BMC Health Services Research

RESEARCH

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Does younger children's social health insurance alleviate household impoverishment due to illness?

Jiali Zhou[1], Yong Zhan[1*], Huashuai Chen[1] and Sijie Chen[2]

Abstract

Background The ambitious expansion of social health insurance in China has played a crucial role in preventing and alleviating poverty caused by illness. However, there is no government-sponsored health insurance program specifically for younger children and inequities are more pronounced in healthcare utilization, medical expenditure, and satisfaction in some households with severely ill children. This study assessed the effectiveness of child health insurance in terms of alleviating poverty caused by illness.

Methods Data were collected from two rounds of follow-up surveys using the China Family Panel Studies 2016 and 2018 child questionnaires to investigate the relationship between child health insurance and household medical impoverishment (MI). Impoverishing health expenditure (IHE) and catastrophic health expenditure (CHE) were measured to quantify "poverty due to illness" in terms of absolute and relative poverty, respectively. Propensity score matching with the difference-in-differences (PSM-DID) method, robustness tests, and heterogeneity analysis were conducted to address endogeneity issues.

Results Social health insurance for children significantly reduced household impoverishment due to illness. Under the shock of illness, the incidences of IHE and CHE were significantly lower in households with insured children. The poverty alleviation mechanism transmitted by children enrolled in social health insurance was primarily driven by hospitalization reimbursements and the proportion of out-of-pocket medical payments among the total medical expenditure for children.

Conclusions Children's possession of social health insurance significantly reduced the likelihood of household poverty due to illness. The poverty-reducing effect of social medical insurance is most significant in rural areas, low-income families, no-left-behind children, and infants. Targeted poverty alleviation strategies for marginalized groups and areas would ensure the equity and efficiency of health system reforms, contributing to the goal of universal health insurance coverage in China.

Keywords Social health insurance, Severe illness shock, Child health, Medical impoverishment, Poverty alleviation

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Introduction

Over the past four decades, China has experienced rapid demographic and epidemiological transitions, and an economic boom that has lifted millions out of poverty [1]. However, even a modest social security system can be costly, especially with the shrinking labor force and increasing number of beneficiaries [2] influenced by China's urbanization and one-child policy. Severe illness continues to impose significant financial hardship on households, particularly on poor urban residents with limited insurance coverage [3]. Such residents must bear significant health expenditures to treat severe illnesses, which often brings a heavy medical risk to their families [4]. This financial strain is exacerbated when illness leads to income loss and reduced working capacity, creating a vicious cycle of illness and poverty. This "illness-poverty-illness" cycle or "poverty trap" [5–7] is further reinforced by a "medical poverty trap" [8] characterized by escalating out-of-pocket (OOP) health payments. In this context, understanding the relationships between health shocks, economic burdens, and the effects of children's social health insurance is crucial in this context. These relationships are illustrated in Fig. 1.

Health shocks lead to medical impoverishment (MI) [9], catastrophic health expenditure (CHE), and impoverishing health expenditure (IHE), the primary contributors to economic burden [10–13]. Furthermore, rapid health expenditure growth creates additional pressure on household finances [14]. China still faces social inequality in economic health burdens by region and medical insurance coverage, which is reflected in the high ratio of OOP payments to total health expenditure [15]. Significant differences in health status exist among different socioeconomic groups and areas in China [16, 17], with many younger children being overlooked and excluded from city health systems [18–20]. Uninsured children are less likely to seek medical care and receive necessary treatments compared to their insured counterparts, resulting in an elevated risk of poor health and mortality [21]. To address this issue, it is imperative to identify the gaps in health insurance studies and examine how children's health insurance can reduce families' economic burden and prevent households from falling into the medical poverty trap. Encouraging younger children to participate in social insurance would be logical both economically and socially.

