.0196)	−0.0280*** (0.0099)	0.0600*** (0.0114)	−0.0277*** (0.0099)
Ethnic minority	−0.0595*** (0.0164)	−0.0935*** (0.0109)	−0.0316*** (0.0115)	−0.0935*** (0.0109)
Self-assessed health	0.1108*** (0.0111)	−0.0773*** (0.0059)	−0.0058 (0.0066)	−0.0782*** (0.0059)
Social activity	−0.0111** (0.0051)	0.0039 (0.0027)	0.0239*** (0.0031)	0.0045* (0.0027)
Chronic disease	−0.0681*** (0.0099)	−0.0241*** (0.0057)	0.0583*** (0.0061)	−0.0222*** (0.0057)
Family size	−0.0256*** (0.0031)	0.0107*** (0.0019)	−0.0078*** (0.0020)	0.0108*** (0.0019)
ln(household income)	0.0397*** (0.0017)	−0.0294*** (0.0019)	0.0081*** (0.0011)	−0.0298*** (0.0019)
Eligibility for social assistance	−0.0656*** (0.0127)	0.0457*** (0.0087)	0.0144 (0.0093)	0.0465*** (0.0087)
Asphalt roads	0.0232** (0.0103)	−0.0815*** (0.0061)	0.0123* (0.0064)	−0.0812*** (0.0061)
Sewer system	0.0685*** (0.0134)	−0.1915*** (0.0067)	0.0507*** (0.0077)	−0.1911*** (0.0067)
ln(per capita GDP)	0.0824*** (0.0091)	−0.0921*** (0.0052)	0.0482*** (0.0056)	−0.0919*** (0.0051)
Medical beds	−0.0048*** (0.0009)	−0.0050*** (0.0005)	0.0024*** (0.0005)	−0.0050*** (0.0005)
Observations	38,103	32,637	38,129	32,654
R-squared	0.4686	0.6281	0.5455	0.6283

Standard errors are in parentheses. The statistical significance is shown as follow: \*\*\* denotes  $p < 0.001$ ; \*\* denotes  $p < 0.01$ ; and \* denotes  $p < 0.05$ . The labor supply variable was set as the logarithm of the number of months worked in the past year. The physical examination variable was set as whether physical examination had been undertaken since the last interview. Column (2) in Table 4 and columns (1–2) in Table 6 jointly give the estimation results of the labor supply for the mediation model, corresponding to models (2), (5), and (6), respectively. Column (2) in Table 4 and columns (3–4) in Table 6 jointly give the estimation results of the physical examination for the intermediary effect model, corresponding to models (2), (7), and (8), respectively.

is still in essence a transitional health insurance system arrangement that does not really address the separation between urban and rural in health insurance and does not fully promote health insurance equity. The unified integration policy can better achieve the effect of reducing long-term poverty. Therefore, considering the fairness of

health insurance from the perspective of policy practice will be a policy design direction to be considered in the future reform of China's health insurance system. China's policy experience has important lessons for developing countries that continue to improve their health insurance systems.

TABLE 7 The estimation of dynamic DID and robustness check.

Variable	Vulnerability	Vulnerability	Vulnerability	Vulnerability
	(1)	(2)	(3)	(4)
$Dpolicy_{ist}$		−0.0605***	−0.0586***	
		(0.018)	(0.014)	
$Dpolicy_{ist}(\text{placebo})$				0.0122
				(0.011)
$Dpolicy_{ist-3}$	−0.0143			
	(0.009)			
$Dpolicy_{ist-2}$	−0.0090			
	(0.013)			
$Dpolicy_{ist-1}$	−0.0251			
	(0.016)			
$Dpolicy_{ist+1}$	−0.1149***			
	(0.013)			
$Dpolicy_{ist+2}$	−0.1005***			
	(0.017)			
$Dpolicy_{ist+3}$	−0.0824***			
	(0.016)			
Control	Y	Y	Y	Y
Observations	33,452	18,034	33,452	33,452
Adj. $R^2$	0.628	0.665	0.646	0.626

Standard errors are in parentheses. The statistical significance is shown as follows: \*\*\* denotes  $p < 0.001$ ; \*\* denotes  $p < 0.01$ ; and \* denotes  $p < 0.05$ . The estimation results in column (1) of Table 7 is according to model (4). Column (2) in Table 7 reports the robustness estimation results according to model (2) after excluding the CHARLS 2018 sample.

## 4.2 Heterogeneity analysis indicates that integration policy improves the benefits for vulnerable groups

Previous literature on the evaluation of the policy effect of China's basic medical insurance showed that although the NCMS significantly improved the healthcare utilization for rural residents, it did not significantly reduce the out-of-pocket payments for rural residents (8, 9, 12). The URBMI for urban residents has more significant policy effects, which not only can significantly reduce the medical burden of urban residents but has a significant health promotion effect. However, the rich benefit more from health insurance funding of the URBMI than the poor (13, 15). According to the heterogeneity analysis in our study, the URRBMI merged from the NCMS and URBMI can significantly reduce poverty vulnerability for low-consumption and poor health level groups, and can better reduce medical expenditure for low-consumption groups. First, the urban–rural health insurance integration policy was designed to promote equity in health insurance by increasing the healthcare reimbursement benefits for rural residents without significantly increasing the cost of participation. Second, the implementation of the integration policy has expanded the catalog of medical services and medicines. These policy initiatives have enhanced the accessibility of healthcare services for vulnerable groups. Third, the integration policy has elevated the level of health insurance financing from county to prefecture-level cities. The low-income groups will not be deprived of the economic protection provided by health insurance because of the administrative geographical location.

It provides further key policy evidence that promoting health insurance equity can benefit vulnerable groups.

## 4.3 Mechanism analysis

Previous studies have explored the mechanisms for the impact of the urban–rural health insurance integration especially using the reimbursement channels of rural residents' inpatient care utilization (17–19). The implementation of the urban–rural medical insurance integration has provided equitable health insurance treatment for rural residents by narrowing the reimbursement gap between urban and rural areas. The catalog of medicines and the scope of healthcare services have been greatly expanded. Rural residents have fully meet their demand for healthcare utilization, improving the under-treatment situation. Village (or community) health centers that provide primary healthcare to rural residents have higher reimbursement rates after the integration policy.

The urban–rural health insurance integration promotes the financial pooling of the NCMS from county level to prefecture-level cities and effectively alleviates the “lock-in” effect by the county-level finance pooling of the NCMS on rural employment. Improving the portability of health insurance greatly increases the possibility for rural residents to seek healthcare services across urban and rural areas, and the mobility of rural residents for looking for a job with much better employment opportunities and higher income in cities. The urban–rural health insurance integration will be more likely to

increase the labor supply of rural residents in cities indirectly and eventually reduces the possibility of future poverty among rural residents.

The urban–rural health insurance integration may also change rural families' expectations for future health investment, producing an investment incentive effect in advance. It will increase physical examinations to meet the actual demand for healthcare service utilization, and rural residents can recover the loss of health human capital in a timely manner. Therefore, the integration policy indirectly increases the labor supply of rural residents to enhance the resilience of rural residents to get out of poverty in the future, and alleviate long-term poverty.

## 4.4 Contributions and limitations

Our findings provide meaningful marginal contributions as follows: first, compared to previous studies, we have distinguished the differences in the role of the OSOS and OSMS in evaluating the effectiveness of the urban–rural health insurance integration policy. Second, heterogeneity analysis indicates that the urban–rural health insurance integration policy achieves the most important policy goal of health equity, allowing vulnerable groups to benefit more from the social health insurance system. The URRBMI merged from the NCMS and URBMI greatly improves the poverty alleviation effects. This has not been further explored in previous studies (17–19, 36). Third, based on a previous paper, we carefully evaluated the policy by controlling for individual fixed effects rather than regional fixed effects, and explored the potential bias issues of staggered DID through a more concise research design. We also provide the dynamic effects of policy evaluation through dynamic DID.

Our paper also has some limitations. First, the impact of urban–rural health insurance integration policy on poverty vulnerability through indirect channels such as labor supply and physical examination, but the policy effects of the indirect channel are very weak in absolute terms. Further research is needed to verify whether there are some other impact channels. Second, in order to assess the difference in policy effects between the OSOS and OSMS for robust outcomes, we used a linear probability model for estimation and identification. Third, the CHARLS only published community-level data in 2011, and there may be data bias when matching to other years.

## 5 Conclusion

In this paper, we examined the impact of the urban–rural health insurance integration policy on the long-term poverty of rural residents. We found that the urban–rural health insurance integration policy significantly reduced poverty vulnerability, and the OSOS is more effective than the OSMS. The urban–rural health insurance integration policy can significantly reduce poverty vulnerability for low-consumption and poor health level groups, and can better reduce medical expenditure for low-consumption groups. Labor supply and physical examination are indirect channels. Our study confirms that the urban–rural health insurance integration achieves the policy effect of reducing the poverty vulnerability of rural residents. As policy implementation continues to improve, the OSMS will gradually shift to the OSOS, and we believe that integrating policies to alleviate

poverty is becoming increasingly critical. Promoting equity in the health insurance system remains a powerful and important policy option to alleviate poverty, especially for vulnerable groups.

## Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: <http://charls.pku.edu.cn/>.

## Author contributions

ZL: Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Project administration, Software, Supervision, Writing – original draft, Writing – review & editing. YC: Conceptualization, Data curation, Formal analysis, Methodology, Resources, Software, Writing – original draft, Writing – review & editing. JD: Conceptualization, Data curation, Formal analysis, Methodology, Resources, Software, Writing – review & editing.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpubh.2023.1328265/full#supplementary-material>

## References

1. The State Council Information Office of the People's Republic of China. White Paper on China's Practice of Human Poverty Reduction Beijing: the Xinhua News Agency. (2021). [updated 04-06; cited 2023-07-09]. Available at: [https://www.gov.cn/zhengce/2021-04/06/content\\_5597952.htm](https://www.gov.cn/zhengce/2021-04/06/content_5597952.htm).
2. Xinhua News Agency The State Council Information Office of the People's Republic of China The Right to Development: China's Concept, Practice, and Contribution: the Xinhua News Agency. (2016) [cited 2023-07-09]. Available at: [https://www.gov.cn/zjhengce/2016-12/01/content\\_5141177.htm](https://www.gov.cn/zjhengce/2016-12/01/content_5141177.htm).
3. National Healthcare Security Administration. National Statistical Bulletin on Medicare Advancement: National Healthcare Security Administration. (2023) [cited 2023-11-09]. Available at: [http://www.nhsa.gov.cn/art/2023/7/10/art\\_7\\_10995.html](http://www.nhsa.gov.cn/art/2023/7/10/art_7_10995.html).
4. National Health Commission of the People's Republic of China. We will solve the problem of poverty resulting from illness and returning to poverty, and win the battle of healthy poverty alleviation. people.cn. (2018) [cited 2023-07-09]. Available at: <http://health.people.com.cn/n1/2018/04/25/c14739-29949739.html>.
5. The State Council Information Office of the People's Republic of China. National Health Commission of the People's Republic of China held a series of press conferences on all for the Health of the People - Our Decade (Session 4): National Health Commission of the People's Republic of China. (2022) [cited 2023-11-09]. Available at: [http://www.scio.gov.cn/xwfb/bwxwfb/gbwfbh/wsjkwyh/202307/t20230703\\_721269.html](http://www.scio.gov.cn/xwfb/bwxwfb/gbwfbh/wsjkwyh/202307/t20230703_721269.html).
6. Sommers BD, Oellerich D. The poverty-reducing effect of Medicaid. *J Health Econ.* (2013) 32:816–32. doi: 10.1016/j.jhealeco.2013.06.005
7. You X, Kobayashi Y. The new cooperative medical scheme in China. *Health Policy.* (2009) 91:1–9. doi: 10.1016/j.healthpol.2008.11.012
8. Wagstaff A, Lindelow M, Jun G, Ling X, Juncheng Q. Extending health insurance to the rural population: an impact evaluation of China's new cooperative medical scheme. *J Health Econ.* (2009) 28:1–19. doi: 10.1016/j.jhealeco.2008.10.007
9. Lei X, Lin W. The new cooperative medical scheme in rural China: does more coverage mean more service and better health? *Health Econ.* (2009) 18:S25–46. doi: 10.1002/hec.1501
10. Babiartz KS, Miller G, Yi H, Zhang L, Rozelle S. China's new cooperative medical scheme improved finances of township health centers but not the number of patients served. *Health Aff (Millwood).* (2012) 31:1065–74. doi: 10.1377/hlthaff.2010.1311
11. Yi H, Zhang L, Singer K, Rozelle S, Atlas S. Health insurance and catastrophic illness: a report on the new cooperative medical system in rural China. *Health Econ.* (2009) 18:S119–27. doi: 10.1002/hec.1510
12. Yip W, Hsiao WC. Non-evidence-based policy: how effective is China's new cooperative medical scheme in reducing medical impoverishment? *Soc Sci Med.* (2009) 68:201–9. doi: 10.1016/j.socscimed.2008.09.066
13. Pan J, Lei X, Liu GG. Health insurance and health status: exploring the causal effect from a policy intervention. *Health Econ.* (2016) 25:1389–02. doi: 10.1002/hec.3225
14. Lin W, Liu GG, Chen G. The urban resident basic medical insurance: a landmark reform towards universal coverage in China. *Health Econ.* (2009) 18:S83–96. doi: 10.1002/hec.1500
15. Pan J, Tian S, Zhou Q, Han W. Benefit distribution of social health insurance: evidence from China's urban resident basic medical insurance. *Health Policy Plan.* (2016) 31:853–9. doi: 10.1093/heapol/czv141
16. Meng Q, Fang H, Liu X, Yuan B, Xu J. Consolidating the social health insurance schemes in China: towards an equitable and efficient health system. *Lancet.* (2015) 386:1484–92. doi: 10.1016/S0140-6736(15)00342-6
17. Huang X, Wu B. Impact of urban-rural health insurance integration on healthcare: evidence from rural China. *China Econ Rev.* (2020) 64:101543. doi: 10.1016/j.chieco.2020.101543
18. Chen H, Ding Y, Tang L, Wang L. Impact of urban-rural medical insurance integration on consumption: evidence from rural China. *Econ Anal Policy.* (2022) 76:837–51. doi: 10.1016/j.eap.2022.09.018
19. Zhou Q, He Q, Eggleston K, Liu GG. Urban-rural health insurance integration in China: impact on healthcare utilization, financial risk protection, and health status. *Appl Econ.* (2022) 54:2491–09. doi: 10.1080/00036846.2021.1998323
20. Center for Health Statistics and Information. *An analysis report of National Health Services Survey in China, 2013.* Beijing: National Health and Family Planning Commission of the People's Republic of China (2013).
21. Meng Q, Fang H, Liu X, Yuan B, Xu J. Consolidating the social health insurance schemes in China: towards an equitable and efficient health system. *Lancet.* (2015) 386:1484–92. doi: 10.1016/S0140-6736(15)00342-6
22. Yip WC, Hsiao WC, Chen W, Hu S, Ma J, Maynard A. Early appraisal of China's huge and complex health-care reforms. *Lancet.* (2012) 379:833–42. doi: 10.1016/S0140-6736(11)61880-1
23. Callaway B, Sant'Anna PHC. Difference-in-differences with multiple time periods. *J Econ.* (2021) 225:200–30. doi: 10.1016/j.jeconom.2020.12.001
24. de Chaisemartin C, D'Haultfœuille X. Fuzzy differences-in-differences. *Rev Econ Stud.* (2018) 85:999–28. doi: 10.1093/restud/rdx049
25. Goodman-Bacon A. Difference-in-differences with variation in treatment timing. *J Econ.* (2021) 225:254–77. doi: 10.1016/j.jeconom.2021.03.014
26. Sun L, Abraham S. Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. *J Econ.* (2021) 225:175–99. doi: 10.1016/j.jeconom.2020.09.006
27. Chaudhuri S, Jalan J, Suryahadi A. Assessing household vulnerability to poverty from cross-sectional data: a methodology and estimates from Indonesia \*. Columbia University Discussion Paper (2002):1–25.
28. Naudé W, Santos-Paulino AU, McGillivray M. Measuring vulnerability: An overview and introduction. *Oxf. Dev. Stud.* (2009) 37:183–91. doi: 10.1080/13600810903085792
29. Glewwe P, Hall G. Are some groups more vulnerable to macroeconomic shocks than others? Hypothesis tests based on panel data from Peru. *J Dev Econ.* (1998) 56:181–206. doi: 10.1016/S0304-3878(98)00058-3
30. Pritchett L, Suryahadi A, Sumarto S. Quantifying vulnerability to poverty: a proposed measure, applied to Indonesia (2000). doi: 10.1596/1813-9450-2437,
31. Amemiya T. The maximum likelihood and the nonlinear three-stage least squares estimator in the general nonlinear simultaneous equation model. *Econometrica.* (1977) 45:955–68. doi: 10.2307/1912684
32. Katz E. Bias in conditional and unconditional fixed effects logit estimation. *Polit Anal.* (2001) 9:379–84. doi: 10.1093/oxfordjournals.pan.a004876
33. von Hippel PT, Workman J. From Kindergarten through Second Grade, U.S. Children's obesity prevalence grows only during summer vacations. *Obesity* (2016) 24:2296–00. doi: 10.1002/oby.21613
34. Baron RM, Kenny DA. The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *J Pers Soc Psychol.* (1986) 51:1173–82. doi: 10.1037//0022-3514.51.6.1173
35. Judd CM, Kenny DA. Process analysis: estimating mediation in treatment evaluations. *Eval Rev.* (1981) 5:602–19. doi: 10.1177/0193841x8100500502
36. Zhu K, Zhang L, Yuan S, Zhang X, Zhang Z. Health financing and integration of urban and rural Residents' basic medical Insurance Systems in China. *Int J Equity Health.* (2017) 16:194. doi: 10.1186/s12939-017-0690-z





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# The effect of urban–rural resident basic medical insurance on physical health of the rural older adult in China

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**Introduction:** Urban–Rural Resident Basic Medical Insurance (URRBMI) is an important system for effectively transferring disease risks to the rural older adult. As China experiences rapid aging, maintaining the physical health of the rural older adult is key to achieving the goal of healthy aging.

**Methods:** The study explores the impact of URRBMI on physical health of the rural older adult in China using the Chinese Longitudinal Healthy Longevity Survey (CLHLS) data in 2018. Ordinary least square models were used to analyze the relationship between URRBMI and physical health of the rural older adult, and we used instrumental variable method to address the potential endogenous problem.

**Results:** We find that URRBMI greatly improves physical health of the rural older adult. The heterogeneity analysis indicates that URRBMI contributes more significantly to the rural older adult in eastern areas and the advanced rural older adult. The results also suggested that URRBMI improves physical health of the rural older adult through increasing life satisfaction and enhancing the timeliness of medical services.

**Recommendations:** This study implies that we need to further improve the participation rate, increase the actual reimbursement ratio and increase financial subsidies for URRBMI in central and western areas, and further integrate the distribution of medical resources to promote physical health of the rural older adult.

## KEYWORDS

urban–rural resident basic medical insurance, rural older adult, activities of daily living, CLHLS, China

## Introduction

Population aging has become increasingly serious in all countries of the world, increasing life expectancy and changes in the disease spectrum have led to a worrying health status for the older adult. The older adult, especially rural older adult, as a vulnerable health group in the population as a whole (1), they generally face more serious disease risks, we should put more emphasis on the physical health of the rural older adult (2). In order to spread the disease risks, many countries around the world have established medical insurance schemes (3, 4). China began to integrate Urban–Rural Resident Basic Medical Insurance (URRBMI) based on the Urban Resident Basic Medical Insurance and the New Cooperative Medical Scheme in 2016. The primary goal of URRBMI is to decrease the medical costs, promote the utilization of medical services and contribute to better health. The physical health of the rural older adult contributes to their life quality and well-being, and is also strongly linked to healthy aging. With the deepening aging, we must pay attention to the rural older adult and discover the healthy function of URRBMI for the rural older adult. Thus, it is an essential topic to discuss

whether URRBMI affects physical health of the rural older adult in China, this will help improve URRBMI policy and further enhance its healthy effects.

The Chinese government has always placed the protection of people's health as a strategic priority for development, and has continuously improved its policies for the promotion of people's health. Achieving the goal of "Healthy China" means that the achievements of development must benefit all residents fairly (5), especially the vulnerable and high-risk groups, ensuring that "no one is left behind." Aging is an important demographic feature in China (6, 7). The aging problem is especially serious in rural China. According to the statistical data, China's rural population aged over 60 has reached 121 million, and the rural population aging at 23.81% (8), the scale of the rural older adult in China is huge. The number of older adult with limitations in Activities of Daily Living (ADL) will increase to 37.3 million in 2050 (1), and their demand for medical insurance is increasing.