Most countries have established national healthcare systems to improve the health and wellbeing of vulnerable groups such as infants, children, adolescents, and young adults. The 1998 Urban Employee Basic Medical Scheme and Urban and Rural Resident Basic Medical Scheme (URRBMS) in China covered 1.36 billion people (95% of the population) in 2021 [22], including employees and retirees in private or state-owned enterprises. The 2016 New Cooperative Medical Scheme (NCMS) covers urban and rural residents from the formal labor market, including children, non-working adults, and self-employed individuals [19, 23]. In the United States, programs such as Medicaid and the Children's Health Insurance Program (CHIP) represent a national effort to guarantee health insurance for children [21]. In the case of Medicaid, the program currently finances approximately 41% of U.S. births, with CHIP currently serving approximately half of all children [25]. Similarly, the National Health Service (NHS) in the United Kingdom, which was established in 1948, provides free healthcare at the point of use for the UK population through four publicly funded systems. Most children rely on the NHS for healthcare, although prescriptions, and optical and dental services for adults over 18 years are not covered [26].

China's Basic Health Insurance System has undergone several key stages of development. In 1998, approximately 90% of farmers paid all medical expenses OOP and health insurance coverage in urban areas declined from 53 to 42% [27, 28]. The situation improved with the State Council approving and implementing Basic Medical Insurance (BMI) for urban formal sector workers but not

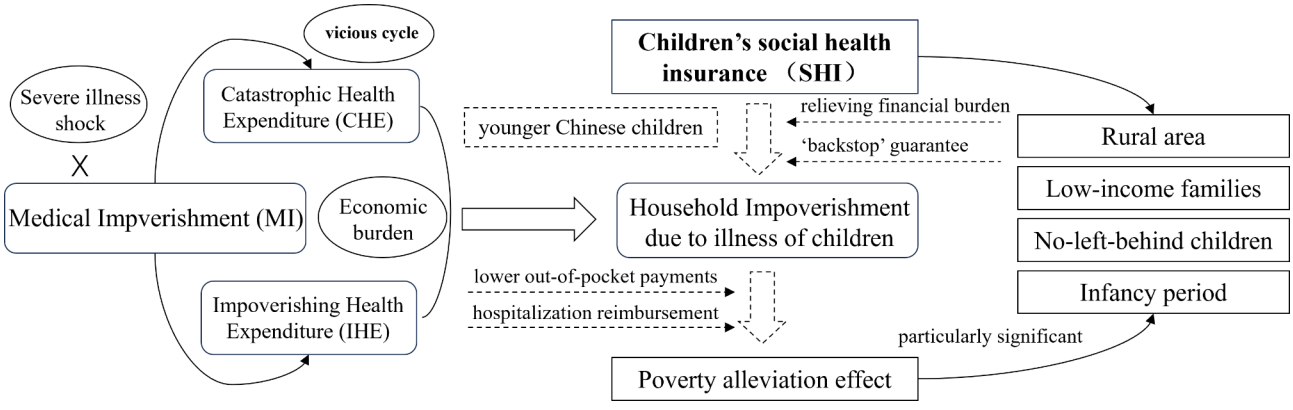

Fig. 1 Poverty alleviation mechanism of children's enrolling in social health

their families [29]. In 2003, the New Rural Cooperative Medical Scheme (NRCMS) was officially re-launched as an optimization of the initial NCMS designed to enhance coverage for rural households. Between 2003 and 2005, the national medical insurance system improved rapidly. In 2007, the Urban Residents Basic Medical Insurance (URBMI) was piloted in 79 cities to cover non-working urban residents, including children, students, the elderly, and disabled groups uncovered since the 1980s [30], marking a significant step in integrating children into the healthcare insurance system. According to the 2019 Medical Security Development Statistical Bulletin of the National Healthcare Security Administration of China [31], by the end of 2019, the comprehensive medical security policy of health insurance for poverty alleviation had benefited 200 million poor people and a total of 4.18 million people had been lifted out of poverty due to illness.