Previous studies have examined the relationship between basic medical insurance and health status but have come to different conclusions. Several scholars have stated that basic medical insurance positively affects health status (9–11), because medical insurance can reduce the price of medical services (12), offer more opportunities for medical care and higher-quality health services (13). However, other researchers have shown that basic medical insurance has little effect on the improvement of residents' health (14–16), the probable explanation lies in the fact that the current policy only focuses on the most basic issues, the finite reimbursement rates, and the limited protection for the health vulnerable population (17).

Many interesting results have been found on the above issues, but there are still some gaps needed to be filled. Several previous studies have mostly focused on the whole population. So far, however, in a rapidly aging society, there is an insufficient wealth of research dedicated to the health of basic medical insurance for the rural older adult, we are particularly concerned about the rural older adult in China, who are the most vulnerable to illness. Furthermore, most of the previous studies used self-assessed health to measure health status, but self-assessed health is subjective, so this study overcomes the shortcomings of self-assessed health by using ADL to represent the objective health status of rural older adult. Improving the physical health of the rural older adult is an essential task to cope with the healthy aging, we must keep an eye on the rural older adult and explore the role of URRBMI for the rural older adult. It will help enrich the theory of basic medical insurance and the study of healthy aging issues.

This study uses the data from CLHLS in 2018 to explore how URRBMI influences physical health of the rural older adult in China. The article made the following contributions: First, the purpose of the study is to provide new empirical proof for current relevant studies by examining the influence of URRBMI on the physical health of the rural older adult under the context of healthy aging. Second, we discussed the heterogeneous influence of URRBMI on physical health of the rural older adult from the viewpoints of different areas and ages, and offers some critical perspectives for improving the URRBMI in the future. Third, we also discussed the influence mechanism between URRBMI and physical health of the rural older adult.

The remainder of this study is organized as follows. Section 2 proposes the research hypothesis. Section 3 presents the data sources and empirical models. Section 4 presents the empirical results. Section

5 offers the discussion and policy recommendations, and finally, Section 6 offers the research conclusions and limitations.

## Research hypothesis

URRBMI is an essential part of the social welfare scheme in the rural areas. When rural older adult are not enrolled in the URRBMI, they have to pay the full medical costs when they fall ill, and therefore they may choose not to receive treatment, which may be detrimental to their health. After participating in the URRBMI, on the one hand, the price of medical services has been decreased owing to the broaden of URRBMI coverage, and the health of the rural older adult can be promoted by decreasing out-of-pocket costs and enhancing their medical services utilization (18). On the other hand, URRBMI offers the rural older adult with protection against disease (19), it has changed the previous traditional concept of not seeking medical services for illnesses, and increased their motivation to pay attention to their physical health, and their awareness of physical health protection has become stronger and stronger. Therefore, participation in the URRBMI is expected to provide greater protection for the physical health of the rural older adult (20), so we propose the following hypothesis:

*H1: URRBMI can improve the health status of the rural older adult.*

The principle of territorial financing and management of URRBMI in China means that there are obvious regional characteristics in the medical insurance resources actually possessed by each region. Due to the disparity in economic levels among the eastern, central and western areas, there are regional disparities in medical services received by the rural older adult in different regions. The eastern region of China is more economically developed (21, 22), and the financial subsidies invested in URRBMI have also increased (23), so the level of medical insurance coverage is generally better in the eastern region. The advanced medical resources and perfect medical conditions are mainly distributed in the eastern region (24, 25), differences in the access to medical services in the eastern, central and western areas may further widen the gap in the medical insurance benefits for the rural older adult. Generally speaking, URRBMI contributed more strongly to the physical health of the rural older adult in eastern areas. We propose the following hypothesis:

*H2a: The effect of URRBMI on physical health of the rural older adult in eastern areas is more significant than in central and western areas.*

The life cycle theory provides an explanation for the fact that the rate of illness dramatically increases as people grow older (26). As we all know, age plays a fundamental role in the physical health of the older adult. Compared to the advanced rural older adult, younger rural older adult make relatively less use of medical services, because they are younger and their physiological functions have not deteriorated significantly. With increasing age, the health degradation rate of the advanced older adult rises. The advanced rural older adult are generally subject to more disease risks, and their specialized medical services need increases, which means that the advanced rural older adult are more in need of the protection of URRBMI. Wu et al.

also found that the medical insurance significantly reduces the mortality risk of the advanced older adult (27). Therefore, there is a possible age difference, and URRBMI has a more obvious promotion effect on the physical health of the advanced rural older adult. We propose the following hypothesis:

*H2b: The effect of URRBMI on physical health of the advanced rural older adult is more significant than the younger rural older adult.*

URRBMI promotes the access to medical services for the rural older adult and is an essential guarantee for meeting the medical demands of the rural older adult. By reimbursing the medical costs of the rural older adult, the disease financial burden has been reduced, thus minimizing the influence of catastrophic medical expenditures on the lives of the rural older adult and reducing to a greater extent the disease risks among the rural older adult. Finkelstein et al. also believes that medical insurance may have a positive effect on health due to the increased financial accessibility of medical care (28). At the same time, URRBMI helps rural older adult to reduce precautionary savings, increase current life consumption expenditures, and alleviate the pressure of life caused by medical care (29), the increase in relative incomes effectively improves life quality of the rural older adult and improve their life satisfaction, thus contributing to the improvement of their physical health.

*H3a: Life satisfaction mediates the effect of URRBMI on physical health of the rural older adult.*

According to the Anderson Health Services Utilization Model (30), timeliness of medical services utilization can improve the physical health of the rural older adult through more specialized medical resources (31). URRBMI, as a public policy to promote health, is beneficial to improving the accessibility of medical services for rural older adult, so that they can be more promptly informed of their own health status and can enhance health awareness of the rural older adult (32), thereby avoiding the expansion of disease risks. Hoffman et al. also believes that medical insurance can further improve people's health through the accessibility of medical services utilization (33). Therefore, URRBMI can promote the health status of the rural older adult by enhancing the timeliness of medical services utilization. We propose the following hypothesis:

*H3b: Timeliness of medical services mediates the effect of URRBMI on physical health of the rural older adult.*

## Data, variables, and empirical model

### Data

The study uses the latest data from CLHLS in 2018. CLHLS data is a national, large-scale database for the older adult (34–36), so CLHLS data samples are nationally representative. Besides, the 2018 CLHLS data include detailed variables of URRBMI, physical health of the rural older adult, and timeliness of medical services, and so on, which are the basis for this analysis. According to the purpose of the study, the sample was selected according to the following criteria: to

retain the aged 65 and above, have rural household registration and live in rural areas at the time of the survey. Additionally, the invalid samples with missing key information including URRBMI, ADL, gender, age, marriage, education years, smoke, drink, exercise, physical examination, co-residence, life satisfaction, timeliness of medical services and who pays for medical services mainly were eliminated, and the final valid samples is 9,551 (Figure 1).

## Variables

### Dependent variable

The dependent variable is physical health of the rural older adult. We use the ADL to reflect physical health. ADL is objective indicator of physical condition and can indicate the health condition of the rural older adult (37), and referring to the previous literature (38–41), ADL has been widely used to measure physical health, so we use ADL reflect the health status of the rural older adult. ADL was measured by the following items: (1) Bathing; (2) Dressing; (3) Indoor moving; (4) Toileting; (5) Continence of defecation; (6) Eating. Each item was scored from 1 to 3, and the total score of ADL could reveal the health status. The more scores the respondents received, the higher ADL reliance would be, which means they are in poor health (38). At the same time, we use a binary variable defined as ADL-1 that equals 0 if the respondent reported no limitation in six items above, and otherwise equals 1. We take ADL as a key proxy variable physical health of the rural older adult.

### Independent variable

The independent variable is whether the rural older adult participated in URRBMI (*URRBMI*). The rural older adult enrolled in the URRBMI were assigned a value of 1, otherwise 0.

### Control variables

According to the other studies (42–44), we selected the control variables as follows: gender (*Gender*), age (*Age*), marriage (*Marriage*), education years (*Education*), smoke (*Smoke*), drink (*Drink*), exercise (*Exercise*), physical examination (*Examination*), co-residence (*Residence*).

### Instrumental variable

This study uses who pays for medical services mainly (*Expense*) as an instrumental variable, we set *Expense* as 1–3, representing medical insurance payment, pay personally, and others, respectively. We use *Expense* as the instrumental variable, the reasons are as follows: First, whether or not the rural older adult are enrolled in URRBMI is affected by the variable of who pays for medical services mainly, therefore, who pays for medical services mainly affects the willingness of the rural older adult to participate in URRBMI. Second, the variable of who pays for medical services mainly has no direct influence on the physical health of the rural older adult.

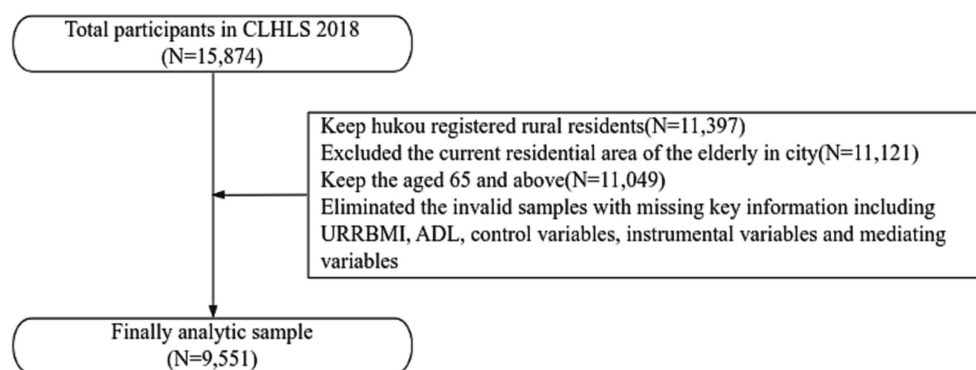


FIGURE 1  
Sample selection procedure of this study.

## Mediating variable

Life satisfaction (*satisfaction*) and timeliness of medical services (*Service*) may relate to the URRBMI and physical health of the rural older adult, which may affect the relationship between them. Relevant studies demonstrated that timely access to medical services could improve the chances of healthy survival for the older adult (45), and life satisfaction is known to be positively correlated with physical health (46). Referring to the previous literature (39, 47–50), the study selected *satisfaction* and *Service* to examine the mediating effect.

The above variables and their definitions are shown Table 1, and their descriptive statistics are given in Table 2.

## Empirical model

Referring to the previous literature (43, 51, 52), the regression model is set as follows:

$$ADLi = \beta_1 + \beta_2 URRBMI_i + \beta_3 Controls + \varepsilon_i \quad (1)$$

where *ADL* refers to the rural older adult physical health; *URRBMI* represents the variable of URRBMI; *Controls* stands for the above control variables;  $\beta_1$  indicates the intercepted item;  $\beta_2$  denotes the coefficient of URRBMI;  $\beta_3$  is the coefficients of control variables;  $\varepsilon_i$  is a normally distributed random error vector.

$\beta_2$  is the coefficient of interest. If  $\beta_2 < 0$ , it means that URRBMI promotes the physical health of the rural older adult. If so, H1 is confirmed. In contrast, if  $\beta_2 > 0$ , it indicates that URRBMI weakens the health status of the rural older adult. If so, according to the research, H1 does not stand.

## Empirical results

### Benchmark regression results

In this section, ordinary least square models were used to analyze the regression of physical health of the rural older adult. The estimated

results are shown in Table 3. We see that all the coefficients of *URRBMI* are significantly negative at the 1% level. It means that URRBMI can prompt physical health of the rural older adult and confirm the H1 is right.

For all the control variables, most of the estimates are in agreement with theoretical expectations. Specifically speaking, the coefficients of *Gender*, *Age*, and *Residence* are positive at the 5% level, which suggests that the better health of the rural older adult is more apparent among males, younger, and residence alone. Furthermore, at the 1% level, the coefficients of *Marriage*, *Education*, *Smoke*, *Drink*, *Exercise*, *Examination* is all negative. The findings show that married rural older adult have better physical health status, and education years, regular exercise, regular physical examination can prompt the physical health of the rural older adult.

## Robustness test

In this study, we use the method of replacing the dependent variable for the robustness test, and since *ADL-1* is a dummy variable, we adopt a binary logistic regression model to estimate the results. The results are given in Columns (1, 2) of Table 4. The coefficients of *URRBMI* are significantly negative at the 5% level, it means that URRBMI improve the physical health of the rural older adult, this suggests that URRBMI has a protective effect on the physical health of the rural older adult. The outcome is in accordance with the previous results, suggesting that the results keep highly robust and further support the conclusions of this study. The results for the control variables are also in agreement with the above results obtained from the ordinary least square models.

## Endogenous test

As we all know, there may be a bi-directional causality between URRBMI and the health status of the rural older adult. Generally speaking, rural older adult in poorer health is more inclined to participate in URRBMI, this leads to endogenous problems as the health status of the rural older adult inversely affects the behavior of

TABLE 1 The definitions of all variables.

Variables	Symbols	Definitions
Dependent variable		
Activities of daily living	ADL	<i>ADL</i> is equal to 6–18 scale, representing the rural older adult physical health, respectively.
	ADL-1	<i>ADL-1</i> is equal to 1 if the rural older adult is restriction in six daily activities, and otherwise 0.
Independent variable		
Urban–Rural resident basic medical insurance	URRBMI	<i>URRBMI</i> is equal to 1 if the rural older adult participated in the URRBMI, and otherwise 0.
Mediating variable		
Life satisfaction	Satisfaction	<i>Satisfaction</i> is equal to 1–5, representing very good, good, so so, bad, very bad.
Timeliness of medical services	Service	<i>Service</i> is equal to 1 if the rural older adult can get timeliness of medical services, and otherwise 2.
Instrumental variable		
who pays for medical services mainly	Expense	<i>Expense</i> is equal 1–3, representing medical insurance payment, pay personally, and others.
Control variables		
Gender	Gender	<i>Gender</i> is equal 1 if the rural older adult is male, and otherwise 2.
Marriage	Marriage	<i>Marriage</i> is equal 1 if the rural older adult is in marriage period, and otherwise 0.
Age	Age	<i>Age</i> is 65–117.
Education years	Education	<i>Education</i> is 0–16, indicating that education years
Smoke	Smoke	<i>Smoke</i> is equal 1 if the rural older adult is smoke, and otherwise 0.
Drink	Drink	<i>Drink</i> is equal 1 if the rural older adult is drink, and otherwise 0.
Exercise	Exercise	<i>Exercise</i> is equal 1 if the rural older adult is exercise, and otherwise 0.
Physical examination	Examination	<i>Examination</i> is equal 1 if the rural older adult have regular physical examination, and otherwise 0.
Co-residence	Residence	<i>Residence</i> is equal 0–2, representing alone, with household member, institution.

TABLE 2 Descriptive statistics.

Variables	Obs	Mean	S.D.	Min	Max
ADL	9,551	7.149	2.613	6.000	18.000
ADL-1	9,551	0.206	0.404	0.000	1.000
URRBMI	9,551	0.836	0.370	0.000	1.000
Gender	9,551	1.575	0.494	1.000	2.000
Marriage	9,551	0.375	0.484	0.000	1.000
Age	9,551	85.677	11.695	65.000	117.000
Education	9,551	4.260	5.791	0.000	16.000
Smoke	9,551	0.163	0.369	0.000	1.000
Drink	9,551	0.147	0.354	0.000	1.000
Exercise	9,551	0.239	0.427	0.000	1.000
Examination	9,551	0.692	0.462	0.000	1.000
Residence	9,551	0.841	0.406	0.000	2.000
Expense	9,551	1.572	0.587	1.000	3.000
Satisfaction	9,551	2.248	0.781	1.000	5.000
Service	9,551	1.037	0.188	1.000	2.000

whether or not to participate in URRBMI (53). Therefore, we solve the endogenous problem using the instrumental variable method (54). Columns (3, 4) of Table 4 present the estimation outcomes of the endogeneity test. The coefficient of *URRBMI* is still negative, the result is agreement with the previous findings and further demonstrates our

conclusion. Compared to not controlling the endogeneity, we also find that the value of the regression coefficients of *URRBMI* decreases after controlling the endogeneity, suggesting that the impact of URRBMI in promoting the physical health of the rural older adult is underestimated if endogeneity is not addressed.



TABLE 3 The Benchmark regression result.

Variables	(1)	(2)
URRBMI	−0.302***	−0.241***
	(0.072)	(0.065)
Gender		0.127**
		(0.056)
Marriage		−0.235***
		(0.064)
Age		0.0663***
		(0.002)
Education		−0.0128***
		(0.004)
Smoke		−0.232***
		(0.072)
Drink		−0.295***
		(0.072)
Exercise		−0.630***
		(0.057)
Examination		−0.727***
		(0.053)
Residence		0.879***
		(0.062)
Constant	7.402***	1.607***
	(0.066)	(0.273)
Observations	9,551	9,551
R-squared	0.001	0.211

\*\*\* $p < 0.01$ , \*\* $p < 0.05$ ; Standard errors are in parentheses (the same below).

TABLE 4 Regression results of robustness test and endogenous test.

Variables	Robustness test		Endogenous test	
	(1)	(2)	(3)	(4)
URRBMI	−0.158**	−0.187***		−3.973**
	(0.066)	(0.071)		(1.597)
Expense			−0.030***	
			(0.006)	
Control variables	No	Yes	Yes	Yes
Constant	−1.218***	−0.414***	0.872***	10.806***
	(0.060)	(0.132)	(0.022)	(1.323)
Observations	9,551	9,551	9,551	9,551
Phase F-value			21.186	
DWH test p-value				0.007

\*\*\* $P < 0.01$ , \*\* $p < 0.05$ .

### Heterogeneity analysis

We also investigate the heterogeneous effect from different regions and age. The estimation results are shown in Table 5. Columns (1), (2), and (3) are the results for western, central and

eastern areas. Columns (4, 5) are the outcomes of younger rural older adult and advanced rural older adult.

At the 1% level, the *URRBMI* coefficients were significantly negative in the eastern region, but there is no influence on the central and western regions. The influence of *URRBMI* on the physical health

TABLE 5 Estimation results of heterogeneous analysis.

Variables	Region difference			Age difference	
	Western	Central	Eastern	Younger rural older adult	Advanced rural older adult
	(1)	(2)	(3)	(4)	(5)
URRBMI	−0.172	−0.102	−0.314***	−0.022	−0.329***
	(0.123)	(0.143)	(0.099)	(0.050)	(0.103)
Control variables	Yes	Yes	Yes	Yes	Yes
Constant	2.447***	1.475***	1.358***	6.445***	7.876***
	(0.450)	(0.478)	(0.418)	(0.121)	(0.192)
R-squared	0.156	0.203	0.254	0.031	0.135
Observations	2,379	2,919	4,253	3,504	6,047

\*\*\**p* < 0.01.

TABLE 6 Results of mediating effect.

Variables	(1)	(2)	(3)	(4)
	Satisfaction	ADL	Service	ADL
URRBMI	0.062***	−0.270***	−0.016***	−0.227***
	(0.0213)	(0.0638)	(0.00521)	(0.0644)
Satisfaction		0.468***		
		(0.0306)		
Service				0.852***
				(0.127)
Control variables	Yes	Yes	Yes	Yes
Constant	2.198***	0.579**	1.055***	0.708**
	(0.090)	(0.278)	(0.022)	(0.303)
R-squared	0.034	0.230	0.012	0.215
Observations	9,551	9,551	9,551	9,551

\*\*\**P* < 0.01, \*\**P* < 0.05.

of the rural older adult varies in different regions. Hence, this finding confirmed H2a, the effect of URRBMI on physical health of the rural older adult in eastern areas is more significant than in central and western areas.

Age was classified into two groups, 65–80 years old is considered as the younger rural older adult, and aged over 80 is considered as the advanced rural older adult. Columns (4, 5) in Table 5 present the results, the coefficient of URRBMI is significantly negative at the 1% level for the advanced rural older adult, while it is not significant for the younger rural older adult. The result suggests that the URRBMI promotes the health status of the advanced rural older adult, but it has no influence on the younger rural older adult. Hence, this finding confirmed H2b, the effect of URRBMI on physical health of the advanced rural older adult is more significant than the younger rural older adult.

### Mediating effect

Mediated effects analysis can help researchers verify the processes and mechanisms of factor interactions. This study uses Hayes’

identification methodology and test steps to test the mediating effect (55, 56). The model is set as follows:

$$Mediator_i = \gamma_1 + \gamma_2 URRBMI_i + \gamma_3 Controls + \varepsilon_i \quad (2)$$

$$ADL_i = \eta_1 + \eta_2 URRBMI_i + \eta_3 Mediator_i + \eta_4 Controls + \varepsilon_i \quad (3)$$

where *Mediator* indicates the variable of *satisfaction* or *service*, and the other variables are the same with the Model (1). If  $\eta_2$  and  $\eta_3$  are both significant, it suggests that life satisfaction and timeliness of medical services are partially mediating variables; but if  $\eta_2$  is not significant but  $\eta_3$  is significant, it suggests that life satisfaction and timeliness of medical services are fully mediating variables.