The ambitious expansion of social health insurance coverage has played a crucial role in preventing and alleviating poverty caused by illness. "Sandwich classes" emerged during China's urbanization and capacity reduction processes [3]. Unlike the rural poor, the sandwich class of poor urban residents did not benefit from poverty alleviation policies. Furthermore, poor urban demographics primarily include children, students, and individuals not covered by URBMI, making them more vulnerable to falling into or deepening poverty due to higher health risks and a lack of stable income sources. This vulnerability can significantly increase household poverty and intergenerational poverty transmission in severe cases. The sandwich generation faces dual care commitments to both aging parents and children, further complicating the limited resource distribution [32]. These trends underscore the critical role of children's social health insurance in mitigating the financial burden of illness in vulnerable households and emphasize the need for targeted policy interventions to enhance coverage and benefits.

Literature review

Overview

Considerable research on social medical insurance has been conducted to help prevent households from falling into the dilemma of "illness of poverty" [33] or "sinking back into poverty due to illness", also known as the "medical poverty trap" or "poverty due to illness" [5–9]. Most studies have found that medical insurance alleviates poverty. For example, a study of Senegal's medical insurance system revealed that it increased Medicare utilization and protected families from catastrophic health expenditures [34]. Similarly, a study conducted in 2006 collected family data from rural banks in Bangladesh and found that small-scale medical insurance significantly contributed to poverty alleviation [35]. In Ghana, researchers discovered that high-OOP medical expenditures could push households back into poverty, whereas joining social medical insurance could reduce their CHE [36]. By 2014, over 98.9% of the rural population in China was enrolled in the NCMS. In 2019, 102.51 million urban residents, including non-employed and self-employed residents, college students, and children, participated in URBMI [37]. China is in the process of implementing URBMI nationwide to provide duplicate insurance [38]. As the "backstop" guarantee of the health system has gradually been realized, primary research has shifted focus from the poverty reduction effect of health insurance [5, 39, 40] to equity in healthcare access, considering

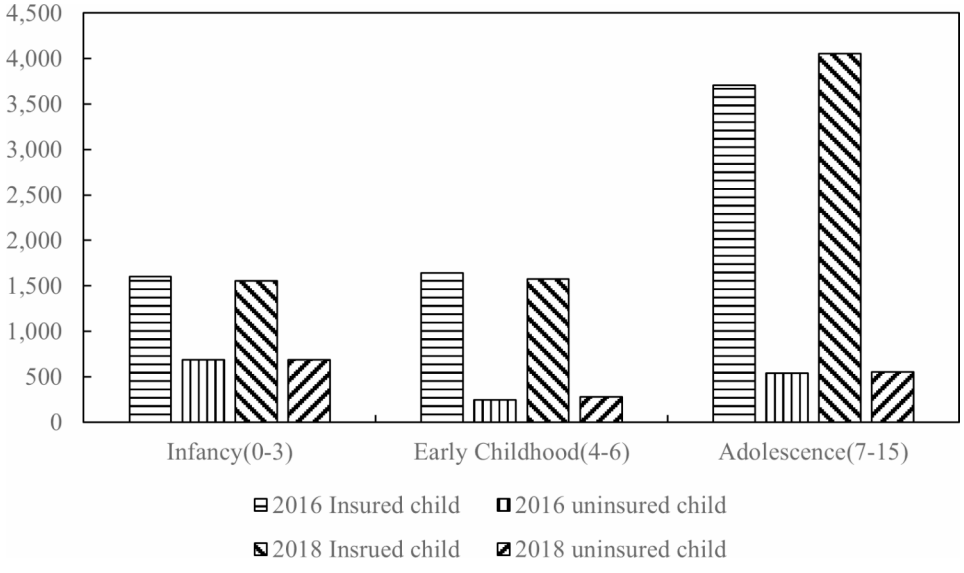

Fig. 2 Distribution of social insurance coverage for different age groups in 2016 and 2018

disparities among different regions, age groups, and other demographics [40–42]. However, few studies have focused on children's health insurance or used nationally representative data to evaluate the effect of health insurance in terms of reducing IHE and CHE.