From the results of the Table 6. After adding two mediating variables, life satisfaction and timeliness of medical services, respectively. We can find that the coefficients of life satisfaction and timeliness of medical services were significant at the 1% level, it suggested that URRBMI improves the physical health of the rural older adult through increasing life satisfaction and enhancing the timeliness of medical services, respectively, with

both variables playing partial mediating roles, respectively. Hence, this finding confirmed H3a and H3b.

## Discussion and recommendations

As an important medical security system design in China, URRBMI undertakes a number of missions such as ensuring health rights and safeguarding health justice (57). The study indicated that URRBMI is consistent with the fundamental goal of improving people's health.

(1) In this study, we found that URRBMI can prompt physical health of the rural older adult. The results are consistent with the previous studies: medical insurance can significantly improve the health status of the older adult (58–61). As we all know, URRBMI can effectively reduce the medical expenditures, and increase the probability that rural older adult have access to higher-quality medical services which prompts the physical health of the rural older adult (62). Besides, with increasing age, the physical functions of the rural older adult deteriorate and their physical health gets worse. The study also suggested that marriage is a protective factor for physical health of the rural older adult, this is consistent with the findings of Fuhrer's study (63). Regular exercise helps strengthen the immune system and thus reduces the likelihood of disease, so rural older adult who exercise regularly are in better physical health.

Due to the positive physical health implication of URRBMI on the rural older adult, it is quite necessary to further improve its participation rate (64). We should improve the design of URRBMI policy. Continuously expanding the coverage of URRBMI is a precondition for promoting the improvement of physical health of the rural older adult. Expansion of medical insurance coverage significantly increases medical services utilization (65). Particularly, it is difficult to ensure the sustainability of broad coverage due to the current policy of voluntary participation. To further broaden the wide coverage of URRBMI, consideration could be given to compulsory participation in the URRBMI for rural older adult.

(2) The study's results suggested that URRBMI contributes more significantly to the rural older adult in eastern area and the advanced rural older adult. Because the sophisticated and high-quality health resources are largely distributed in the eastern region (24), rural older adult in eastern area enjoys a higher level of URRBMI, release higher medical demand and can gain medical services more easily (66). However, the economic development is slower in the central and western areas. Even though the URRBMI has increased the demand for medical services by the rural older adult, the demand for medical services still cannot be met within the constraints of the existing medical conditions, so the promotion of URRBMI is not significant. Furthermore, as age increases, the physical health of the advanced rural older adult deteriorates and they need to consume more medical services to maintain their health (67), and the frequency and intensity of the advanced rural older adult use URRBMI is higher than that the younger rural older adult.

Due to the disparity in economic levels between the eastern, central and western areas, there are regional differences in the impact of URRBMI on the physical health of the rural older adult. We should narrow the basic medical insurance compensation gap among eastern, central and western areas. Specifically, we should continue to increase financial subsidies for URRBMI in the central and western

areas, and gradually raise the overall level of URRBMI and minimize regional disparities. Reducing regional disparities in URRBMI reimbursement contributes to achieve the regional equalization of basic medical insurance services. Meanwhile, generous insurance reimbursement can decrease the price of medical services (68), it is particularly important to promote the physical health of the advanced older adult. We should maintain the balance of income and expenditure of the medical insurance fund, reduce the threshold line, raise the ceiling line, and increase the actual insurance reimbursement rate to alleviate the financial burden of illness for the rural older adult, especially provide more precise safeguards for the advanced rural older adult.

(3) The results also showed that URRBMI improves physical health of the rural older adult through increasing life satisfaction and enhancing the timeliness of medical services. On the one hand, URRBMI has reduced the burden of medical expenses on the rural older adult and relatively increased their regular income, thus the rural older adult can spend more of their income on such areas as daily leisure consumption and preventive health care, and their quality of life has improved accordingly, which in turn has increased their life satisfaction and improved their physical health. On the other hand, timeliness of medical services shortens the time to acquire medical services, enhances the availability of medical services for rural older adult, thus enhancing their physical health.

To increase the timely access to medical services for rural older adult, we should further integrate the distribution of medical resources. By optimizing the integration of medical resources, improving the efficiency of medical resources allocation, thus forming a reasonable and orderly pattern of access to medical services (69), which significantly improves spatial accessibility of medical services. It will help rural older adult obtain various types of medical services close to their homes, which could gain medical services immediately when they need it.

## Conclusion and limitation

Using the CLHLS data in 2018, this study analyzed the influence of URRBMI on the health status of the rural older adult. We have come to the following conclusions:

First, the URRBMI greatly improves physical health of the rural older adult, and the results are robust. Second, there are regional and age differences in the impact of URRBMI on the physical health of the rural older adult. URRBMI plays a more vital role in prompting physical health of the rural older adult in the eastern area. Furthermore, compared with the younger rural older adult, the effect of URRBMI on improving the physical health of the advanced rural older adult is more obvious. Third, we provide extra evidence that life satisfaction and timeliness of medical services plays a mediating effect in the association between URRBMI and physical health of the rural older adult in China. The compensation mechanism of URRBMI has relatively lowered the price of medical services and enhanced the leisure consumption for the rural older adult, thereby increasing life satisfaction and promoting physical health, and URRBMI guarantees timely access to medical services for the rural older adult, which prevents minor illness from become serious ones (70).

However, there are following limitations in our study and further research is needed. First, the impact of chronic diseases on

ADL may be significant, this could affect the analysis results. However, due to the incompleteness of the chronic disease data, chronic disease was not included as a control variable in this study. Second, as the research object of this study is the rural older adult and the relationship between URRBMI and their physical health, this study did not include the urban older adult, the comparison of the two groups could be studied as a new topic in the future.

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## Author contributions

XP: Conceptualization, Writing – original draft. SH: Data curation, Software, Writing – original draft. XL: Supervision, Writing – review & editing.

## References

- Zeng Y, Chen HS, Wang ZL, Land KC. Implications of changes in households and living arrangements for future home-based care needs and costs for disabled elders in China. *J Aging Health*. (2014) 27:519–50. doi: 10.1177/0898264314552690
- Guo LM, Zhang WK. Knowledge mapping of population health: a bibliometric analysis. *Heliyon*. (2022) 8:e12181. doi: 10.1016/j.heliyon.2022.e12181
- Kumar S, Gonzalez F. Effects of health insurance on birth weight in Mexico. *Health Econ*. (2018) 27:1149–59. doi: 10.1002/hec.3662
- Abrokwa SO, Callison K, Meyer DJ. Social health insurance and the use of formal and informal care in developing countries: evidence from Ghana's national health insurance scheme. *J Dev Stud*. (2019) 55:1477–91. doi: 10.1080/00220388.2017.1414192
- Lee J, Schram A, Riley E, Harris P, Baum F, Fisher M, et al. Addressing health equity through action on the social determinants of health: a global review of policy outcome evaluation methods. *Int J Health Policy*. (2018) 7:581–92. doi: 10.15171/ijhpm.2018.04
- Chen MS, Zhou GL, Si L. Ten years of progress towards universal health coverage: has China achieved equitable healthcare financing? *BMJ Glob Health*. (2020) 5:e003570. doi: 10.1136/bmjgh-2020-003570
- Fu XL, Su YL, Zeng CY, Liu LQ, Guo Y, Wu YY. The mediation and interaction of depressive symptoms in activities of daily living and active aging in rural elderly: a cross-sectional survey. *Front Public Health*. (2022) 10:942311. doi: 10.3389/fpubh.2022.942311
- Akimov AV, Gemueva KA, Semenova NK. The seventh population census in the PRC: results and prospects of the Country's demographic development. *Her Russ Acad Sci*. (2021) 91:724–35. doi: 10.1134/S1019331621060083
- Cheng LG, Liu H, Zhang Y, Shen K, Zeng Y. The impact of health insurance on health outcomes and spending of the elderly: evidence from China's new cooperative medical scheme. *Health Econ*. (2014) 24:672–91. doi: 10.1002/hec.3053
- Pan J, Lei X, Liu GG. Health insurance and health status: exploring the causal effect from a policy intervention. *Health Econ*. (2015) 25:1389–402. doi: 10.1002/hec.3225
- Hou B, Wu YX, Huang SY. Participating in health insurance and health improvements for the relatively poor population: a propensity score analysis. *Front Public Health*. (2022) 10:968009. doi: 10.3389/fpubh.2022.968009
- Huh J, Reif J. Did Medicare part D reduce mortality? *J Health Econ*. (2017) 53:17–37. doi: 10.1016/j.jhealeco.2017.01.005
- Sommers BD, Gawande AA, Baicker K. Health insurance coverage and health—what the recent evidence tells us. *New Engl J Med*. (2017) 377:586–93. doi: 10.1056/nejmsb1706645
- Chen YY, Jin GZ. Does health insurance coverage lead to better health and educational outcomes? Evidence from rural China. *J Health Econ*. (2012) 31:1–14. doi: 10.1016/j.jhealeco.2011.11.001
- Huang X, Wu BX. Impact of urban-rural health insurance integration on health care: evidence from rural China. *China Econ Rev*. (2020) 64:101543. doi: 10.1016/j.chieco.2020.101543

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- Zhang Y, Sun YQ, Xie ML, Chen YP, Cao SH. Health shocks, basic medical insurance and common prosperity: based on the analysis of rural middle-aged and elderly groups. *Front Public Health*. (2022) 10:1014351. doi: 10.3389/fpubh.2022.1014351
- Sun JL, Tao R, Wang L, Jin LM. Does social medical insurance achieve a poverty reduction effect in China? *Front Public Health*. (2022) 9:800852. doi: 10.3389/fpubh.2021.800852
- Wang ZH, Li XJ, Chen MS, Si L. Social health insurance, healthcare utilization, and costs in middle-aged and elderly community-dwelling adults in China. *Int J Equity Health*. (2018) 17:17. doi: 10.1186/s12939-018-0733-0
- Su CW, Huang SW, Tao R, Haris M. Does economic overheating provide positive feedback on population health? Evidence from BRICS and ASEAN countries. *Front Public Health*. (2021) 9:661279. doi: 10.3389/fpubh.2021.661279
- Kato H, Goto R, Tsuji T, Kondo K. The effects of patient cost-sharing on health expenditure and health among older people: heterogeneity across income groups. *Eur J Health Econ*. (2022) 23:847–61. doi: 10.1007/s10198-021-01399-6
- Meng Q, Xu L, Zhang YG, Qian JC, Cai M, Xin Y, et al. Trends in access to health services and financial protection in China between 2003 and 2011: a cross-sectional study. *Lancet*. (2012) 379:805–14. doi: 10.1016/S0140-6736(12)60278-5
- Qin YD, Chen L, Li JB, Wu YY, Huang SH. Greater inequalities in dental caries treatment than in caries experience: a concentration index decomposition approach. *BMC Oral Health*. (2021) 21:564. doi: 10.1186/s12903-021-01935-z
- Qin M, Zhuang Y, Liu HY. Old age insurance participation among rural-urban migrants in China. *Demorg Res*. (2015) 33:1047–66. doi: 10.4054/DemRes.2015.33.37
- Cui FF, Ma QQ, He XY, Zhai YK, Zhao J, Chen BZ, et al. Implementation and application of telemedicine in China: cross-sectional study. *JMIR Mhealth Uhealth*. (2020) 8:e18426. doi: 10.2196/18426
- Bai P, Tang YX, Zhang WK, Zeng M. Does economic policy uncertainty matter for healthcare expenditure in China? A spatial econometric analysis. *Front Public Health*. (2021) 9:673778. doi: 10.3389/fpubh.2021.673778
- Pu XH, Wang YL, Zhang WK, Zeng M. Can basic medical insurance reduce elderly family income inequality in China? *Front Public Health*. (2022) 10:838733. doi: 10.3389/fpubh.2022.838733
- Wu WC, Li C, Gao B. Heterogeneity of the impact of the social old-age insurance and the medical insurance on the mortality risk of the elderly. *Front Public Health*. (2022) 10:807384. doi: 10.3389/fpubh.2022.807384
- Finkelstein SL, Papovich C, Rudnick G, Egami E, Floch EL, Rieke MJ, et al. Turning Back the clock: inferring the history of the eight O'clock arc. *Astrophys J*. (2009) 700:376–86. doi: 10.1088/0004-637x/700/1/376
- Zhou Q, Liu GG, Krumholz S. Is Chinese National Health Insurance Effective in the face of severe illness? A perspective from health service utilization and economic burden. *Soc Indic Res*. (2017) 132:1307–29. doi: 10.1007/s11205-016-1330-5

30. Boer AGEMD, Wijker W, Haes HCJMD. Predictors of health care utilization in the chronically ill: a review of the literature. *Health Policy*. (1997) 42:101–15. doi: 10.1016/s0168-8510(97)00062-6
31. Finkelstein A, Taubman S, Wright B, Bernstein M, Gruber J, Newhouse JP, et al. The Oregon health insurance experiment: evidence from the first year. *Q J Econ*. (2012) 127:1057–106. doi: 10.1093/qje/qjs020
32. Wu H, Liu YQ. Examining inequality in utilisation of health management services for the elderly in rural Henan China. *BMC Health Serv Res*. (2020) 20:758. doi: 10.1186/s12913-020-05630-7
33. Hoffman C, Paradise J. Health insurance and access to health care in the United States. *Ann N Y Acad Sci*. (2010) 1136:149–60. doi: 10.1196/annals.1425.007
34. Zeng Y. *Introduction to the Chinese longitudinal healthy longevity survey (CLHLS)*. Netherlands: Springer (2008).
35. Gu D, Feng Q, Zeng Y. Chinese longitudinal healthy longevity study. In: NA Pachana, editor. *Encyclopedia Geropsychol*. Singapore: Springer. (2016):1–14.
36. Mai SM, Cai JJ, Li L. Factors associated with access to healthcare services for older adults with limited activities of daily living. *Front Public Health*. (2022) 10:921980. doi: 10.3389/fpubh.2022.921980
37. Mlinac ME, Feng MC. Assessment of activities of daily living, self-care, and independence. *Arch Clin Neuropsych*. (2016) 31:506–16. doi: 10.1093/arclin/acw049
38. Yang Y. Characterising long term care needs among Chinese older adults with cognitive impairment or ADL limitations. *J Cross Cult Gerontol*. (2020) 35:35–47. doi: 10.1007/s10823-019-09382-8
39. Zhang XF, Dupre ME, Qiu L, Zhou W, Zhao Y, Gu DA. Urban-rural differences in the association between access to healthcare and health outcomes among older adults in China. *BMC Geriatr*. (2017) 17:151–62. doi: 10.1186/s12877-017-0538-9
40. Yu CY, Liang H, Wang BY, Liang F, Liu EP, Xiang N. The association between reproductive history and the multidimensional health of older adults in rural China and its gender differences evidence from the Chinese longitudinal healthy longevity survey. *Front Public Health*. (2022) 10:952671. doi: 10.3389/fpubh.2022.952671
41. Gao YM, Du L, Cai JP, Hu TF. Effects of functional limitations and activities of daily living on the mortality of the older people: a cohort study in China. *Front Public Health*. (2023) 10:1098794. doi: 10.3389/fpubh.2022.1098794
42. Tian G, Li R, Cui YR, Zhou T, Shi Y, Yang WY, et al. Association between disability, social support and depressive symptoms in Chinese older adults: a national study. *Front Public Health*. (2022) 10:980465. doi: 10.3389/fpubh.2022.980465
43. Wang ZW, Chen YC, Pan TY, Liu XD, Hu HW. The comparison of healthcare utilization inequality between URRBMI and NCMS in rural China. *Int J Equity Health*. (2019) 18:90. doi: 10.1186/s12939-019-0987-1
44. Cui LY, Li JS, Xie DN, Wang MH, He FR, Chen JF, et al. Role of the social support and health status in living arrangement preference of the elderly in China—a cross-sectional study. *Front Public Health*. (2022) 10:860974. doi: 10.3389/fpubh.2022.860974
45. Gu D, Zhang Z, Zeng Y. Access to healthcare services makes a difference in healthy longevity among older Chinese adults. *Soc Sci Med*. (2009) 68:210–9. doi: 10.1016/j.socscimed.2008.10.025
46. Bakkeli NZ. Health, work, and contributing factors on life satisfaction: a study in Norway before and during the COVID-19 pandemic. *Ssm Popul Health*. (2021) 14:100804. doi: 10.1016/j.ssmph.2021.100804
47. Reyes Fernández B, Rosero-Bixby L, Koivumaa-Honkanen H. Effects of self-rated health and self-rated economic situation on depressed mood via life satisfaction among older adults in Costa Rica. *J Aging Health*. (2015) 28:225–43. doi: 10.1177/0898264315589577
48. Steptoe A, Fancourt D. Leading a meaningful life at older ages and its relationship with social engagement, prosperity, health, biology, and time use. *P Natl Acad Sci U S A*. (2019) 116:1207–12. doi: 10.1073/pnas.1814723116
49. Zhao Y, Xu X, Dupre ME, Xie QQ, Qiu L, Gu DN. Individual-level factors attributable to urban-rural disparity in mortality among older adults in China. *BMC Public Health*. (2020) 20:20. doi: 10.1186/s12889-020-09574-9
50. Zhang XF, Dupre ME, Qiu L, Zhou W, Zhao Y, Gu DN. Age and sex differences in the association between access to medical care and health outcomes among older Chinese. *BMC Health Serv Res*. (2018) 18:1004. doi: 10.1186/s12913-018-3821-3
51. Zhang ZY, Wang JB, Jin MJ, Li M, Zhou LT, Jing FY, et al. Can medical insurance coverage reduce disparities of income in elderly patients requiring long-term care? The case of the People's Republic of China. *Clin Interv Aging*. (2014) 9:771–7. doi: 10.2147/CIA.S58771
52. Jiang H, Zhao MM, Tian GM, Zhao ZH, Ding D, Yin M. Perceived effect of financial risk protection by the urban-rural resident basic medical insurance scheme: a mixed-methods study of rural residents in China. *BMJ Open*. (2021) 11:e047699. doi: 10.1136/bmjopen-2020-047699
53. Kananurak P. Healthcare use and voluntary health insurance after retirement in Thailand. *Appl Health Econ Health*. (2014) 12:299–313. doi: 10.1007/s40258-014-0081-1
54. Ding Y. Personal life satisfaction of China's rural elderly: effect of the new rural pension programme. *J Int Dev*. (2016) 29:52–66. doi: 10.1002/jid.3264
55. Hayes AF. Beyond baron and Kenny: statistical mediation analysis in the new millennium. *Commun Monogr*. (2009) 76:408–20. doi: 10.1080/03637750903310360
56. Bolin JH. Introduction to mediation, moderation, and conditional process analysis: a regression-based approach. New York, NY: the Guilford press. *J Educ Meas*. (2014):51. doi: 10.1111/jedm.12050
57. Sun TT, Tao R, Su CW, Umar M. How do economic fluctuations affect the mortality of infectious diseases. *Front Public Health*. (2021) 9:678213. doi: 10.3389/fpubh.2021.678213
58. Liang Y, Lu PY. Medical insurance policy organized by Chinese government and the health inequity of the elderly: longitudinal comparison based on effect of new cooperative medical scheme on health of rural elderly in 22 provinces and cities. *Int J Equity Health*. (2014) 13:37. doi: 10.1186/1475-9276-13-37
59. Powell D, Seabury S. Medical care spending and labor market outcomes: evidence from workers' compensation reforms. *Am Econ Rev*. (2018) 108:2995–3027. doi: 10.1257/aer.20150912
60. Fan H, Yan QY, Coyte PC, Yu WG. Does public health insurance coverage lead to better health outcomes? Evidence from Chinese adults. *Inquiry J Health Care*. (2019) 56:46958019842000. doi: 10.1177/0046958019842000
61. Sun J, Lyu SJ. Does health insurance lead to improvement of health status among Chinese rural adults? Evidence from the China family panel studies. *Int J Health Ser*. (2020) 50:350–9. doi: 10.1177/0020731420914824
62. Card D, Dobkin C, Maestas N. Does medicare save lives? *Q J Econ*. (2009) 124:597–636. doi: 10.1162/qjec.2009.124.2.597
63. Fuhrer R, Stansfeld SA. How gender affects patterns of social relations and their impact on health: a comparison of one or multiple sources of support from "close persons". *Soc Sci Med*. (2002) 54:811–25. doi: 10.1016/s0277-9536(01)00111-3
64. Sun J, Yao NL, Lyu SJ. The association between urban and rural resident basic medical insurance and depressive symptoms among Chinese middle-aged and older adults: evidence from the China health and retirement longitudinal study. *Int J Health Plan Manage*. (2021) 36:1916–35. doi: 10.1002/hpm.3305
65. Kondo A, Shigeoka H. Effects of universal health insurance on health care utilization, and supply-side responses: evidence from Japan. *J Public Econ*. (2013) 99:1–23. doi: 10.1016/j.jpubeco.2012.12.004
66. Li CF, Tang CX, Wang HP. Investigating the association of health system characteristics and health care utilization: a multilevel model in China's ageing population. *J Glob Health*. (2020) 10:020802. doi: 10.7189/jogh.10.020802
67. Bolhaar J, Lindeboom M, Klaauw BVD. A dynamic analysis of the demand for health insurance and health care. *Eur Econ Rev*. (2012) 56:669–90. doi: 10.1016/j.euroeconrev.2012.03.002
68. Xie XQ, Hu Y. The reimbursement rate of new rural cooperative medical scheme and self-rated health among rural middle-aged and elderly. *Front Public Health*. (2022) 10:627169. doi: 10.3389/fpubh.2022.627169
69. Chen F, Jiang QQ, Lu ZX, Cao SY. General practitioners' perspectives of the integrated health care system: a cross-sectional study in Wuhan, China. *Fam Pract*. (2021) 38:103–8. doi: 10.1093/fampra/cmaa088
70. Wang YX, Yang W, Avendano M. Income-related inequalities in informal care: evidence from the longitudinal healthy longevity survey in China. *J Gerontol B Psychol*. (2021) 76:1691–6. doi: 10.1093/geronb/gbab043





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# Assessing social protection influence on health status in the European Union

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**Introduction:** Health status and access to healthcare services are crucial factors that directly impact the well-being of individuals and societies. In the European Union (EU), social protection measures are significant in supporting citizens' health and providing access to healthcare resources.