Three strategies of health insurance to eliminate poverty

Health insurance plays a significant role in eliminating poverty. Three main approaches found in health insurance studies can be used to explain the poverty alleviation effect. First, health insurance works by cutting down household OOP medical payments. Studies have demonstrated that health insurance significantly reduces household OOP medical payments by 86% and reduces the poverty rate of households by 7.5% [36]. Expanding medical subsidies through health insurance also significantly reduces OOP expenses and medical debt among low-income and uninsured groups [44]. In China, health insurance has effectively reduced illness-related OOP payments for outpatient and inpatient care [45]. Second, health insurance promotes the health performance of medical services utilized by residents. For example, some scholars believe that NCMS in some Chinese counties and cities capitalizes on outpatient and inpatient services in pilot areas [46]. Furthermore, it has been found that China's NRCMS has improved the condition of "no treatment for illness" (residents refusing medical attention). This is also a notable factor in terms of improving resident health and maintaining a steady supply of skilled household labor by fully utilizing health services [47]. Third, an optimized rural medical insurance system has the potential to prevent people from slipping back into poverty because of the high medical expenses associated with severe illness [48]. It has been revealed that with every 10% increase in the number of participants in Medicare, the personal bankruptcy rate would decrease by 8% [49]. Similarly, research conducted in Chinese cities such as Linyi in Shandong Province has found that serious illness expenditure decreased from 8.98 to 8.25% following the introduction of the NCMS [50].

Despite the importance of comprehensive medical insurance, empirical studies examining the poverty alleviation effects of government-led health insurance in China have not reached a consensus [3, 51, 52]. Although public health insurance schemes such as the NRCMS and URBMI, have been proven to have a positive effect on the health of the rural population [40, 47, 53], current research indicates that the rapid escalation of medical expenses could weaken the poverty reduction effect of full medical insurance coverage [40, 54]. Furthermore, OOP payments are much higher in China than in Organisation for Economic Co-operation and Development (OECD) countries [15, 22, 40]. Therefore, China still faces high costs regarding OOP medical services and health inequality, particularly in rural areas, and the soaring cost of OOP payments triggers financial difficulties in vulnerable groups such as those in low-income households, infants, and migrant workers who remain uninsured [16, 53, 55]. Some studies have further indicated that the NRCMS does not significantly reduce medical burdens [46, 47, 56].

Studies on children's health insurance

In addition to studies on Medicare coverage for adults, many scholars have focused on the relationship between children's health insurance and illness-related poverty. Data from the National Medical Care Expenditure Survey of 1977 and National Medical Expenditure Survey launched in 1987 revealed disparities in children's health insurance status in the U.S. and their use of health services during each of these years and over time. This research revealed that uninsured children possessed a lower Medicare utilization ratio and that their families were associated with a greater likelihood of poverty than those of insured children [57]. Another study found that Medicaid, the single largest source of health coverage in the U.S., lifted at least 2.6 million people out of poverty. This poverty relief policy has been the most effective at assisting disabled people and children, as measured by data from the 2011 U.S. Census Bureau Population Survey [58]. Health insurance for children has also been proposed to reduce the incidence of chronic diseases and mortality among children and play a crucial role in eliminating poverty [26, 59, 60].

In contrast to the research in Western countries, research on social health insurance for children in China is limited. Most previous studies have focused on adults, mainly middle-aged and elderly populations [45, 47, 61], with less attention dedicated to children's health insurance compared with studies conducted in the U.S. Few studies have explored the relationship between children's social health insurance and poverty. Most research has concentrated on participation rates and the reimbursement of children's social medical insurance, as well as the health services hierarchy and factors that impact insurance coverage [19, 55, 62, 63]. Intrinsic causality is yet to be determined. Unlike specialized social health insurance systems designed for children in developed countries, China's insurance system has largely been modeled on adult standards, often overshadowing the specific needs of children under the NCMS and URBMI frameworks [19, 62]. Children's health needs and developmental stages that differ from those of adults in terms of physical characteristics, health risks, and family resource allocation [21, 26, 41, 63]. Furthermore, China has a strong political and community consensus regarding the importance of women's and children's wellbeing, emphasizing that "children are the future and hope of the motherland"

[64]. Furthermore, China's one-child family policy has significantly influenced demographic patterns [32, 65] and childbearing attitudes [64] within families.

The impact of basic medical insurance on children cannot be assumed to mirror that on adults. Studies exploring the relationship between children's basic medical insurance and "poverty due to illness" are scarce. This term refers to the economic dilemma that households face as a result of the cost of healthcare and lost income from illness [66, 67]. The internal causal relationship between children's social health insurance and household financial stability has yet to be conclusively determined. Does social health insurance effectively alleviate household financial burdens related to medical expenses and prevent vulnerable groups from falling into poverty? Addressing this question would greatly enhance efforts to eliminate poverty and strengthen children's health security systems. The evidence-based approach employed in this study shifts the focus from adults to younger children in China, effectively assessing the poverty-reducing effects of social health insurance on this vulnerable group.

Data and methods

Data description

Following Li and Fang (2018) [62], this study applied two rounds of follow-up survey data from the China Family Panel Studies (CFPS) 2016 and 2018 child questionnaires to the primary variables utilized in the assessment of children's characteristics, which were predominantly derived from the questionnaires conducted in 2016 and 2018. The Child and Adolescent Database of the CFPS that this study used encompassed children from birth to 15 years of age, providing a comprehensive demographic and developmental profile of this age cohort within the context of Chinese society. Additionally, the CFPS was organized and managed by the Institute of Social Science Survey of Peking University, which was officially implemented nationwide in 2010 and followed up every two years. The samples from 2016 to 2018 covered 31 provinces (municipalities, autonomous regions) in China with the total population accounting for approximately 95% of the country's total population, excluding Hong Kong, Macau, and Taiwan. Therefore, the samples can be regarded as nationally representative.

Model setting

The phenomenon of sinking back into poverty as a result of illness is referred to as poverty due to illness in China [5–9, 33]. To recognize the poverty-reducing effects of children's social health insurance, this study constructed the microeconometric model defined in Eq. (1) and shown in Fig. 1 to analyze the poverty alleviation mechanisms of social health insurance by referring to research proposed by relevant scholars. Several individual, household, and regional factors simultaneously affect family decisions to have younger children (aged under 15 years) insured and other results concerned with. These factors would lead to biased results when using the least-squares method. Therefore, this study employed the fixed-effects model, which is widely used to avoid problems caused by time-invariant missing variables.

$$Poor_{ist} = \alpha_0 + \alpha_1 SHI_{ist} + \alpha_2 SIS_{ist} + \alpha_3 SIS_{ist} \times SHI_{ist} + \chi_{ist} + \lambda_t + \delta_s + \varphi_i + \varepsilon_{ist} \quad (1)$$

where $Poor_{ist}$ is s a dummy variable designed to measure whether the family of child i in province s has experienced poverty due to illness at time t ($0 = no\ and\ 1 = yes$). SHI_{ist} represents whether child i in province s at time t has been insured ($0 = no\ and\ 1 = yes$). SIS_{ist} represents whether the family is suffering from a severe illness shock for child i in province s at time t ($0 = no\ and\ 1 = yes$). $SIS_{ist} \times SHI_{ist}$ is the interaction item between social health insurance and the severe illness shock of children, which refers to the safeguard effect of children's enrollment in social health insurance when a household is suffering from a health shock. α_i is a compound term composed of the corresponding regression coefficients. χ_{ist} denotes a set of covariates controlled for children, household, and family, as well as other confounding factors. λ_t is a dummy variable representing the research question. δ_s denotes the fixed effects at the provincial level. φ_i denotes the fixed effects at the individual level. ε_{ist} is a random disturbance term.