**Methods:** This study investigates the relationship between social protection and health status in EU countries. We collected data from Eurostat on the EU member states' health status, healthcare expenditure, and social protection expenditure. The paper used structural equation modeling (SEM) and cluster analysis to analyze the complex interplay among these variables.

**Results:** Findings revealed a strong positive correlation between EU countries' social protection expenditure and healthcare status. Higher social protection spending was associated with improved access to healthcare services and facilities. Moreover, the analysis showed that countries with higher social protection expenditure tended to exhibit better overall health status indicators among their populations.

**Discussion:** The results suggest that adequate social protection expenditure positively influences health status in the European Union. By investing in robust social protection programs, governments can enhance citizens' access to healthcare services and resources, ultimately leading to improved health outcomes. These findings underscore the importance of prioritizing social protection policies to address health disparities and promote public health in the EU.

## KEYWORDS

healthcare, health status, healthcare expenditure, social protection, social protection expenditure

## Introduction

Health status is a fundamental indicator of a society's well-being and development. In the European Union (EU) context, promoting and maintaining good health among its citizens is a top priority for ensuring a prosperous and equitable future. Social protection measures have long been recognized as crucial in safeguarding individuals and communities from various risks, including health-related risks. These protective mechanisms, from health insurance schemes to social assistance programs, are pivotal in supporting vulnerable populations and enhancing access to essential healthcare services.

The current state of healthcare and social protection in the European Union (EU) is heavily influenced by the overarching goal of promoting the well-being and development of its citizens. With a focus on ensuring prosperous and equitable futures, EU member states prioritize measures that support good health and provide social protection against various

risks, including those related to health. However, these systems face significant challenges, particularly in light of factors such as population aging, financial crises, and the COVID-19 pandemic. These pressures highlight the need for modernization to improve efficiency in resource allocation, both financial and human, within healthcare systems.

Improving the efficiency of financial and human resource allocation to healthcare systems within the European Union represents a priority for European social protection and healthcare strategies. The health of the European population is monitored through indicators such as population health improvement concerning the quality of healthcare services, attracting and retaining specialists in the medical system, or enhancing the quality of life in connection with new treatments and medical protocols in the field (1). The fragmentation of the healthcare system and inadequate social protection, as observed in the American system, may generate challenges to the population's health, which can rapidly deteriorate during pandemics, as seen in 2020 during the COVID-19 pandemic (2). The relationship between social protection and health status has become a subject of increasing interest among policymakers, researchers, and public health experts. Understanding how social protection influences health outcomes in the EU is vital for developing effective and targeted policies to address health disparities and foster better health for all citizens.

Recognizing the crucial link between social protection and health outcomes, policymakers, researchers, and public health experts are increasingly interested in understanding how social protection initiatives impact the health of EU citizens. This understanding is essential for the development of targeted policies aimed at addressing health disparities and promoting better health outcomes for all.

The research gap that the study aims to address within the broader context of healthcare and social protection in the European Union is the need for a comprehensive understanding of the intricate connections between social protection initiatives and health indicators. While it is widely recognized that social protection plays a vital role in promoting better health outcomes and mitigating health disparities, there is still a lack of in-depth analysis regarding the specific mechanisms through which these programs contribute to improved health status among EU residents.

The paper seeks to provide evidence-based insights into the significant role of social protection in shaping health outcomes within the EU context to address this gap. We aim to fill this gap by employing a comprehensive approach that combines robust data analysis with relevant theoretical frameworks. Through empirical study, we aim to identify and elucidate the pathways through which social protection measures influence various health indicators, such as access to healthcare services, health behaviors, and health outcomes. Furthermore, the paper aims to make several significant contributions to the existing body of knowledge on healthcare and social protection within the European Union.

The COVID-19 pandemic has highlighted the critical importance of robust healthcare systems and comprehensive social protection measures in safeguarding the well-being of EU citizens. The pandemic has exposed vulnerabilities in healthcare infrastructures and exacerbated existing health disparities (3), underscoring the urgent need for effective policies that address these shortcomings (4). This study contributes to ongoing efforts to strengthen healthcare and social protection systems within the European Union, providing valuable insights that are particularly relevant in light of recent events like the COVID-19 pandemic.

The paper's structure is as follows: after reviewing the existing literature, the paper exposes the methodological framework. The results of this study are expected to offer evidence-based insights into the significant role of social protection in shaping health outcomes in the EU. The discussions will contribute to a deeper understanding of the complex dynamics between social protection and health status. The conclusions encapsulate the findings of the paper.

## Literature review

The World Health Organization (WHO) defines public health as “the organized efforts of society to promote, protect, improve, and restore the health of individuals, specified groups, or the entire population” (5). Essentially, public health is a comprehensive and integrated approach that aims to improve the health status of the entire population by promoting a healthy environment, preventing diseases, and promptly addressing existing health issues.

The efficiency of healthcare services has been the subject of extensive debates and concerns in health economics in recent years (6). This action involves providing accessible and patient-centered medical care by allocating limited healthcare resources and rejecting certain potentially beneficial programs or treatments for specific individuals. It is a suitable practice to ensure a rational, equitable, and cost-effective allocation of healthcare resources (6). Rising healthcare costs and demands have placed considerable pressure on health authorities to develop effective strategies for resource allocation. Efficient healthcare services require identifying mechanisms for cost-effectively allocating limited resources and ensuring maximum benefits for patient populations (6–9).

The economic perspective regarding healthcare systems becomes increasingly important, considering the escalating costs and growing burden of diseases (10–12). In this context, optimizing these systems becomes crucial to ensure optimal utilization of limited resources and providing quality services at sustainable costs. Economic evaluation plays a vital role in the decision-making process for healthcare organizations and practitioners, providing valuable information regarding the impact and effectiveness of various policies and programs (6).

Despite the importance of these economic evaluations, a decline in healthcare resources remains a significant challenge, particularly in low-income countries or during periods of economic recession and public spending cuts (11, 13–16). The COVID-19 pandemic has further amplified the pressure on limited healthcare resources, presenting health systems with new challenges. In these challenging circumstances, adopting efficient policies and measures based on rigorous economic evaluations becomes even more critical to ensure effective resource management and adequate population protection.

Various authors (17–20) have addressed structuring public health financial allocations in studies conducted within European countries. In Eastern Europe, Cacace (19) observes a need to improve financial allocations for health systems, given the growing receipts for general social insurance. Abor and Abor (21) and Béland et al. (22) recommend budgetary rebalancing measures, increased collection rates, and efficient utilization of allocated financial resources in the healthcare system. Kwon and Kim (23) believe that enhancing the resilience and sustainability of the healthcare system is necessary through strategies targeting disease prevention and control, health

monitoring, and efficient population information through the digitization of administrative and medical systems.

Healthcare allocations differ based on economic performance, contributing to poor performance when the healthcare system is underfunded (24–26). A proactive policy in healthcare funding is necessary, as a healthy population leads to more robust economic growth and requires fewer social protection services.

At the same time, research in health economics continues to play a vital role in addressing issues of accessibility and equity in healthcare delivery. Academic works in this field explore ways to streamline expenses, identify more cost-effective medical practices, and prioritize medical services for vulnerable groups (10–12). Research can contribute to shaping appropriate policies and strategies to address healthcare system challenges while ensuring universal access to essential medical services.

The European Union (EU) places significant attention on the implications of its policies on public health and social security to ensure equal access to high-quality and affordable medical and social services. The EU supports member states in achieving common objectives and promotes cooperation among countries to address common challenges (27). In health policies, the EU focuses on strategic objectives, including promoting good health, protecting citizens from cross-border health threats, supporting dynamic healthcare systems, and facilitating better access to medical services for EU citizens. However, various challenges remain, such as addressing the specific health needs of an aging population, adapting to demographic changes, reducing avoidable diseases, and tackling emerging health issues such as antimicrobial resistance.

Social protection services, including social assistance, are considered by Yokobori et al. (28) to play an essential role in improving access to healthcare services among vulnerable populations. Multiple systematic analyses have demonstrated the positive impact of social insurance on health. For example, social protection and social insurance provision have been associated with improved maternal and child health service utilization (28–30). Spaan et al. (31) identify positive effects on health resulting from improvements in the health insurance system. However, Acharya et al. (32) found that improving the health insurance system did not significantly improve health for vulnerable groups, only benefiting the overall population. Sustainable and well-managed social programs can improve individual health and contribute to overall public health by creating a favorable health development and maintenance environment. These findings have significant practical and managerial implications (28). Integrating public health perspectives into developing and implementing social policies can create more comprehensive and targeted approaches to improving population health (27).

Based on previous research findings, we have formulated the first hypothesis of the research: Hypothesis H1. Social protection expenditure positively influences health status, alongside healthcare expenditure, within the European Union countries.

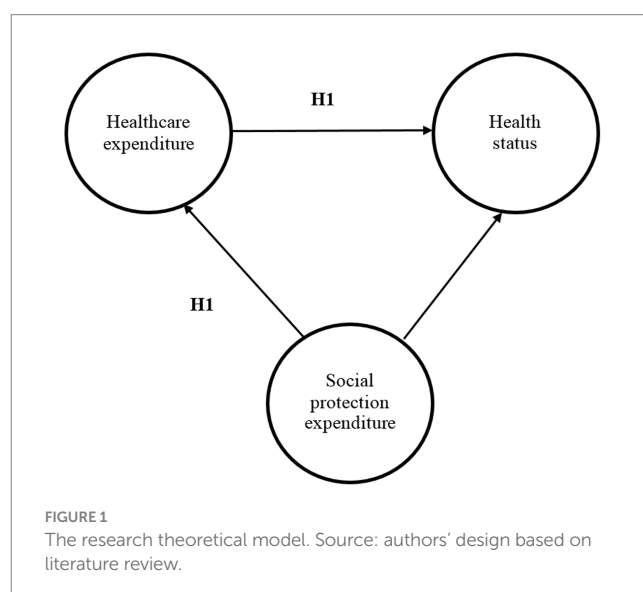
Numerous studies have highlighted the positive association between social protection expenditure and health outcomes (24–29). Social protection programs, such as universal healthcare coverage, income support, and social welfare initiatives, are designed to mitigate socio-economic disparities and provide individuals with access to essential healthcare services and resources (33–37). Ensuring equitable access to healthcare and addressing social determinants of health, social protection expenditure is expected to impact health status

positively, leading to improved overall well-being and reduced morbidity and mortality rates (28).

Moreover, the synergy between social protection expenditure and healthcare expenditure is essential to achieve optimal health outcomes. While healthcare expenditure directly contributes to the provision of medical services and treatments, social protection expenditure complements these efforts by addressing broader social determinants of health, such as poverty, education, and housing (38–40). By investing in both healthcare infrastructure and social protection programs, countries can create a supportive environment conducive to better health outcomes for their populations (19, 20). The research gap lies in the need for a comprehensive understanding of the intricate connections between social protection initiatives and health indicators.

Figure 1 presents the theoretical model of the research. The proposed framework elucidates the interplay between social protection policies, healthcare spending, and population health outcomes, highlighting the complex relationships and pathways through which these factors interact. At its core, the conceptual framework is grounded in the recognition of the pivotal role that social protection mechanisms play in promoting health and well-being. Social protection expenditure encompasses a range of policies and programs aimed at addressing socio-economic inequalities, ensuring access to essential services, and mitigating the impact of adverse social determinants on health. In tandem with social protection expenditure, healthcare expenditure represents a critical determinant of population health outcomes. Healthcare expenditure encompasses the financial resources allocated toward healthcare infrastructure, medical services, and public health initiatives. Healthcare systems and services investments aim to improve access to quality healthcare, enhance preventive measures, and address the burden of disease, ultimately contributing to better health outcomes among the population.

The conceptual framework postulates that social protection expenditure and healthcare expenditure are complementary and synergistic in their effects on health status. Social protection policies create an enabling environment conducive to better health outcomes. Healthcare expenditure, on the other hand, directly impacts access to



medical services, treatments, and preventive care, thereby influencing individual and population health.

Within the European Union, the healthcare system is closely correlated with the social protection system to ensure access to healthcare services for vulnerable populations (41). This interconnectedness is fundamental in addressing health inequalities and ensuring that no person is left behind due to financial resources or other social constraints. Numerous academic papers emphasize the importance of extensive social protection services, including social assistance, during the COVID-19 pandemic (3, 4, 42). In this pandemic, vulnerable populations have been more exposed to health and social risks, and social protection services have proved essential in providing the necessary support to overcome difficulties and challenges.

The European Union has implemented collaborative strategies and programs that respond to common challenges in social protection and health (43). The healthcare domain can play an essential role in increasing the active working population and, therefore, can promote social inclusion and combat poverty (44). Various authors bring essential aspects of the link between social protection and public health to the forefront, emphasizing the positive impact of sustained well-being through significant social protection measures on the population's overall health status (45–47). Researchers have identified that expanding and strengthening social protection systems can benefit public health, with countries having robust social protection programs showing better outcomes in this area (47–50).

McCartney et al. (50) and Ullah and Harrigan (47) have highlighted several relevant aspects regarding the influence of social protection on public health. These studies have shown that well-designed social policies, such as health insurance, social assistance, pensions, or support for people with disabilities, positively impact population health. Social protection can reduce health inequalities and improve health indicators for the entire population by ensuring access to quality medical services and adequate financial support.

Academic literature (1, 6) signals financial allocations for healthcare and social protection services imbalances. Social protection must include easy and free access to healthcare services for vulnerable populations exposed to poverty and aging to promote equitable healthcare access. Better health for vulnerable categories and prolonged active life improve the quality of life and reduce social protection expenses.

Structural reforms in social protection systems and investments in healthcare must go hand in hand to achieve public policy objectives and ensure universal access to quality medical care. Health investments are crucial to ensuring a healthy and equitable society within the European Union. A more efficient healthcare system can be achieved through responsible resource management and the implementation of appropriate reforms capable of meeting present challenges and addressing the health needs of EU citizens (43).

Based on previous research findings, we have formulated the second hypothesis of the research: Hypothesis H2. EU countries can be grouped into homogeneous clusters based on health status, healthcare expenditure, and social protection expenditure. This hypothesis is rooted in the recognition of inherent variations among EU member states regarding their healthcare systems, social protection policies, and health outcomes.

Numerous empirical studies have demonstrated the existence of distinct patterns and similarities among countries in terms of health

status, healthcare expenditure, and social protection expenditure (17–19, 24–26). These variations can be attributed to diverse socio-economic, political, and cultural factors that shape the healthcare landscape and social welfare policies across different EU nations. Furthermore, understanding the heterogeneity among EU countries is crucial for informing evidence-based policymaking and facilitating knowledge exchange and collaboration among member states. Homogeneous clusters provide insights into best practices implemented by countries with comparable profiles, thereby promoting mutual learning and fostering innovation in healthcare and social protection policies.

Efforts to improve healthcare and social protection systems must be integrated and coherent to ensure the health and well-being of all citizens. In this regard, collaboration among decision-makers, healthcare and social assistance experts, and representatives from civil society is essential to identify the most efficient and sustainable solutions (26). Social protection and access to healthcare are interdependent and play a crucial role in ensuring an equitable and inclusive healthcare system for all citizens.

## Materials and methods

This research investigates the relationship between social protection and health status in European Union countries. To achieve this objective, we collected data from Eurostat on health status, healthcare expenditures, medical resources, and social protection expenditures in 2020 for EU member states. Table 1 presents the research variables. Eurostat provides comprehensive and reliable data on various socio-economic indicators for EU member states. The indicators selected align closely with the research objectives, which aim to examine the relationship between social protection, healthcare expenditures, and health outcomes within the European Union. By using data from Eurostat and other official sources, we can effectively address the research objectives and generate evidence-based insights.

This study used Structural Equation Modeling (SEM) and cluster analysis to examine the complex interaction between these variables. SEM allows examining social protection expenditures' direct and indirect effects on health status while controlling for potential confounding factors. This methodological approach is suitable for investigating the complex relationships and interdependencies between social protection and health status in the

TABLE 1 Selected variables.

Variable	Dataset	Measure
HS1	Share of people with good or very good perceived health by sex	Percentage
HS2	Healthy life years at age 65 by sex	Year
HE1	Total healthcare expenditure	Euro per inhabitant
HE2	Total healthcare expenditure	Percentage of gross domestic product (GDP)
SPE1	Total expenditure	Euro per inhabitant
SPE2	Social protection benefits	Net social protection as a percentage of GDP

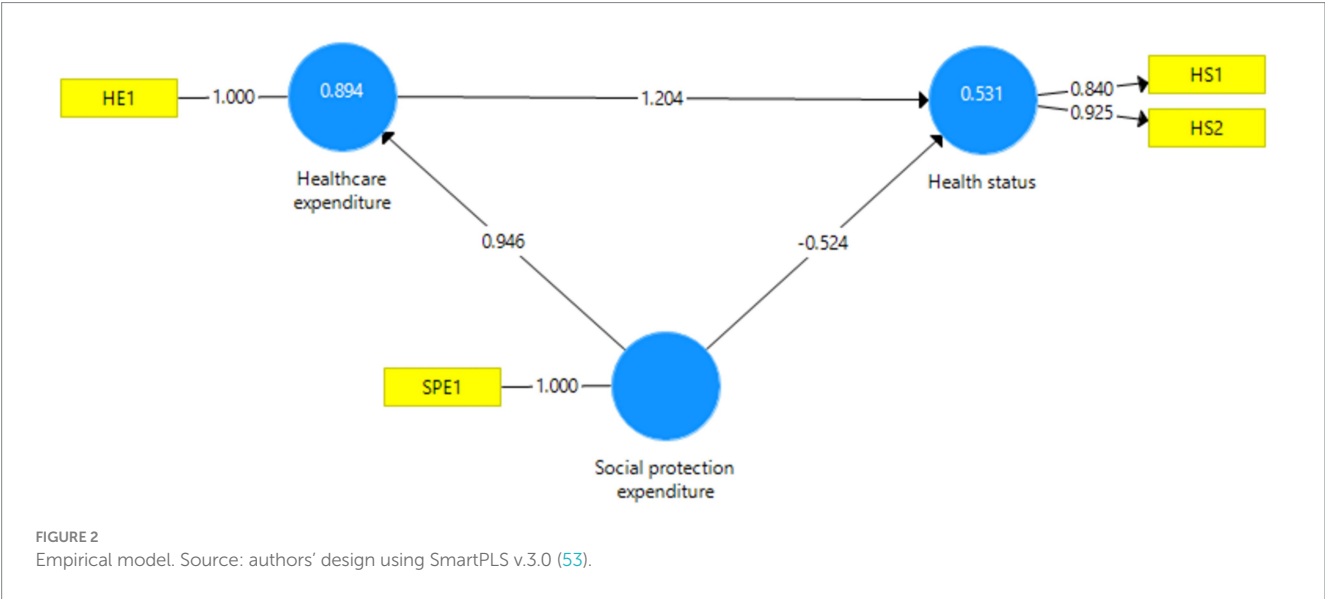
Source: authors' design based on collected data from Eurostat.



TABLE 2 Descriptive statistics.