Existing literature has identified adverse selection within China's URBMI and Urban Employee Basic Medical Insurance, which is also a recognized phenomenon in other insurance markets [67–69]. This indicates that urban residents with worse health statuses or higher health risks are more likely to be enrolled in medical insurance programs [70]. Adverse selection in child enrollees leads to an underestimation of the poverty alleviation effect of children's social health insurance. Therefore, the ideal approach is to compare children who have enrolled in social health insurance for the first time with those who have never been enrolled. This comparison helps isolate the impact of children's social health insurance on household poverty alleviation. To address this issue, this study employed propensity score matching (PSM) with the difference-in-differences (DID) approach to assess the statistical significance of group differences and interaction effects, consistent with the approaches applied in the primary insurance studies [5, 19, 46, 70–72]. This methodology enabled us to measure the effect of children's social health insurance on reducing household impoverishment due to illness accurately.

Consistent estimates can be obtained through PSM even if the impact of social health insurance on the likelihood of poverty due to illness is nonlinear. The systematic differences between the treatment (insured children) and reference (uninsured children) groups were minor, satisfying the preexisting common trend assumption of PSM. The DID method enhances the statistical accuracy of the results. To eliminate endogeneity bias, it was essential to ensure that all samples were assigned to obtain two yearly data points for 2016 and 2018. A balanced panel set was then constructed by synthesizing unbalanced panel data for 2016 and 2018.

The insured group was defined as "child aged under 15 years who did not enroll in social health insurance in 2016 but enrolled in social health insurance in 2018" and the reference group was defined as "child aged under 15 years who did not enroll in social health insurance in 2016 or 2018." Children who were enrolled in social medical insurance in 2016 and 2018, as well as those who were insured in 2016 but discontinued their coverage by 2018 were excluded. Children under 15 years of age were chosen as the research sample, as individuals aged 16 years and above were categorized within the Adult Database in the CFPS. Building on this distinction, this study adopted the developmental stage classification method proposed by the United Nations Children's Fund (UNICEF) to delineate the growth of individuals into three distinct phases of childhood development, namely infancy (ages 0–3), early childhood (ages 4–6), and adolescence (ages 7–15), in 2016 and 2018 using histograms.

As shown in Fig. 2, the variations in insurance coverage across different age groups changed between the two years. The child sample was concentrated in the adolescent group with more insured than uninsured children. In both years, the adolescent group had the highest percentage of insured children with slight improvements from 87.31% in 2016 to 88.06% in 2018. The infant group had the lowest insurance coverage, slightly decreasing from 70.09% in 2016 to 69.33% in 2018. This trend may be attributable to educational policies, family economic status, and insurance awareness. For example, in China, children aged 7 to 15 years are typically in the compulsory education phase and schools may encourage parents to purchase social insurance for their children to ensure their safety and health both within and outside the school environment. This observation underscores that children under the age of 15 years are particularly vulnerable to health shocks, which impact their wellbeing and the household's economic situation, highlighting the innovative value and practical significance of this study.

In the first step, the PSM function $P\left(SHI_{it}=1|\,X_{it}\right)$ was estimated, representing the probability of child i being enrolled in social health insurance at time t under specific conditions. Second, a logit model with robust standard errors was applied to estimate the propensity scores of the children. The kernel Matching function was implemented during weight estimation to ensure that the treatment group (insured children) and reference group (uninsured children) had similar characteristics (observed and unobserved) as a consequence of randomization. In the third step, a balance test was employed among covariates. Subsequently, the average treatment effect on insured children (τ_{ATT}^{PSM}) [73–75] was estimated using Eq. (2).

$$\begin{aligned}\tau_{ATT}^{PSM} &= E_{p(X_i)|SHI_i=1} \\ &= E\left(\Delta Y_{1it}|SHI_i=1,P\left(X_i\right)\right) \\ &-E\left(\Delta Y_{0it}|SHI_i=0,P\left(X_i\right)\right)\end{aligned} \tag{2}$$

where, $\Delta Y_{1it}=Y_{1it}-Y_{1it-1},\Delta Y_{0it}=Y_{0it}-Y_{0it-1}$, Y_{1it} is the possible poverty alleviation effect when the child i enrolls in social health insurance at time t, and Y_{0it} is the possible poverty alleviation effect when the child i does not enroll in social health insurance at time t. To further examine the impact of social health insurance on household impoverishment due to illness, the general DID model was employed, as specified in Eq. (3):

$$\begin{aligned}Poor_{ist} = \alpha_0 + \alpha_1 Insured_{is} + \alpha_2 Year + \alpha_3 Insured_{is} \\ \times Year + \chi_{ist} + \lambda_t + \delta_s + \varphi_i + \varepsilon_{ist}\end{aligned} \tag{3}$$

where $Poor_{ist}$ is a dummy variable indicating whether the family of child i in province s has experienced poverty due to illness at time t $(0=no,\ 1=yes)$. $Insured_{is}$ represents whether child i in province s belongs to the treatment group $(0=not\,insured,\ 1=insured)$. $Year$ is a dummy variable representing the intervention year (2018) $(0=pre_{intervention}, 1=post_{intervention})$. $Insured_{is}\times Year$ is the interaction item between the two. α_1 represents the estimated average difference in $Poor_{ist}$ between the treatment and reference groups. α_2 captures the expected average change in $Poor_{ist}$ from before to after the intervention. α_3, the DID estimator, indicates the average treatment effect on the treated (τ_{ATT}^{PSM}) [76]. The model also includes a set of covariates χ_{ist}, as well as fixed effects for time (λ_t), province (δ_s), and individual (φ_i). The term $?_{ist}$ represents the random disturbance term.

Measures

Dependent variables

The critical issue is whether children's health insurance can alleviate the household dilemma of poverty due to illness. Therefore, the dependent variable should be related to poverty due to illness, specifically that arising from children's illnesses. Following the World Health Organization's measurement index for economic risk related to

severe illness [30], two indices were posited to quantify the likelihood of poverty due to illness from the perspectives of absolute and relative poverty, namely IHE and CHE. These indices are utilized according to relevant research [11, 23, 77] and are defined as described below.

Measuring IHE

Referring to previous studies [13, 23, 78], IHE is a dummy variable that takes a value of one when a household's non-health budget (NHB) is lower than the poverty line k. NHB is defined as a standardized indicator for family i with children interviewed and is equal to the value of the annual household income (AHI) minus the annual health expenditure (AHE) on children. The posited threshold k is based on the poverty line given by the 2019 Yearbook of China's Poverty Alleviation and Development shared by the International Poverty Reduction Center in China, which was defined as 2952 yuan in 2016 and 2995 yuan in 2018. In this regard, health expenditure is impoverishing if it satisfies the condition $NHB \leq k$, indicating that IHE occurs when medical expenses push a household below the poverty line after deducting health-related costs. IHE primarily reflects the situation where a household falls into poverty after paying for children's medical expenses, clearly illustrating the scenario of poverty due to illness following the financial impact of a child's healthcare costs. IHE is represented as follows:

$$IHE = \begin{cases} 1\, if\ AHI \geqslant k\ and\ AHI - AHE \leqslant k \\ 0\, in\ other\ case \end{cases}. \quad (4)$$