	N	Minimum	Maximum	Mean	Std. deviation	Skewness	Kurtosis
HS1	27	44.30	83.70	68.1296	9.41140	−0.868	0.537
HS2	27	4.40	15.90	9.0444	2.73163	0.252	0.041
HE1	27	712.57	5875.34	2858.4474	1790.67771	0.423	−1.470
HE2	27	5.77	12.82	9.1744	1.94804	0.019	−1.089
SPE1	27	1661.23	24823.13	8310.2726	5922.09617	0.967	0.475
SPE2	27	14.16	33.09	23.1756	4.91408	0.065	−0.935

Source: authors' design based on collected data from Eurostat.



context of diverse countries in the European Union. Furthermore, SEM offers several distinct advantages over alternative methods. Traditional regression analysis, for instance, may struggle to capture the complex interdependencies inherent in social protection systems and their impact on health outcomes (51). Additionally, while econometric techniques such as panel data analysis can account for temporal dynamics, they may not adequately capture the intricate causal pathways and feedback loops characteristic of social protection and health interactions. SEM, on the other hand, provides a flexible and robust framework for modeling such complex relationships, making it an ideal choice for this study's analytical needs (52).

Cluster analysis will enable the identification of groups of countries with similar characteristics regarding social protection, healthcare expenditures, and health status. This analysis will provide a deeper insight into the existing variations among EU member states and help us understand how specific factors can influence the relationship between social protection and population health.

In conjunction with SEM, cluster analysis is employed further to enrich the understanding of the heterogeneity among EU member states in terms of social protection, healthcare expenditures, and health status. By identifying distinct clusters of countries with similar characteristics, this analysis facilitates the identification of patterns that may not be immediately apparent through traditional statistical methods. Moreover, cluster analysis complements SEM by providing a visual and intuitive representation of the underlying structures

within the data, thus enhancing the interpretability and applicability of the findings.

The integration of SEM and cluster analysis within the methodological framework of this study allows for a comprehensive and nuanced exploration of the complex relationships between social protection and health status in the European Union. By leveraging the strengths of these analytical techniques, the paper aims to uncover novel insights that can inform evidence-based policymaking and contribute to the enhancement of public health and social welfare across the region.

### Results

Investigating hypothesis H1 involved using Partial Least Squares Structural Equation Modeling. The software utilized for hypothesis testing was SmartPLS v3.0. The theoretical model was tested, with each latent variable having two observable variables: health status (HS1 and HS2), healthcare expenditure (HE1 and HE2), and social protection expenditure (SPE1 and SPE2). The obtained model showed SRMR 0.148 and NFI 0.357, as well as high reliability. The descriptive statistics are presented in Table 2. To enhance model reliability and validity, we removed the observable variables reported to GDP (HE1 and SPE2), which affected the relationship between latent variables, as recommended by Hair et al. (3). The resulting valid model is illustrated in Figure 2.



TABLE 3 Discriminant validity.

	Health status	Healthcare expenditure	Social protection expenditure
Health status	0.884		
Healthcare expenditure	0.709	1	
Social protection expenditure	0.615	0.946	1

Source: authors' design using SmartPLS v.3.0.

TABLE 4 Specific indirect and total effects.

	Original sample	Sample mean	Standard deviation	T statistics	p values
Social protection expenditure -> Healthcare expenditure -> Health status	1.139	1.179	0.467	2.437	0.015
Healthcare expenditure -> Health status	1.204	1.237	0.48	2.508	0.012
Social protection expenditure -> Health status	0.615	0.632	0.076	8.077	0.000
Social protection expenditure -> Healthcare expenditure	0.946	0.953	0.019	49.483	0.000

Source: authors' design using SmartPLS v.3.0.

The model exhibits good fit indices (SRMR 0.075 and NFI 0.904). The reliability of the latent variable, health status, characterized by two observable variables, is excellent (Cronbach's Alpha 0.727; Composite Reliability 0.877; Average Variance Extracted 0.781). The model's discriminant validity is also excellent, as depicted in Table 3 using the Fornell–Larcker criterion (4).

Using a bootstrapping procedure, we obtained path coefficients within the model, illustrating direct and indirect relationships between latent variables. Table 4 presents the total and indirect effects recorded between latent variables.

The relationships from Table 4 confirm the validity of hypothesis H1. Social protection expenditures significantly positively influence health status, but healthcare expenditure mediated this influence. Social protection is typically associated with substantial vulnerable groups with poor health status (8–10), which results in a negative direct relationship between social protection expenditure and health status. Social protection should be directed towards health-related expenditures to involve more individuals in the active working population.

To explore hypothesis H2, we conducted cluster analysis using the method of within-groups average linkage with a squared Euclidean distance interval. The resulting dendrogram, depicted in Figure 3, illustrates the clustering of countries into homogeneous groups.

The first cluster comprises countries characterized by high values across the selected research variables (Table 5). Notably, Ireland stands out with the highest percentage of individuals reporting good or excellent health status, at 83.7%, followed by several other countries such as Austria, Netherlands, Sweden, and Belgium, all with percentages exceeding 70%. Additionally, Sweden leads in the number of healthy years for individuals aged 65, with 15.9 years, followed closely by Ireland and Germany. In terms of healthcare expenditures, Luxembourg tops the list with total expenditures of 5,875.34 euros per inhabitant, followed by Denmark, the Netherlands, Ireland, and Germany. Surprisingly, countries with the highest healthcare expenditures, such as Luxembourg, Denmark, and the Netherlands, do not necessarily have the highest percentages of individuals reporting good health, indicating a lack of direct correlation between healthcare spending and health outcomes. However, there appears to be a positive association between higher social protection and

healthcare expenditures and healthier populations, as reflected in higher GDP *per capita*.

On the other hand, the second cluster comprises countries with lower values across the selected research variables (Table 6). For instance, Lithuania reports the lowest percentage of individuals with a good or excellent perception of health, at 44.3%, compared to Greece with 78.6%. The number of healthy years at age 65 is also lower in this cluster, with a mean of 7.8 years compared to the EU average of 9.0 years. Moreover, total healthcare expenditures in this cluster are significantly lower than the EU average, ranging from 712.57 euros per inhabitant in Romania to 2689.82 euros per inhabitant in Italy. Similarly, social protection expenditures are lower in this cluster compared to the EU mean, with Croatia reporting the lowest value and Italy the highest.

Overall, the clustering analysis reveals substantial disparities among EU countries in terms of population health status, healthcare expenditures, and social protection levels. While each country faces challenges in providing sustainable healthcare and social protection systems, those investing more in these sectors tend to have better population health outcomes. In conclusion, hypothesis H2 is supported, as EU countries can indeed be grouped into homogeneous clusters based on health status, healthcare expenditure, and social protection expenditure.

## Discussion

The paper's findings are broadly consistent with prior studies that emphasize the solid link between social protection and public health within the European Union. Like the previous studies cited (47, 50), our research also suggests that improving well-being through social protection measures can positively impact the quality of life and overall health of EU citizens. This alignment underscores the importance of understanding and leveraging these connections to inform the development of policies aimed at promoting a healthier and more equitable society within the EU. Health investments are essential for the European Union in addressing the challenges identified in its health strategy, especially considering the accentuated impact of the economic crisis. The EU faces critical factors, such as an

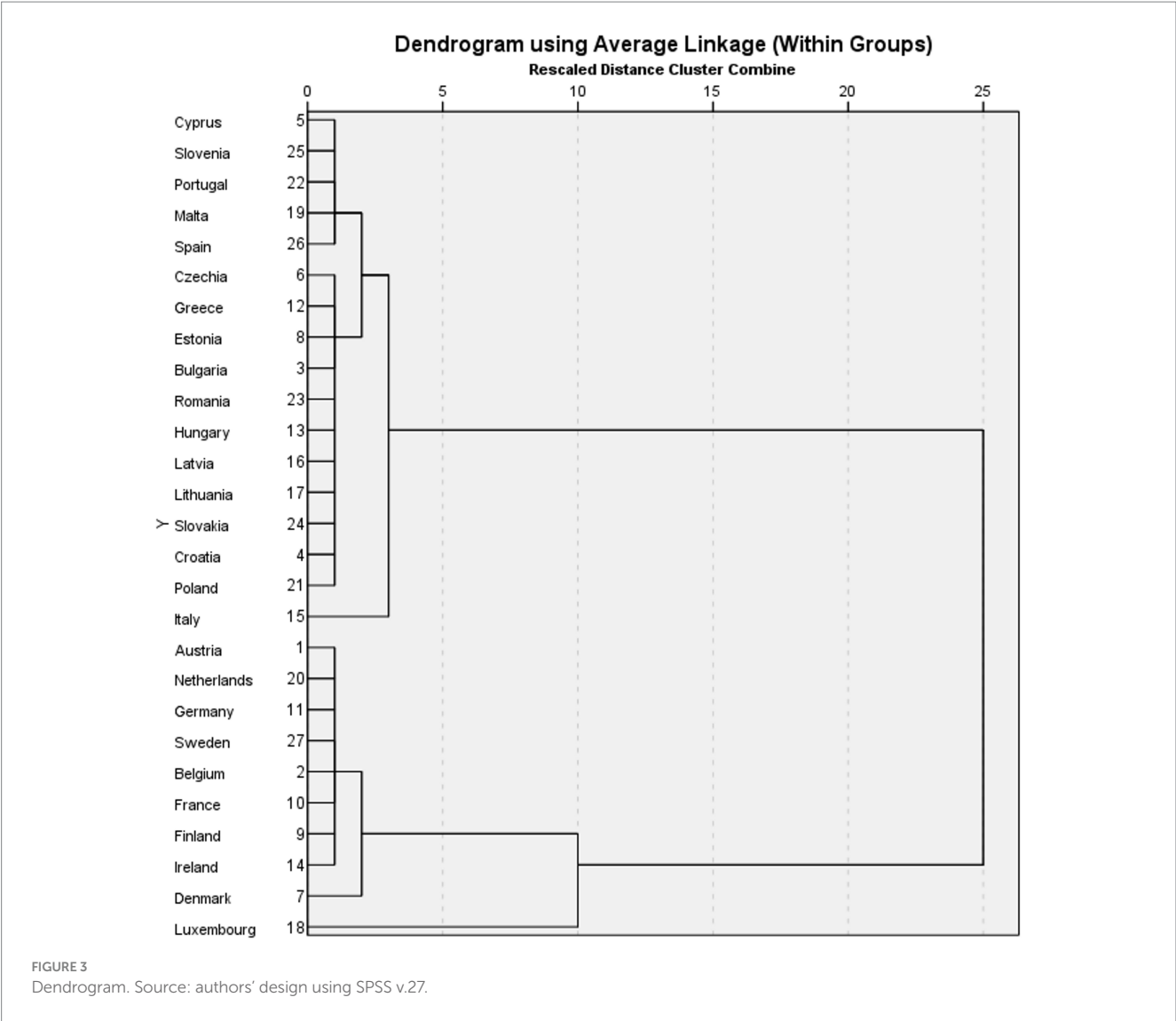


TABLE 5 Cluster 1.

	HS1	HS2	HE1	HE2	SPE1	SPE2
Austria	74.0	8.1	4865.28	11.39	14511.96	29.97
Netherlands	77.9	9.9	5108.39	11.14	14973.43	23.94
Germany	63.9	11.1	5192.41	12.82	13509.79	28.74
Sweden	76.5	15.9	5260.21	11.33	13597.06	25.46
Belgium	75.4	10.8	4462.34	11.20	13021.27	28.98
France	68.4	11.1	4159.55	12.16	13034.78	33.09
Finland	70.0	9.9	4137.71	9.61	13724.60	27.89
Ireland	83.7	11.9	5311.33	7.10	11606.48	14.16
Denmark	71.3	11.2	5642.26	10.53	17585.71	26.82
Luxembourg	73.6	10.9	5875.34	5.77	24823.13	21.49
Cluster means	73.5	11.1	5001.5	10.3	15038.8	26.1
UE mean	68.1	9.0	2858.4	9.2	8310.3	23.2

Source: authors' design using SPSS v.27.

TABLE 6 Cluster 2.

	HS1	HS2	HE1	HE2	SPE1	SPE2
Cyprus	77.5	7.3	2063.70	8.41	5923.02	22.48
Slovenia	67.2	10.3	2109.68	9.45	5824.37	25.11
Portugal	51.3	7.7	2049.89	10.55	5354.66	24.62
Malta	75.7	12.8	2747.22	10.84	5090.18	19.25
Spain	73.0	11.6	2537.76	10.71	7089.21	27.57
Czechia	63.4	7.5	1859.16	9.24	4430.58	21.28
Greece	78.6	7.6	1469.31	9.51	4547.81	26.53
Estonia	58.4	7.1	1564.65	7.75	3969.42	18.27
Bulgaria	66.7	9.3	753.65	8.52	1661.23	18.18
Romania	73.0	5.9	712.57	6.27	2027.42	16.83
Hungary	62.1	7.6	1031.55	7.30	2588.09	17.67
Latvia	49.7	4.4	1154.22	7.45	2766.14	16.49
Lithuania	44.3	5.9	1335.32	7.54	3472.47	18.62
Slovakia	65.3	4.7	1219.91	7.23	3352.20	19.04
Croatia	63.7	5.0	962.91	7.77	3008.81	23.34
Poland	61.6	8.2	901.94	6.49	3292.14	21.16
Italy	73.3	10.5	2689.82	9.63	9591.40	28.76
Cluster means	65.0	7.8	1597.8	8.5	4352.3	21.5
UE mean	68.1	9.0	2858.4	9.2	8310.3	23.2

Source: authors' design using SPSS v.27.

increasing older adult population, a rising number of chronic diseases, higher demands for medical assistance, and elevated costs associated with technological advancements in healthcare (35). Achieving better value for money through appropriate reforms and investments in the healthcare system is crucial to addressing these challenges (54).

Health investments can bring significant benefits by improving the efficiency and quality of medical services without necessarily incurring higher costs (55). Through appropriate reforms and efficient resource management, more thoughtful use of healthcare funds can lead to savings and better health outcomes for the population (43).

In this paper, we aimed to investigate a hypothesis (H1) suggesting that social protection expenditure positively influences health status in EU countries, and this influence occurs through healthcare expenditure. To test this hypothesis, we employed structural equation modeling to analyze the relationships between variables and to examine whether healthcare expenses mediate the effect of social protection expenditures on health status. The results obtained from structural equation modeling support hypothesis H1. According to the research findings, we identified a significant positive correlation between healthcare expenditures and health status, confirming previous research conclusions (1, 28, 43, 56, 57) about the importance of healthcare investments in promoting a healthy population and societal well-being. We found a significant positive influence of social protection expenditures on health status mediated through healthcare expenditure. A greater allocation of resources towards social protection is frequently related to larger vulnerable groups with meager health. This fact explains the negative influence of social protection expenditures on health status in EU countries. Directing social protection expenditures towards health-related aspects improves the population's health in EU countries and consequently

reduces the future demand for social protection due to fewer vulnerable population groups. A higher allocation of resources in social protection can facilitate access to quality medical services, thereby promoting better population health. These results suggest that an integrated and balanced approach combining social protection and healthcare expenditures can improve health and well-being in the EU population.

Hypothesis H2 suggests that EU countries can be grouped into homogeneous clusters based on health status, healthcare expenditures, and social protection expenditures. To test this hypothesis, we used cluster analysis to examine relevant data from a set of European countries. The results obtained from cluster analysis largely confirm hypothesis H2. We identified distinct groups of countries with similar characteristics regarding health status, healthcare expenditures, and social protection expenditures. These clusters provide relevant insights into the health and well-being situation in various regions of the European Union.

One provoking aspect observed in the cluster analysis is the existence of groups of countries with high levels of healthcare and social protection expenditures but varying health statuses. Within the cluster analysis, we noticed that certain countries stand out due to specific characteristics that position them uniquely in the European context. For example, countries like Luxembourg and Denmark stood out for high healthcare and social protection expenditures, accompanied by relatively good health status. In contrast, countries like Bulgaria and Romania recorded low levels of expenditures, as well as health and social protection.

It is essential to mention that these conclusions are based on the data available during analysis, and the situation may evolve. However, cluster analysis offers a valuable perspective on the diversity and

similarities among EU countries regarding healthcare and social protection domains.

Health status affects work capacity, pushing entire groups towards the category of vulnerable populations with low incomes, who access social protection services more frequently (58). Investing in social protection services alone is insufficient to protect populations from poverty. The paper advocates for effective investments in healthcare and social protection systems to combat poverty and social exclusion. Improving the population's health level strengthens employability, drawing more individuals out of vulnerable segments and breaking the vicious cycle of poor health, poverty, and social exclusion (43).

Regarding social security policy, the EU complements the activities of member states by encouraging cooperation and sharing best practices (27). It recognizes the importance of adequate social protection for vulnerable groups and self-employed individuals in atypical work conditions. Cross-border workers and greater labor mobility require consolidated cooperation to prevent unfair social competition and ensure fair working conditions. The EU's focus on health and social policies aims to promote a healthier and more inclusive society while recognizing the diversity and autonomy of the national social security system (27).

Consistent with prior studies, our research highlights the importance of social protection measures in enhancing the well-being and overall health of EU citizens. Furthermore, the study supports the assertion that health investments are essential for addressing the challenges outlined in the EU's health strategy, particularly considering the impact of economic crises and demographic shifts.

## Theoretical implications

By examining various aspects of social protection, this study aims to highlight how these policies can improve health outcomes and the overall well-being of EU citizens. Adequate social protection can provide financial support and assistance to individuals, enabling them to afford essential medical services and treatments. This fact could lead to earlier detection and better management of diseases, as well as reduce health disparities among different socio-economic groups.

Social protection policies can act as a buffer against economic instability and social determinants of health. Unexpected economic events can negatively impact health, as individuals facing financial stress may neglect their well-being. Social protection programs, such as unemployment benefits or housing support, can provide a safety net during difficult times, reducing the potential negative impact on health outcomes. By targeting vulnerable populations and providing adequate resources, social protection measures can contribute to narrowing health disparities among different social categories, fostering a more inclusive and healthier society overall.

The paper emphasizes the importance of robust social protection policies in promoting better health outcomes and improving the well-being of individuals in the EU. By understanding these potential connections, decision-makers can work towards developing more effective social protection strategies that positively impact public health throughout the region.

However, special attention must be given to understanding the complexity and specificities of each national healthcare system. Solutions are not universally applicable and must be tailored to each country's needs and population. In this regard, the exchange of best

practices and international collaboration between health economists and decision-makers can be a valuable tool to identify the best approaches and policies to ensure sustainable and efficient healthcare services for all citizens.

## Practical and managerial implications

Through this study, decision-makers have the potential to improve specific policies and interventions to ensure better health and well-being for EU citizens. Social and healthcare policies and programs can be adapted to provide specific support to vulnerable groups, improving access to medical and social services and reducing health disparities among different population strata. From a managerial perspective, the paper offers valuable information for the optimal allocation of financial and human resources. Identifying the connections between social protection and adopting healthy behaviors can guide the development of interventions to encourage healthy habits and prevent disease onset. The paper serves as an essential source of information for decision-makers in the social and medical domains. It provides a complex perspective on the interactions between social protection and health for EU citizens.

This comprehensive understanding can catalyze policy changes that prioritize the most vulnerable populations, ensuring their access to essential services and resources. By integrating these findings into policy formulation, decision-makers can foster a more inclusive and equitable society where health outcomes are not predetermined by socio-economic status or other factors. Public health practitioners can leverage these insights to design targeted interventions that address the specific needs of marginalized communities, thereby fostering healthier behaviors and reducing the burden of preventable diseases. Moreover, by aligning social protection mechanisms with health promotion efforts, policymakers can create synergies that amplify the impact of interventions and promote sustainable improvements in population health. In essence, this research provides a roadmap for policymakers and practitioners to collaborate effectively in addressing the complex interplay between social factors and health outcomes, ultimately leading to a healthier and more resilient EU population.

## Limitations and future research

Although the study contributes to understanding the relationships between social protection and population health in the EU, it also presents certain limitations. A significant limitation may be connected to measuring social protection and health. Both notions are multifaceted and can be influenced by many factors, including socio-economic and cultural settings. Thus, describing and adequately quantifying these variables can pose methodological challenges.

Longitudinal studies could provide a more comprehensive perspective on the evolution of this relationship over time. Additionally, future research could explore and analyze in more detail the intermediary or mediating factors underlying the connections between social protection and health. Understanding the precise mechanisms through which social protection influences health can provide valuable information for developing appropriate policies and interventions.

Moreover, it is essential to mention that the specific context of the European Union and other regional particularities can influence the data and results obtained in this study. Therefore, it is necessary to continue research and analysis in this field to gain a more complex and detailed perspective on the relationships between social protection expenditures, healthcare expenditures, and health status in EU countries.

## Conclusion

The study presents compelling evidence of the significant association between social protection measures and improved health outcomes among EU member states. Notably, higher levels of social protection expenditure correlate with decreased mortality rates, increased life expectancy, and improved access to healthcare resources, emphasizing the crucial role of robust social protection programs in promoting better health among EU residents.

Utilizing structural equation modeling (SEM) provides a sophisticated approach to exploring the intricate relationship between social protection initiatives and health status while considering potential confounding factors. This methodological advancement enhances the understanding of how social protection influences health outcomes in the EU, offering valuable insights for policy formulation and intervention design.

The research underscores the imperative of prioritizing and investing in social protection policies to enhance overall public health in the European Union. Cohesive and well-designed social protection measures are vital for improving individual health, fostering social cohesion, and reducing health disparities across diverse population segments. Strategic resource allocation and policy alignment with citizens' health needs are essential for fostering a healthier and more equitable society.

Future research should continue to explore various social, economic, and cultural factors influencing this dynamic interaction, recognizing the complexity of the relationship between social protection and health status. As the EU faces ongoing health challenges and societal risks, sustained efforts to design and implement inclusive social protection measures are crucial for fostering healthier and more prosperous communities throughout the region. Embracing evidence-based policy interventions is paramount for the EU to reaffirm its commitment to enhancing the health and quality of life of its diverse population. Moreover, further research is needed to delve deeper into understanding how social protection contributes to better health outcomes, considering additional factors such as socio-economic determinants and cultural influences.

## References

1. Antohi VM, Ionescu RV, Zlati ML, Mirica C, Cristache N. Approaches to health efficiency across the European space through the Lens of the health budget effort. *Int J Environ Res Public Health*. (2022) 19:3063. doi: 10.3390/ijerph19053063
2. Gaffney A, Himmelstein DU, Woolhandler S. COVID-19, and US health financing: perils and possibilities. *Int J Health Serv*. (2020) 50:396–407. doi: 10.1177/0020731420931431
3. Barron GC, Laryea-Adjei G, Vike-Freiberga V, Abubakar I, Dakkak H, Devakumar D, et al. Safeguarding people living in vulnerable conditions in the COVID-19 era through universal health coverage and social protection. *Lancet Public Health*. (2022) 7:e86–92. doi: 10.1016/S2468-2667(21)00235-8
4. Blofield M, Knaul FM, Calderón-Anyosa R, Peterman A, Franzoni JM, O'Donnell M, et al. A diagonal and social protection plus approach to meet the challenges of the COVID-19 syndemic: cash transfers and intimate partner violence interventions in

## Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

## Ethics statement

This study did not require ethical review and approval following the local legislation and institutional requirements.

## Author contributions

CB: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. AV: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Latin America. *Lancet Glob Health*. (2022) 10:e148–53. doi: 10.1016/S2214-109X(21)00444-7

5. World Health Organization. *Health promotion glossary of terms 2021*. Geneva: World Health Organization (2021). Available at: <https://ruralindiaonline.org/en/library/resource/health-promotion-glossary-of-terms-2021/> (Accessed July 15, 2023).

6. Berezowski J, Czapla M, Manulik S, Ross C. Rationing in healthcare—a scoping review. *Front Public Health*. (2023) 11:1160691. doi: 10.3389/fpubh.2023.1160691

7. Scheunemann LP, White DB. The ethics and reality of rationing in medicine. *Chest*. (2011) 140:1625–32. doi: 10.1378/chest.11-0622

8. Bhatia N. We need to talk about rationing: the need to normalize discussion about healthcare rationing in a post-COVID-19 era. *J Bioeth Inq*. (2020) 17:731–5. doi: 10.1007/s11673-020-10051-6



9. Ranabhat CL, Acharya SP, Adhikari C, Kim CB. Universal health coverage evolution, ongoing trend, and future challenge: a conceptual and historical policy review. *Front Public Health*. (2023) 11:1041459. doi: 10.3389/fpubh.2023.1041459
10. Frenk J, Moon S. Governance challenges in global health. *N Engl J Med*. (2013) 368:936–42. doi: 10.1056/NEJMr1109339
11. Kelidhar I, Mosadeghrad AM, Jafari SM. Rationing in health systems: a critical review. *Med J Islam Repub Iran*. (2017) 31:47. doi: 10.14196/mjiri.31.47
12. Yousef MH, Alhalaseh YN, Mansour R, Sultan H, Alnadi N, Maswadeh A, et al. The fair allocation of scarce medical resources: a comparative study from Jordan. *Front Med*. (2021) 7:7. doi: 10.3389/fmed.2020.603406
13. Gravelle H, Schroyen F. Optimal hospital payment rules under rationing by waiting. *J Health Econ*. (2020) 70:102277. doi: 10.1016/j.jhealeco.2019.102277
14. Moosa MR, Luyckx VA. The realities of rationing in health care. *Nat Rev Nephrol*. (2021) 17:435–6. doi: 10.1038/s41581-021-00404-8
15. Laar A, DeBruin D, Ofori-Asenso R, Laar ME, Redman B, Caplan A. Rationing health and social goods during pandemics: guidance for Ghanaian decision makers. *Clin Ethics*. (2021) 16:165–70. doi: 10.1177/147750920977095
16. Almesned S, Alakhfash AA, Almesned FS, Almesned A. Healthcare rationing and economic evaluation in health care. *J Environ Sci Public Health*. (2021) 5:536–43. doi: 10.26502/jesph.96120149
17. Mihalache I-C, Tomaziu-Tudosia M, Apetroi FC. The Organization of Health Sector Financing in the member states of the European Union and health policies. *Traders Int Trade Acad J*. (2019) 2:185–204. Available at: <https://dergipark.org.tr/en/download/article-file/1034541> (Accessed August 22, 2023).
18. Bernd R. Funding for public health in Europe in decline? *Health Policy*. (2019) 123:21–6. doi: 10.1016/j.healthpol.2018.11.014
19. Cacace M. Case study C: transforming healthcare financing in central and eastern European countries In: E Schüring, editor. *Handbook on social protection systems*. Cheltenham, UK: Edward Elgar Publishing (2021). 79–83.
20. Wielechowski M, Grzeda L. Health care financing in the European Union countries—structure and changes. *Acta Sci Polonorum Oeconomia*. (2020) 19:71–80. doi: 10.22630/ASPE.2020.19.1.8
21. Abor PA, Abor JY. Implications of COVID-19 pandemic for health financing system in Ghana. *J Health Manag*. (2020) 22:559–69. doi: 10.1177/0972063420983096
22. Bèland D, Marchildon GP, Medrano A, Rocco P. COVID-19, federalism, and health care financing in Canada, the United States, and Mexico. *J Comp Policy Anal Res Pract*. (2021) 23:143–56. doi: 10.1080/13876988.2020.1848353
23. Kwon S, Kim E. Sustainable health financing for COVID-19 preparedness and response in Asia and the Pacific. *Asian Econ Policy Rev*. (2022) 17:140–56. doi: 10.1111/aep.12360
24. Spasova S, Terry W. *Social protection expenditure and its financing in Europe. A study of National Policies*. Brussels, Belgium: European Social Policy Network (2019).
25. Mance D, Vretenar N, Gojkovic J. Comparison of European Union public health systems. *3rd International Scientific Conference on Recent Advances in Information Technology, Tourism, Economics, Management and Agriculture – ITEMA 2019 – Bratislava, Slovakia. Sel Pap*. (2019):65–77. doi: 10.31410/ITEMA.S.P.2019.65
26. Rokicki T, Perkowska A, Ratajczak M. Differentiation in healthcare financing in EU countries. *Sustain*. (2021) 13:251. doi: 10.3390/su13010251
27. European Parliament. Health and social security (2019). Available at: [https://www.europarl.europa.eu/RegData/etudes/BRIE/2018/630272/EPRS\\_BRI\(2018\)630272\\_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2018/630272/EPRS_BRI(2018)630272_EN.pdf) (Accessed July 26, 2023).
28. Yokobori Y, Kiyohara H, Mulati N, Lwin KS, Bao TQ, Aung MN, et al. Roles of social protection to promote health service coverage among vulnerable people toward achieving universal health coverage: a literature review of international organizations. *Int J Environ Res Public Health*. (2023) 20:5754. doi: 10.3390/ijerph20095754
29. Comfort AB, Peterson LA, Hatt LE. Effect of health insurance on the use and provision of maternal health services and maternal and neonatal health outcomes: a systematic review. *J Health Popul Nutr*. (2013) 31:81–105.
30. Carter B, Roelen K, Enfield S, Avis W. *Social protection topic guide*. Birmingham, UK IDS University of Birmingham (2019). Available at: [https://opendocs.ids.ac.uk/opendocs/bitstream/handle/20.500.12413/14885/Social\\_Protection\\_Topic\\_Guide\\_online.pdf?sequence=1&isAllowed=y](https://opendocs.ids.ac.uk/opendocs/bitstream/handle/20.500.12413/14885/Social_Protection_Topic_Guide_online.pdf?sequence=1&isAllowed=y) (Accessed August 19, 2023).
31. Spaan E, Mathijssen J, Tromp N, McBain F, Have AT, Baltussen R. The impact of health insurance in Africa and Asia: a systematic review. *Bull World Health Organ*. (2012) 90:685–92. doi: 10.2471/BLT.12.102301
32. Acharya A, Vellakkal S, Taylor F, Masset E, Satija A, Burke M, et al. The impact of health insurance schemes for the informal sector in low- and middle-income countries: a systematic review. *World Bank Res Obs*. (2013) 28:236–66. doi: 10.1093/wbro/lks009
33. International Labor Organization. *Social security for all. Building social protection floors and comprehensive social security systems*. Geneva, Switzerland: ILO (2012).
34. International Labour Organization. *Social health protection: An ILO strategy towards universal access to health care*. Geneva, Switzerland: ILO (2008).
35. International Labor Organization. *Addressing the Global Health crisis: Universal health protection policies*. Geneva, Switzerland: ILO (2014).
36. International Labor Organization. *Universal social protection for human dignity, social justice and sustainable development*. Geneva, Switzerland: ILO (2019).
37. International Labor Organization. *Towards universal health coverage: Social health protection principles*. Geneva, Switzerland: ILO (2020).
38. Scheil-Adlung X. Response to health inequity: the role of social protection in reducing poverty and achieving equity. *Health Promot Int*. (2014) 29:59–67. doi: 10.1093/heapro/dau030
39. Rim JY, Tassot C. *Towards universal social protection. Lessons from the universal health coverage initiative*. Paris, France: OECD (2019).
40. Save the Children International. *Strong, integrated health and social protection systems: essential for achieving children's rights* (2022). Available at: <https://resourcecentre.savethechildren.net/pdf/Strong-integrated-social-protection-and-health-systems.pdf/> (Accessed July 15, 2023).
41. Baptista I, Marlier E, Spasova S, Peña-Casas R, Fronteddu B, Ghailani D, et al. *Social protection and inclusion policy responses to the COVID-19 crisis. An analysis of policies in 35 countries*. Luxembourg: European Social Policy Network (2021). Available at: <https://ec.europa.eu/social/BlobServlet?docId=24715&langId=en> (Accessed August 19, 2023).
42. World Health Organization; Regional Office for the Western Pacific. *Actions for consideration in the care and protection of vulnerable population groups for COVID-19*. Manila, Philippines: WPRO (2020). Available at: <https://apps.who.int/iris/bitstream/handle/10665/333043/WPR-DSE-2020-021-eng.pdf?sequence=5&isAllowed=y> (Accessed August 20, 2023).
43. Seychell M, Hackbart B. The EU health strategy—investing in health. *Public Health Rev*. (2013) 35:4. doi: 10.1007/BF03391689
44. European Commission. *Communication from the Commission. Annual Growth Survey* (2013). CO(2012)750final. Brussels (2012). Available at: <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52012DC0750> (Accessed August 17, 2023).
45. Townsend PB, Whitehead M, Davidson N. *Inequalities in health: the black report & the health divide* Penguin Books Ltd (1992). 450 p.
46. Eikemo TA, Bambra C. The welfare state: a glossary for public health. *J Epidemiol Community Health*. (2008) 62:3–6. doi: 10.1136/jech.2007.066787
47. Ullah F, Harrigan NM. A natural experiment in social security as public health measure: experiences of international students as temporary migrant workers during two Covid-19 lockdowns. *Soc Sci Med*. (2022) 313:115196. doi: 10.1016/j.socscimed.2022.115196
48. Lundberg O. Commentary: politics and public health—some conceptual considerations concerning welfare state characteristics and public health outcomes. *Int J Epidemiol*. (2008) 37:1105–8. doi: 10.1093/ije/dyn078
49. Kotakorpi K, Laamanen JPI. Welfare state and life satisfaction: evidence from public health care. *Economica*. (2010) 77:565–83. doi: 10.1111/j.1468-0335.2008.00769.x
50. McCartney G, Hearty W, Arnot J, Popham F, Cumbers A, McMaster R. Impact of political economy on population health: a systematic review of reviews. *Am J Pub Health*. (2019) 109:E1–E12. doi: 10.2105/AJPH.2019.305001
51. Hair JF, Hult GTM, Ringle CM, Sarstedt MA. *Primer on partial least squares structural equation Modeling (PLS-SEM)*. 2nd ed. Thousand Oaks, CA, USA: Sage (2017).
52. Garson D. *Partial Least Squares (PLS-SEM)*. Available at: [https://www.smartpls.com/resources/ebook\\_on\\_pls-sem.pdf](https://www.smartpls.com/resources/ebook_on_pls-sem.pdf) (Accessed February 12, 2024).
53. Ringle M, Wende S, Becker J-M. *SmartPLS 4*. Monheim am Rhein, Germany: SmartPLS. (2024). Available at: <https://www.smartpls.com>
54. Mihalache I-C, Tomaziu-Tudosia M, Apetroi FC. Economic models of financing health Services in the European Union. *EUFIREF* (2018). Available at: [https://www.researchgate.net/profile/Ionela-Corina-Chersan/publication/330193629\\_PARADIGM\\_SHIFT\\_IN\\_AUDITING\\_THE\\_EUROPEAN\\_PUBLIC\\_INTEREST\\_ENTITIES/ANNUAL\\_REPORTS/links/5c331d5fa6fcdcd6b598b494/PARADIGM\\_SHIFT-IN-AUDITING-THE-EUROPEAN-PUBLIC-INTEREST-ENTITIESANNUAL-REPORTS.pdf?page=211](https://www.researchgate.net/profile/Ionela-Corina-Chersan/publication/330193629_PARADIGM_SHIFT_IN_AUDITING_THE_EUROPEAN_PUBLIC_INTEREST_ENTITIES/ANNUAL_REPORTS/links/5c331d5fa6fcdcd6b598b494/PARADIGM_SHIFT-IN-AUDITING-THE-EUROPEAN-PUBLIC-INTEREST-ENTITIESANNUAL-REPORTS.pdf?page=211) (Accessed July 25, 2023).
55. Brendbekken A, Robberstad BNorheim OF. Public participation: healthcare rationing in the newspaper media. *BMC Health Serv Res*. (2022) 22:407. doi: 10.1186/s12913-022-07786-w
56. Zweifel P. Rationing of health care: is there an economic rationality to it? *Eur J Health Econ*. (2015) 16:797–800. doi: 10.1007/s10198-015-0689-6
57. Zechmeister-Koss I, Stanak M, Wolf S. The status of health economic evaluation within decision making in Austria. *Wien Med Wochenschr*. (2019) 169:271–83. doi: 10.1007/s10354-019-0689-8
58. Zweifel P. Rationing of healthcare services: an economic critique. *J Fam Med Dis Prev*. (2015) 1:005. doi: 10.23937/2469-5793/1510005



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# Long-term care needs and hospitalization costs with long-term care insurance: a mixed-sectional study

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**Background:** With the rapid aging of the population, the health needs of the older adult have increased significantly, resulting in the frequent occurrence of the “social hospitalization” problem, which has led to a rapid increase in hospitalization costs. This study investigates whether the “social hospitalization problem” arising from the long-term care needs can be solved through the implementation of long-term care insurance, thereby improving the overall health of the older adults and controlling the unreasonable increase in hospitalization costs.

**Methods:** The entropy theory was used as a conceptual model, based on data from the China Health and Retirement Longitudinal Study (CHARLS) in 2015 and 2018. The least-squares method was used to examine the relationship between long-term care needs and hospitalization costs, and the role that long-term care insurance implementation plays in its path of influence.

**Results:** The results of this study indicated that long-term care needs would increase hospitalization cost, which remained stable after a series of tests, such as replacing the core explanatory variables and introducing fixed effects. Through the intermediary effect test and mediated adjustment effect test, we found the action path of long-term care needs on hospitalization costs. Long-term care needs increases hospitalization costs through more hospitalizations. Long-term care insurance reduces hospitalization costs. Its specific action path makes long-term care insurance reduce hospitalization costs through a negative adjustment of the number of hospitalizations.

**Conclusion:** To achieve fair and sustainable development of long-term care insurance, the following points should be achieved: First, long-term care insurance should consider the prevention in advance and expand the scope of participation and coverage; Second, long-term care insurance should consider the control in the event and set moderate levels of treatment payments; Third, long-term care insurance should consider post-supervision and explore appropriate payment methods.

## KEYWORDS

long-term care needs, hospitalization costs, long-term care insurance, social hospitalization, long-term care services

## Introduction

In recent years, China's aging population has entered a rapid development stage. By the end of 2022, the number of older adult people aged 60 and above has reached 280.04 million, accounting for 19.8% of the national population. Health problems among older adults are becoming increasingly prominent, with more than 78% of them suffering from more than one chronic disease, and the number of older adults with disabilities is increasing (1). These factors contribute to increased demand for long-term care. China began exploring the establishment of a long-term care insurance system in 2013. In 2016, 15 cities were selected as pilot sites for the long-term care insurance system, and in 2020, an additional 14 pilot sites were added. Before the implementation of the long-term care insurance pilot, long-term care needs were often met through social hospitalization, leading to excessive growth in hospitalization costs. At the same time, with changes in family structure, the traditional family care function is gradually weakening, and the high fees and service quality of social care institutions make it impossible to effectively meet the long-term care needs of persons with disabilities. The primary purpose of the long-term care insurance fund is to cover the costs incurred by qualified institutions and personnel in providing basic care services. Differentiated treatment and guarantee policies are implemented based on the level of care required and the mode of service provision, with an emphasis on encouraging the use of home and community care services. In November 2021, the "14th Five-Year Plan Proposal" noted the need to "steadily establish a long-term care insurance system". In his report to the Communist Party of China's 20th National Congress in October 2022, Xi Jinping underlined the necessity of "establishing a long-term care insurance system". In this context, whether the long-term care insurance system pilot works requires clarification. Moreover, does this system better address the long-term care needs of persons with disabilities and reduce hospital costs?

The current scholarship is more likely to suggest that the contradiction between the increase of long-term care needs and the insufficient supply of care services has increased demand for nonmedical hospitalization (1), which may lead to the increase of hospitalization costs, but no scholars have proven this point. There is no consensus among the academic community on the role of long-term care insurance's impact on long-term care needs on hospitalization costs. Many scholars have found that the implementation of long-term care insurance can reduce hospitalization rates and stay duration (2–4), and empirical studies in China found that the implementation of long-term care insurance can effectively reduce medical expenses (5–11); some scholars also found that the implementation of the long-term care insurance system may have increased hospitalization stay duration for patients (12); others have reached different conclusions through empirical studies. By evaluating the effect of the implementation of the long-term care insurance system in Qingdao, some scholars found that the *per capita* cost only showed a short-term decrease and then a continuous increase (13). Some scholars found heterogeneity in the effects of different long-term care payment methods on cost payments, hospitalization costs, etc. (14). After an empirical study, Wang and Feng found that the home care subsidy reduced medical expenses, while the institutional care subsidy did not significantly impact medical expenses (15).

This study asks the following questions. How do long-term care needs impact hospitalization costs? What is the mechanism of this influence? What role does long-term care insurance play? This study

provides new empirical evidence to clarify these issues. To achieve this, the study explores the effect of long-term care needs for hospitalization costs based on an entropy theory perspective, and crucially, the important role played by long-term care insurance in the mechanism of its influence is worth exploring. This study provides a new theoretical framework for the study of the relationship between long-term care needs and hospitalization costs. In addition, it also provides theoretical support for the practice of long-term care insurance.

## Theoretical analysis and research hypotheses

The current research is rather fragmented, especially the lack of systematic exploration of the relationship between long-term care needs and hospitalization costs, which limits the development of long-term care insurance practice. To address the above problems and considering the complexity of long-term care service system, this paper applies entropy theory to study the relationship between long-term care needs and hospitalization costs from a game theoretical perspective, so as to enrich the relevant theoretical basis and provide reference for long-term care insurance practice. The concept of entropy, proposed by Clausius, is derived from thermodynamics. It indicates the degree of disorder in a material system; the higher the degree of disorder, the higher the entropy value. An increase in entropy can be derived from the second law of thermodynamics: in isolated systems, the system state always transitions from order to disorder, and the quantity that causes this state transition is called the entropy-increasing factor (16). However, it varies in open systems. Puligotzin introduced the concept of a negative entropy factor: for open systems, the system and the outside world for energy or material exchange will form an entropy flow, increased entropy inside the system transfers to outside the system, or the negative entropy outside the system flows into the system so that the system transforms from disorder to order to achieve a stable equilibrium. With the development of the depth and breadth of entropy theory, it has been widely applied in social science fields.

The factors influencing hospitalization costs involve several dimensions, such as individual characteristics, family structure, social insurance, and health behavior. Although hospitalization costs involves many and mixed interest groups and factors, the aspects that lead to its rapid growth can be summarized as long-term care service demanders, medical institutions, and government/social insurance institutions. All three influence each other and play important roles in the game process, and the specific relationships among the three are shown in Figure 1. The three players will have different game strategies in the game process. First, long-term care demanders want to pay less for better long-term care services, and their game strategy is to choose inpatient or nursing care facilities; second, the government/social insurance agencies are responsible for fund raising, payment and supervision, and their game strategy is to choose the way and intensity of payment; third, medical institutions aim to provide quality services and ensure the sustainable operation of medical institutions, and their game strategy is to provide appropriate or excessive medical services, and their game strategy is to provide appropriate or excessive medical services. Firstly, the system was a closed system prior to the establishment and implementation of the LTC guarantee, and the use of entropy theory as an analytical framework for this study can help us to understand and quantify the informational uncertainty and stochasticity associated with the lack of LTC guarantee. In the current care system, due to the lack of institutional

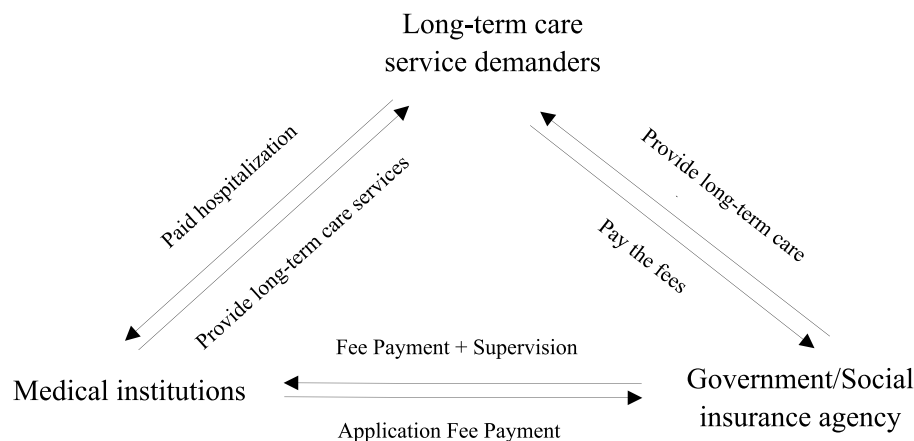


FIGURE 1  
Interaction and relationship of three actors in the long-term care service system.

support for long-term care insurance, people in need of long-term care need to purchase long-term care services from medical institutions, which leads to uncertainty and complexity in the flow of information, and is an important entropic factor that leads to an increase in the cost of hospitalization, and the resulting frequent occurrence of the phenomenon of “social hospitalization,” which leads to a sharp increase in hospitalization costs. The resulting high incidence of “social hospitalization” can lead to a sharp increase in hospitalization costs.

Therefore, the following hypothesis is proposed:

*H1: An increase in long-term care needs leads to increased hospitalization costs.*

Secondly, as pressure on the operation of the Medicare fund increased and the social problem of insufficient long-term care security arose, the long-term care insurance system emerged. With the establishment and implementation of a long-term care insurance system, government policy support and financial subsidies have promoted nursing institutions, day care service centers, and other care institutions, thus forming a long-term care service system beyond medical institutions. The system has become an open system. Entropy theory can be used to optimize decision-making and information flow in order to solve the problem of inadequate long-term care service protection. By analyzing the entropy and uncertainty of information and establishing an information-sharing and exchange platform to promote cooperation and information-sharing between care institutions and medical institutions, government/social insurance institutions and long-term care demanders, bottlenecks and problems in information transfer can be identified and solved, thereby improving the efficiency and quality of long-term care services, as shown in Figure 2. The establishment and implementation of a long-term care insurance system have two effects. On the one hand, it is believed that long-term care insurance raises the income level of its users through subsidies, which indirectly increases demand for “medical care instead of nursing care”, resulting in an entropic effect that increases hospitalization costs. On the other hand, long-term care insurance subsidizes long-term care user costs, which effectively reduces the burden of care for long-term care users and converts their demand for hospitalization into institutional care. This negative

entropy effect can, to a certain extent, alleviate the sharp increase in hospitalization costs caused by the “social hospitalization” problem.

Consequently, the total entropy change in an open long-term care service system can be expressed by the following equation:

$$dS = d_iS + d_eS$$

In equation (1), medical demand for long-term care is an irreversible entropy increase within the long-term care service system, constant with  $d_iS > 0$ ;  $d_eS$  this indicates that the long-term care needs is met by the care institutions after the long-term care insurance was established, and the long-term care service system receives a positive or negative entropy flow from the outside world. The long-term care insurance system can transform the medical needs of some long-term care users from “medical care instead of nursing care” into nursing care needs, at which time the external environment flows into the long-term care delivery system with negative entropy, which can curb the sharp increase in hospitalization costs. Thus, we propose the following hypotheses:

*H2: Long-term care insurance can negatively moderate the relationship between long-term care needs and hospitalization costs.*

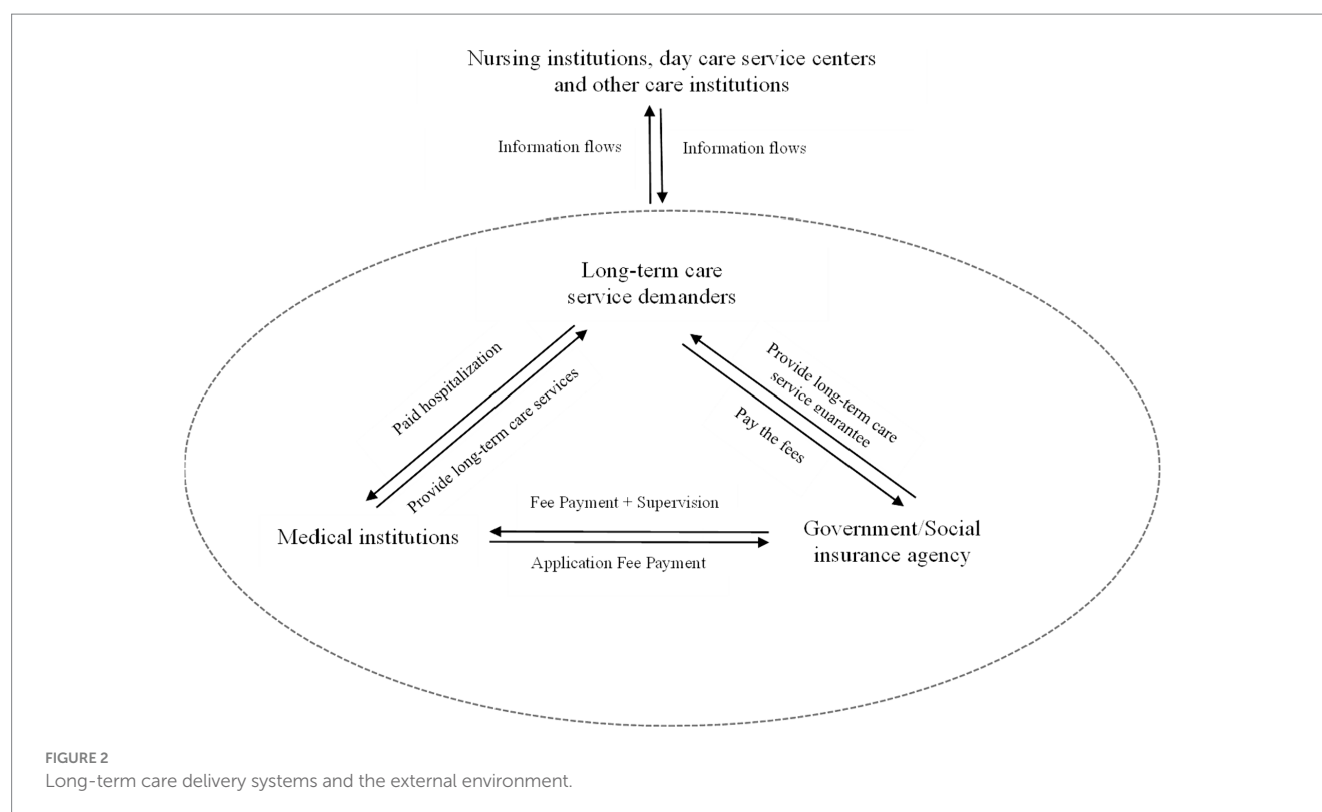
*H3: The interaction effect of long-term care needs and the long-term care insurance system impacts hospitalization costs through the mediating effect of the number of hospitalizations.*

## Data sources, variable selection, and model setting

### Data sources and processing

The China Health and Aging Tracking Survey (CHARLS) 2015 and 2018 data were used for this study because, which were obtained in 2015 and 2018 respectively, after combining them with the PSU file, it was discovered that they contained data for 12 cities from the initial set of pilot cities. As Qingdao did not meet the criteria for double





differencing because the pilot long-term care insurance system was not implemented until 2012, the final 11 pilot cities chosen for this study were Chengde, Qiqihar, Ningbo Shanghai, Shangrao, Jingmen, Chongqing, Anqing, Guangzhou, Chengdu, and Suzhou.

## Variable settings

### Explained variable

Hospitalization costs served as an explanatory variable. The question “What is the approximate total cost of hospitalization in the past year?” is the source of this variable. The total cost of hospitalization in this study was logarithmic to account for non-normality in the study methodology.

### Explanatory variables

The need for long-term care was used as an explanatory variable. Since long-term care needs statistics are scarce, and long-term care insurance in China is still in the pilot stage, proxy variables are used to represent long-term care insurance demand in China. Three factors were chosen to gauge the need for long-term care based on the applicability and dependability of the data sources: natural demand (amount of disability, number of chronic illnesses, and difficulty of living), objective demand (residence pattern), and alternative demand (supplementary and commercial medical insurance). In this study, the weights of each indicator were calculated using the entropy weighting method, which is based on the degree of variation of each indicator to determine the indicator. The specific process of the entropy method is described in the [Appendix](#). It is reasonable to use the entropy

weighting method to calculate long-term care needs because it allows a more objective representation of long-term care needs.

### Control variables

In order to reduce the influence of self-bias on the research results, this study incorporated a series of control variables. The control variables in this study contained the following aspects: (1) personal characteristics: age, sex, marriage, education level, household registration, and retirement; (2) household characteristics such as household income, number of children, and living with children; (3) social insurance characteristics, such as social health insurance and social pension insurance; and (4) health behaviors: smoking, alcohol consumption, self-medication, and medical satisfaction.

### Moderating variable

In this study, long-term care insurance served as the moderating factor. Since the long-term care insurance pilot was conducted after 2015 for the treatment group, 2015 was the pre-treatment ( $t=0$ ) and 2018 was the post-treatment ( $t=1$ ). The treatment group (treat) had a dummy variable before and after the introduction of long-term care insurance ( $t$ ). [Table 1](#) presents variable definitions and descriptive statistics.

### Mediating variable

The number of hospitalizations was the mediating variable. The enquiry “How many times have you been hospitalized in the past



TABLE 1 Variable definitions and descriptive statistics.

Variable type	Variable name	Definition	Average value	Standard deviation
Explained variables	Hospitalization costs	Hospitalization costs in the past year (in dollars)	0.174	1.264
Explanatory variables	Long-term care needs	Long-term care needs composite index	0.015	0.038
Adjustment variables	Long-term care insurance	<i>treat</i> and <i>t</i> the cross term of	0.213	0.409
Intermediate variables	Number of hospitalizations	Number of hospitalizations after taking the logarithm, in days	1.006	0.684
Personal characteristics	Age	Continuous variables of population age in years	60.507	10.587
	Sex	Female = 1; Male = 0	0.498	0.500
	Marriage	Married = 1; No = 0	0.811	0.391
	Education level	Elementary school and below = 0, middle school = 1; high school and junior college = 2; College, bachelor's degree and above = 3	0.436	0.700
	Household Registration	Urban = 1; Rural = 0	0.525	0.499
	Retirement	Retirement = 1; No = 0	0.148	0.355
Family characteristics	Household income	Annual household income after taking the logarithm (in dollars)	7.638	3.749
	Number of children	The continuous variable of the number of children in years	2.713	1.724
	Children living together	Living with children = 1; No = 0	0.295	0.456
Social insurance features	Social health insurance	Participate in social health insurance = 1; No = 0	0.976	0.155
	Social pension insurance	Participate in social pension insurance = 1; No = 0	0.657	0.475
Health behavior features	Smoking	Smoking = 1; No = 0	0.278	0.448
	Drinking	Drink = 1; No = 0	0.306	0.461
	Self-treatment	Self-treatment = 1; No = 0	0.505	0.500
	Medical satisfaction	Satisfactory = 0; fair = 1; poor = 2	0.784	0.697

year?” led to a variable number of hospitalizations. The number of days was treated logarithmically to account for non-normality in the research procedure.

## Model setting

### Baseline regression

The least squares method was employed to determine whether long-term care should result in higher inpatient expenses. The baseline regression was built as follows to evaluate Hypothesis 1.

$$HS = \alpha_0 + \alpha_1 LN + \alpha_2 X + \mu \quad (1)$$

*HS* Represents hospitalization costs; *LN* represents long-term care needs; and *X* represents the control variables, and  $\alpha_0$ ,  $\alpha_1$ , and  $\alpha_2$  are the parameters to be estimated; and  $\mu$  denotes the random error term.

### Mediating effect tests

To test Hypothesis 3, the number of hospitalizations was introduced as a mediating variable *HN*. The mediating effect model is developed as follows:

$$HN = \beta_0 + \beta_1 LN + \beta_2 X + \varepsilon_1 \quad (2)$$

$$HS = \gamma_0 + \gamma_1 LN + \gamma_2 HN + \gamma_3 X + \varepsilon_2 \quad (3)$$

In the above formula, *HN* is the mediating variable number of hospitalizations, and *X* are the control variables, the  $\beta_0$ ,  $\beta_1$ ,  $\beta_2$ ,  $\gamma_0$ ,  $\gamma_1$ ,  $\gamma_2$ , and  $\gamma_3$  are the parameters to be estimated, and  $\varepsilon_1$ ,  $\varepsilon_2$  are the random error terms. Equation (3) places both long-term care needs and the number of hospitalizations on the right-hand side of the model to study their influence on hospitalization costs. Equation (2) examines the impact of demand for long-term care on the number of hospitalizations. The following

factors must be met to determine whether the mediating impact is substantial, according to scholastic test of mediating effect (17): First, the overall impact of the equation's long-term care needs effect on hospitalization costs (1)  $\alpha$  1 The first criterion is whether there is a considerable overall impact of long-term care needs on hospitalization costs in Equation (1); Second, the impact of long-term care needs on the number of hospital admissions in Equation (2)  $\beta$  1 The third criterion concerns the significance of the relationship between the number of hospital days and hospital cost in Equation (3). Whether long-term care needs have a considerable impact on the number of hospitalizations in Equations (2, 3), and whether the impact of hospital stay duration on hospitalization costs in Equation (3).

Thus, a mediating moderating impact exists. The addition of moderating variables (LTCI), the cross term of the independent variable and the moderating variable ( $I_1$ ), and the cross term of the mediating variable and ( $I_2$ ); and the testing of research hypotheses 2 and 3. Following are the exact test procedures to determine whether the long-term care insurance system's installation has a moderating effect, which is based on research by Ye and Wen (18). The moderating effect is first tested for, then the moderating effect with mediation is tested for, and finally, the moderating effect is tested to determine if it is entirely or partially mediated. As a result, the following equation establishes a model for the moderating effect of mediation:

$$HS = c_0 + c_1LN + c_2LTCI + c_3I_1 + c_4X + e_1 \quad (4)$$

$$HN = a_0 + a_1LN + a_2LTCI + a_3I_1 + a_4X + e_2 \quad (5)$$

$$HS = c'_0 + c'_1LN + c'_2LTCI + c'_3I_1 + b_1HN + b_2I_2 + c'_4X + e_3 \quad (6)$$

In order to reduce the influence of self-bias on the research results, this study employed the technique of difference-in-differences (DID) to control potential confounding factors and biases to some extent. In the above formula,  $HS$  represents the cost of hospitalization,  $LN$  represents long-term care needs, and  $HN$  represents the number of hospitalizations, and  $LTCI$  Long-term care insurance is the year ( $t$ ) and whether long-term care insurance is in place (*treat*) interaction term, where  $LTCI = 1$  denotes the treatment group after implementation of long-term care insurance and 0 in other cases.  $I_1$  is the need for long-term care  $LN$  and long-term care insurance  $LTCI$  and  $I_2$  is the number of hospitalizations  $HN$  and long-term care insurance  $LTCI$  is the interaction between the number of hospitalizations and long-term care insurance.

$c_0, c_1, c_2, c_3, c_4, a_0, a_1, a_2, a_3, a_4, c'_0, c'_1, c'_2, c'_3, b_1, b_2$ , and  $c'_4$  are the parameters to be estimated. Finally,  $e_1, e_2$ , and  $e_3$  denote the follow-on error terms.

## Results

### Baseline regression

In this study, we analyze the impact of long-term care needs on hospitalization fares after adding a series of control variables. The

regression results in columns (1)–(4) of Table 2 after adding personal characteristics, family characteristics, social insurance characteristics, and health behavioral characteristics in that order show that long-term care needs significantly increase hospitalization costs at a statistical level of 5%.

### Control variables analysis

The estimation results of one of the control variables are of interest, as exemplified in Column (4) of Table 2. In terms of individual characteristics, the age variable is significantly positive and significant at the 5% statistical level, meaning that the cost of hospitalization increases progressively with age. The gender variable was significantly positive and significant at the 10% level, i.e., the cost of hospitalization was higher for women. In terms of household characteristics, the household income variable is significantly negative and is statistically significant at the 5% level, i.e., as household income increases, the cost of hospitalization decreases. The living with children variable was significantly positive and is significant at the 5% level. In terms of health behavioral characteristics, the self-treatment variable was significantly positive and statistically significant at the 10% level, i.e., the cost of hospitalization increased for those who self-treated. In terms of medical satisfaction, the medical satisfaction variable was significantly negative and significant at the 5% statistical level.

## Robustness tests

### Substitution of explanatory variables

Table 3 presents the results of the robustness test estimates of the impact of long-term care needs on hospitalization costs of replacing the core explanatory variables. Through effective replacement of the core independent variable. The “degree of disability” is used to explore its impact on hospitalization costs, and the degree of incapacity measured separately is an important measure of the ability to look after oneself and can effectively reflect the long-term care needs of an incapacitated person. Therefore, the choice of incapacity degree as a replacement variable for long-term care needs is somewhat justified. Substitution of the core independent variables shows that, with the sequential inclusion of a range of control variables, the degree of disability substantially increases hospitalization costs at the 5% statistical level. These results were generally consistent with the baseline regression results, suggesting that the finding that long-term care needs significantly increased hospitalization costs was strongly robust.

### Introduction of fixed effects

Table 4 presents the results of the robustness test estimates of the impact of long-term care needs on hospitalization costs for the introduction of fixed effects. The introduction of time and city fixed effects to explore the impact of long-term care needs on hospitalization costs can effectively control the effects of time and city on the explanatory variables; therefore, it is reasonable to explore the effects

TABLE 2 Baseline regression results.

Variables		OLS model				
		(1)	(2)	(3)	(4)	
Independent variable		Long-term care needs	1.560** (0.534)	1.589** (0.537)	1.651** (0.537)	1.214** (0.538)
Control variables	Personal features	Age	0.006** (0.002)	0.006** (0.002)	0.006** (0.002)	0.005** (0.002)
		Sex	0.077* (0.041)	0.078* (0.041)	0.070* (0.041)	0.072* (0.042)
		Marriage	−0.013 (0.055)	−0.005 (0.055)	−0.019 (0.054)	0.000 (0.055)
		Level of education (ref: primary and below)				
		Junior high school	0.085 (0.053)	0.092* (0.053)	0.090* (0.052)	0.083 (0.054)
		High school and technical secondary school	−0.018 (0.075)	−0.017 (0.075)	−0.004 (0.074)	−0.025 (0.077)
		College degree, bachelor's degree or above	−0.121 (0.197)	−0.127 (0.196)	−0.114 (0.197)	−0.110 (0.225)
		Household Registration	−0.017 (0.042)	−0.007 (0.043)	−0.013 (0.042)	−0.026 (0.043)
		Retirement	−0.073 (0.060)	−0.103* (0.061)	−0.096 (0.060)	−0.063 (0.061)
		Family features	Household income		−0.009* (0.006)	−0.010* (0.006)
	Number of children			−0.020 (0.012)	−0.024* (0.012)	−0.030** (0.012)
	Children living together			0.112** (0.046)	0.104** (0.046)	0.102** (0.047)
	Social insurance features	Social health insurance			0.195 (0.130)	0.166 (0.128)
		Social endowment insurance			−0.063 (0.044)	−0.013 (0.045)
	Health behavior characteristics	Smoking				−0.061 (0.050)
		Drink alcohol				−0.031 (0.049)
		Self-treatment				0.072* (0.042)
		Medical satisfaction (reference: satisfaction)				
		General				0.092** (0.045)
		Not satisfied				0.100 (0.063)
	R-squared		0.008	0.012	0.014	0.015
Sample size		3,555	3,457	3,420	2,976	

\*\*\*, \*\*, and \* denote significance at the 1, 5, and 10% statistical levels, respectively, with standard errors of the robustness of coefficients in parentheses.

TABLE 3 Robustness tests-replacement of explanatory variables.

Variables	OLS model			
	(1)	(2)	(3)	(4)
Degree of incapacity	0.328*** (0.076)	0.283*** (0.076)	0.298*** (0.075)	0.236** (0.078)
Control variables	Controlled	Controlled	Controlled	Controlled
R-squared	0.013	0.016	0.020	0.020
Sample size	2,335	2,266	2,240	1964

\*\*\*, \*\*, and \* denote significance at the 1, 5, and 10% statistical levels, respectively, with standard errors of the robustness of coefficients in parentheses.

of long-term care needs on hospitalization costs, controlling for time and municipal fixed effects, controlling for time and city fixed effects, and adding a range of control variables, long-term care needs still significantly increased hospitalization costs at the 10% statistical level, which was broadly consistent with the previous regression results, suggesting that the result that long-term care needs significantly increased hospitalization costs was strongly robust.

## Impact analysis mechanism

### Mediating effect

To further explore the path of the effect of long-term care needs on hospitalization costs, this study used stepwise regression to test whether the number of hospitalizations had a mediating effect. [Table 5](#)

TABLE 4 Robustness tests–fixed effects tests.

Variables	OLS model			
	(1)	(2)	(3)	(4)
Long-term care needs	1.597** (0.648)	1.595** (0.665)	1.655** (0.671)	1.206* (0.642)
Control variables	Controlled	Controlled	Controlled	Controlled
Time fixed effects	Yes	Yes	Yes	Yes
Urban fixed effects	Yes	Yes	Yes	Yes
R-squared	0.027	0.030	0.030	0.034
Sample size	3,555	3,457	3,420	2,976

\*\*\*, \*\*, and \* denote significance at the 1, 5, and 10% statistical levels, respectively, with standard errors of the robustness of coefficients in parentheses.

TABLE 5 Mediation moderating effect test.

Variables	(1) Hospitalization costs	(2) Number of Hospitalizations	(3) Hospitalization costs
Long-term care needs	1.214** (0.538)	1.274*** (0.158)	−0.126 (0.518)
Number of hospitalizations			1.052*** (0.060)
Control variables	Controlled	Controlled	Controlled
R-squared	0.015	0.045	0.109
Sample size	2,976	2,978	2,975

\*\*\*, \*\*, and \* are significant at the 1, 5, and 10% statistical levels, respectively, and the standard error of coefficient robustness is in parentheses.

presents the regression results of Equations (1)–(3). As shown in Table 5, when the regression in Equation (2) is performed with long-term care needs as the explanatory variable and the number of hospitalizations as the explained variable, long-term care needs significantly increased the number of hospitalizations. When the number of hospitalizations was used as the explanatory variable for the regression in Equation (3), the number of hospitalizations had a significant positive impact on hospitalization costs. Combined with the regression results of Equations (1)–(3), it was concluded that the path of “long-term care needs-hospitalization duration-hospitalization costs” existed, the number of hospitalizations had a partial mediating effect, and research hypothesis 3 was partially verified.

## Mediating moderating effect

### Direct moderating effect

To clarify the moderating effect of long-term care insurance on the impact of long-term care needs on hospitalization costs, this study incorporated the interaction term of long-term care needs and long-term care insurance into the system for moderating effect analysis. As shown in Column (1) of Table 5, after introducing the moderating variable long-term care insurance and the interaction term of long-term care insurance and long-term care needs, the effect of long-term care needs on hospitalization costs is still significantly positive at the statistical level of 5%, the coefficient of the moderating variable long-term care insurance is significantly negative at the statistical level of 5%, and the coefficient of the interaction term of long-term care insurance and long-term care needs is significantly negative at the statistical level of 10%. It can be seen from the above that long-term care insurance inhibits the positive effect of long-term care needs on

hospitalization costs, that is, long-term care insurance has a significant negative moderating effect on the impact of long-term care needs on hospitalization costs.

## Mediated moderating effect

According to Ye and Wen (18), the concrete steps of the research are as follows: First, test the regression coefficient  $c_3$  in Equation (4). From Column (1) of Table 6, it can be seen that the coefficient of the interaction term between long-term care needs and long-term care insurance was significantly negative and significant at the 5% level. Thus, long-term care insurance had a negative moderating effect. Second, we tested the regression coefficients in Equations (5, 6). From Column (2) of Table 5, we can see that the coefficient of long-term care needs was significantly positive at the statistical level of 5%. From Column (3), it can be seen that the coefficient of the interaction term between long-term care insurance and hospitalization times was significantly negative at the 1% level. Based on this, long-term care insurance indirectly regulated the effect of long-term care needs on hospitalization costs by adjusting the effect of hospitalization days on hospitalization costs. Third, we tested the regression coefficient in Equation (6). The interaction between long-term care needs and insurance had no significant effect on hospitalization costs. Therefore, the moderating effect of long-term care insurance was fully mediated.

## Discussion

The baseline regression results show that long-term care needs significantly increase hospitalization costs. In the hierarchy of needs theory proposed by American psychologist Maslow, needs

TABLE 6 Mediated moderating effect test.

Variables	(1) Hospitalization costs	(2) Number of hospitalizations	(3) Hospitalization costs
Long-term care needs	2.002** (0.662)	1.229** (0.194)	0.177 (0.624)
Long-term care insurance	−0.149** (0.055)	−0.003 (0.016)	0.019 (0.054)
Long-term care needs * Long-term care insurance	−2.139* (1.106)	0.128 (0.325)	−0.143 (1.051)
Hospitalization times			1.408*** (0.067)
Long-term care insurance * hospitalization times			−1.437*** (0.135)
Control variables	Controlled	Controlled	Controlled
R square	0.027	0.030	0.030
Sample size	3,555	3,457	3,420

\*\*\*, \*\*, and \* are significant at the 1, 5, and 10% statistical levels, respectively, and the standard error of coefficient robustness is in parentheses.

are classified into physiological needs, security needs, social needs, respect needs, and self-actualization needs. Corresponding to this disability, there are different levels of long-term care needs, with higher levels pursued only when the lower ones are met. The physical needs of people with disabilities are mainly in the personal care in long-term care needs, and the safety needs of people with disabilities are mainly in the area of timely, adequate, and effective medical care for long-term care needs. When a person with disabilities is in good health, they have a low level of life care needs and relatively simple medical care needs. These long-term care needs can be met by the person with a disability, by their family, or by a briefer hospital stay. However, when the long-term care needs of people with disabilities rise, the inability of people with disabilities themselves and their families to meet their long-term care needs and the need for specialist medical care leads to the “social hospitalization” problem, where people with disabilities pay for specialist medical care through hospitalization, leading to increased hospitalization costs.

The estimation results of one of the control variables are of interest, as exemplified in Column (4) of Table 2. In terms of individual characteristics, the cost of hospitalization increases progressively with age. Possible reasons for this are that as people begin to decline in physical function as they age, they are exposed to an increased risk of illness, requiring life-saving medical treatment and specialist medical care, leading to increased hospitalization costs. The cost of hospitalization for women are higher than males. Possible reasons for this are that there is a significant sex division of labor in family caregiving, with women taking on more caregiving responsibilities when men need family care, but when women need care, the cost of hospitalization is likely to be lower than the cost of care for men, so women are more likely to undertake hospitalization and have higher hospitalization costs than men, and the effects of education level, household registration, and retirement variables on hospitalization costs are not significant.

In terms of household characteristics, as household income increases, the cost of hospitalization decreases. Possible reasons for this are that as household income increases, the person with disabilities and their family members can choose more options to meet their care needs, with home and institutional care having a

substitution effect on inpatient care, leading to a reduction in hospitalization costs. As the number of children increases, hospitalization costs decrease. Possible reasons for this are that as the number of children increases, the children of the person with disabilities can assume more family care responsibilities, meet the care needs of the person with disabilities, and reduce hospitalization costs. The living with children variable was significantly positive. A possible reason for this is that as family structure changes, family nucleation increases, living with children decreases, and when the need to care for grandchildren or one's poor health requires care, one chooses to live with children. However, the nuclear family is often unable to provide long-term home care, and this need for home care translates into a need for medical care, leading to increased hospitalization costs.

In terms of health behavioral characteristics, the cost of hospitalization increased for those who self-treated. Possible reasons for this are that persons who self-treat may be in worse health compared to those who do not self-treat and have relatively more medical care needs, leading to increased costs for their hospitalization. In terms of medical satisfaction, there is a negative correlation between medical satisfaction and the cost of hospitalization. A possible reason for this is that the satisfaction of those who have received medical care is mainly based on the quality, cost, and convenience of medical care, and their medical satisfaction is higher when their health improves after receiving medical care, when the cost of medical care is small and when it is convenient, and those whose health does not improve significantly and whose cost of medical care is higher tend to be in poorer health and have more medical care needs which lead to higher hospitalization costs.

The long-term care insurance inhibits the positive effect of long-term care needs on hospitalization costs. A possible reason is that when people with disabilities pursue lower levels of physiological and safety needs, families and hospitals can meet them, but when the lower levels of physiological and safety needs are met, a person with disabilities will pursue higher levels of needs, including social needs, respect needs, and self-actualization needs. First, in long-term care, social needs are mainly manifested in the emotional and belonging needs of persons with disabilities, but this demand is gradually not met due to changes in the family



structure. The implementation of long-term care insurance provides cash subsidies for family members who are responsible for family care, and family members provide care services at home, which can effectively meet the social and emotional needs of people with disabilities and effectively reduce hospitalization costs. Second, concerning long-term care needs, respect needs are manifested in the fact that people with disabilities still need to be respected and understood by their families and society after losing their self-care ability. Third, in terms of long-term care needs, the need for self-realization is manifested in the fact that people with disabilities also need to achieve self-worth by participating in social activities. Long-term care insurance provides home care through subsidies and enables people with disabilities to stay in professional care institutions, providing service guarantees for older adults with disabilities, so that they can choose to receive family or institutional care services and freely choose and enjoy better care services. It can effectively meet their higher level of care needs, reduce “social hospitalization”, and reduce hospitalization costs.

The care services provided by long-term care insurance for families and professional institutions met the long-term care needs of people with disabilities, replacing some of the original medical needs and thereby reducing hospitalization costs. From the mediating effect test and mediating moderating effect test, we can determine the possible influence path of the substitution effect of long-term care insurance. On the one hand, long-term care insurance mobilizes the enthusiasm of families, communities, and professional care institutions by providing financial compensation using a “combination of medical and health care” model. When formal or informal care for people with disabilities is provided by family members or professional caregivers, the social and respect needs of persons with disabilities be met to a greater extent, and their physical and mental health will also be improved to a certain extent, reducing the need for non-medical hospitalization and effectively reducing hospitalization numbers, thereby reducing the cost of hospitalization. On the other hand, people with disabilities who receive care in hospitals before the establishment of long-term care insurance can freely choose to receive care services at home or professional care institutions under the promotion of long-term care insurance, rather than spending a lot of time and economic costs to become “bedridden patients”, effectively reducing the number of hospitalizations and medical expenses.

## Conclusions and policy recommendations

In order to explore the impact of long-term care needs on hospitalization costs, especially the important role of long-term care insurance in its impact mechanism, based on data from the China Health and Retirement Longitudinal Study (CHARLS) in 2015 and 2018, this study used the least squares method to investigate the impact of long-term care needs on hospitalization costs and its path from the perspective of entropy theory. The results showed that long-term care needs to increase hospitalization costs, and this result remained robust after a series of tests, such as replacing core explanatory variables and introducing fixed effects. Through the mediating effect test and mediating moderating effect test, we found

the path of the impact of long-term care needs on hospitalization costs. Long-term care needs increased hospitalization costs by positively affecting the number of hospitalizations, and long-term care insurance reduces hospitalization costs. The specific path of action makes long-term care insurance reduce hospitalization costs by negatively regulating the number of hospitalizations. Based on the above conclusions, this study proposes the following policy recommendations:

First, long-term care insurance should consider pre-prevention and expand the scope of insurance and protection. According to this study, long-term care needs is an important factor leading to an increase in hospitalization costs. Expanding the scope of long-term care insurance is important for prevention. From the focus on medical care cost protection to solving basic nursing security needs, the scope of insurance and security has greatly expanded. Families and professional nursing institutions can meet the basic nursing needs of persons with mild disabilities and reduce hospitalization costs; second, long-term care insurance should consider the matter under control and develop appropriate levels of treatment payments. In conclusion, it is found that the payment of long-term care insurance benefits can effectively reduce the economic burden on families, promote the choice of home care methods, replace non-hospitalized medical needs, reduce the number of hospitalizations, and inhibit hospitalization costs. Therefore, in the design of long-term care insurance benefits, differentiated treatment protection policies should be implemented and priority should be given to subsidizing home care services, reducing hospitalization needs, and controlling hospitalization costs. Third, long-term care insurance should consider post-supervision and explore the appropriate treatment payment methods. The payment method for long-term care insurance affects the service choices of people with disabilities. Cash payments may reduce the economic burden of people with disabilities and their families, generate income effects, and release hospitalization needs. In addition, a single cash payment method cannot make timely and effective judgments regarding the health status of people with disabilities. The combination of cash payments and nursing services can effectively monitor the health status of people with disabilities, but also improve the health status of people with disabilities through professional nursing services, reduce medical care needs, and control hospitalization costs.

## Limitations and outlook

Due to the current stage of development of China's long-term care insurance system, which is in the pilot phase, and the fact that the CHARLS data is only updated until 2018, it is not possible to conduct a comprehensive and up-to-date assessment of the effectiveness of China's long-term care insurance system. In the future, the authors will consider conducting their own survey based on the implementation of the Chinese long-term care insurance system to facilitate the evaluation of the latest system outcomes.

## Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: <https://charls.charlsdata.com/pages/data/111/zh-cn.html>.

## Ethics statement

The questionnaire was provided by the National Development Research Institute at Peking University. The questionnaire employs data anonymization to ensure the confidentiality of enrollees.

## Author contributions

JiL and TC contributed to the study design. TC, JuL, and XC collected and collated the data. TC, JuL, and XC contributed to conceptualization, writing – original draft, writing – review and editing. JiL, ZL, and TC supervised the study and contributed to the writing – review and editing. TC responded to and revised comments from reviewers and editors. The authors read and approved the final manuscript. All authors contributed to the article and approved the submitted version.

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## References

1. He S, Craig BA, Xu H, Covinsky KE, Stallard E, Thomas J, et al. Unmet need for ADL assistance is associated with mortality among older adults with mild disability. *J Gerontol A Biol Sci Med Sci*. (2016) 70:1128–32. doi: 10.1093/gerona/glv028
2. Tang Y, Chen T, Zhao Y, Taghizadeh-Hesary F. The impact of the long-term care insurance on the medical expenses and health status in China. *Front Public Health*. (2022) 10:847822. doi: 10.3389/fpubh.2022.847822
3. Costa-Font J, Jimenez-Martin S, Vilaplana C. Does long-term care subsidization reduce hospital admissions and utilization? *J Health Econ*. (2018) 58:43–66. doi: 10.1016/j.jhealeco.2018.01.002
4. Choi JW, Park EC, Lee SG, Park S, Ryu HG, Kim TH. Does long-term care insurance reduce the burden of medical costs? A retrospective older adults cohort study. *Geriatr Gerontol Int*. (2018) 18:1641–6. doi: 10.1111/ggi.13536
5. Liu H, Hu T. Evaluating the long-term care insurance policy from medical expenses and health security equity perspective: evidence from China. *Arch Public Health*. (2022) 80:3. doi: 10.1186/s13690-021-00761-7
6. Chen H, Ning J. The impacts of long-term care insurance on health care utilization and expenditure: evidence from China. *Health Policy Plan*. (2022) 37:717–27. doi: 10.1093/heapol/czac003
7. Lei X, Bai C, Hong J, Liu H. Long-term care insurance and the well-being of older adults and their families: evidence from China. *Soc Sci Med*. (2022) 296:114745. doi: 10.1016/j.socscimed.2022.114745
8. Hou Y, Wang Y, Yan S, Zhang W, Zhang L, Yao J. Impact of long-term care insurance on medical service utilization, medical burden and health of middle-aged and older adults people: an empirical study based on difference-in-difference method. *China Health Pol Res*. (2021) 14:35–40.
9. Gao X, Le Z. Research on the impact of long-term care insurance on medical expenses of middle-aged and older adults people in China: based on data from China health and pension tracking survey. *Xinjiang Agric Reclam Econ*. (2021) 2:38–46.
10. Chen S, Li L, Yang J, Jiao L, Golden T, Wang Z, et al. The impact of long-term care insurance in China on beneficiaries and caregivers: a systematic review. *J Glob Health Econ Policy*. (2021) 1:e2021014. doi: 10.52872/001c.29559
11. Ma C, Yu Q, Song Z, Chen H. Long-term care insurance, medical expense control and value-based healthcare. *China Ind Econ*. (2019) 12:42–59.
12. Deraas TS, Berntsen GR, Hasvold T, Førde OH. Does long-term care use within primary health care reduce hospital use among older people in Norway? A national five-year population-based observational study. *BMC Health Serv Res*. (2011) 11:287. doi: 10.1186/1472-6963-11-287
13. Yu X, Liu H, Yang W. The impact of long-term care insurance on medical expenses: a synthetic control study based on Qingdao model. *Insur Stud*. (2019) 2:114–27.
14. Chen C, Guo J. Research on long-term care cost control and payment methods: a case study of long-term medical care insurance pilot in S city. *Health Econ Res*. (2020) 37:49–53.
15. Wang Z, Feng J. The substitution effect of long-term care insurance on medical expenses and the comparison of different compensation models. *Economics (Quarterly)*. (2021) 21:557–76.
16. Feng R, Feng S. *Tracing the origins: the world of entropy*. Beijing: Science Press (2016).
17. Wen Z, Fang J, Xie J, Ouyang J. Methodological research on domestic mediation effect. *Adv Psychol Sci*. (2014) 5:731–45.
18. Ye B, Wen Z. Mediated moderation model test method: screening and integration. *Acta Psychol Sinica*. (2013) 45:1050–60. doi: 10.3724/SPJ.1041.2013.01050

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Appendix

The procedure for entropy weighting method is as follows:

Step 1: Identify indicators.

Given  $n$  samples and  $m$  indicators, let  $X_{ij}$  represent the value of the  $j$ th indicator for the  $i$ th sample ( $i = 1, 2, \dots, n; j = 1, 2, \dots, m$ ).

Step 2: Normalization of indicators.

Normalize the indicators to eliminate scale differences. In this study, all the indicators are positive indicators.

$$X_{ij} = \frac{X_{ij} - \min\{X_{1j}, \dots, X_{nj}\}}{\max\{X_{1j}, \dots, X_{nj}\} - \min\{X_{1j}, \dots, X_{nj}\}}$$

Step 3: Calculate the proportion of the  $i$ th sample value to the  $j$ th indicator, and assess the variability of the indicator.

$$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^n X_{ij}}, i=1, 2, \dots, n; j=1, 2, \dots, m.$$

Step 4: Calculate the entropy value for the  $j$ th indicator.

$$e_j = -k \sum_{i=1}^n P_{ij} \ln(P_{ij}), j=1, 2, \dots, m \quad (k = \frac{1}{\ln(n)} > 0, \text{ so } e_j \geq 0).$$

Step 5: Calculate the redundancy of information entropy.

$$d_j = 1 - e_j, j=1, 2, \dots, m$$

Step 6: Calculate the weights of each indicator.

$$W_j = \frac{d_j}{\sum_{j=1}^m d_j}, j=1, 2, \dots, m$$

Step 7: Calculate the comprehensive scores for each sample.

$$s_i = \sum_{j=1}^m W_j P_{ij}, i=1, 2, \dots, n$$

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