Measuring CHE

CHE occurs when annual medical payments by households with children account for a large portion of total health expenditures [12, 23, 38, 50, 79]. CHE is represented as a dummy variable that takes a value of one if the household's annual OOP medical payments exceed 40% of its capacity-to-pay (CTP). CTP is calculated by deducting subsistence spending from a household's actual income. As noted previously, CHE is measured by documenting household health payments that are large relative to the CTP [12]. The incidence of CHE can intuitively reflect the dilemma of poverty due to illness and is particularly prevalent in lower-income families who often rely more on OOP medical expenditures for healthcare. When a household experiences CHE, it signifies that the burden of medical costs has disrupted its normal functioning, compelling it to cut back on essential expenses and potentially leading to increased poverty. CHE is defined as follows:

$$CHE = \begin{cases} 1\, if\ OOP/CTP \geqslant 40\% \\ 0\, in\ other\ case \end{cases}. \quad (5)$$

Independent variable

The kernel-independent variable, namely severe illness shock (SIS), is a dichotomous variable described below. Following relevant studies, this research focused on two measures to quantify the SIS based on the occurrence of severe illness in children [67, 77, 80]. Specifically, it takes a value of one when the interviewed children accept inpatient care or the household's total medical expenditure exceeds 5000 yuan (approximately 687 dollars at the current exchange rate) [81]. Otherwise, it takes a value of zero. In China, 5000 yuan was selected as a criterion to identify major health shocks as it was approximately five times a household's monthly income as of 2016 according to the Statistical Communiqué of the 2016 National Economic and Social Development Report by the National Bureau of Statistics. This value is also recognized as the maximum subsidy line of China's minimum livelihood guarantee program (Dibao), which ranged from less than 2000 to more than 5000 yuan per capita per year in 2014 [82]. Additionally, this amount has represented a significant expense in previous years. For the majority of families in the study sample, illness had to be life threatening or have serious implications for their ability to work if left untreated.

Covariates

To limit the influence of possible confounders, this study analyzed research within the previous decade to identify factors as covariates to prevent potential endogeneity problems induced by sample bias [19, 74, 81–85], including the following.

(1) Child characteristics: age, gender (male/female), residence status (urban/rural), and schooling (yes/no), illness episodes (monthly).
(2) Mother characteristics: age, education (0 = illiterate; 1 = primary school; 2 = junior high school; 3 = senior high school or some school; 4 = college; 5 = postgraduate; 6 = PhD or higher), health status (1 = very good health; 2 = good health; 3 = relative health; 4 = general health; 5 = poor health), ever insured (yes/no), ever smoked (yes/no), ever consumed alcohol more than three times per week (yes/no).
(3) Household characteristics: household size, age ≥ 60 years (yes/no), and household income per capita.

All covariates listed above have been noted as major contributors to the dilemma of poverty due to illness, as indicated by the descriptive statistics in Table 1. This

Table 1 The descriptive statistics of variables

Variable and Value	Insured child					Uninsured child				
	Mean	S.D.	Max	Min	*N*	Mean	S.D.	Max	Min	*N*
Dependent variable:										
IHE	0.041***	0.198	1	0	14,167	0.016	0.127	1	0	2995
1 = Yes; 0 = No										
CHE	0.035***	0.184	1	0	14,167	0.139	0.346	1	0	2995
1 = Yes; 0 = No										
Independent variable:										
SIS	0.114***	0.317	1	0	14,167	0.181	0.385	1	0	2995
1 = Yes; 0 = No										
Covariates:										
Child characteristics										
Schooling	0.731***	0.444	1	0	14,167	0.508	0.500	1	0	2994
1 = Yes; 0 = No										
Age (years)	7.422***	4.242	16	0	14,167	5.352	4.688	16	0	2995
Gender	0.535	0.499	1	0	14,167	0.52	0.500	1	0	2991
1 = Male; 0 = Female										
Residence status	0.420***	0.494	1	0	14,167	0.456	0.498	1	0	2995
1 = Urban; 0 = Rural										
Illness episodes (monthly)	0.419***	0.814	13	0	14,167	0.420	0.723	5	0	2706
Mother characteristics										
Health status	2.787***	1.130	5	0	11,903	2.708	1.128	5	0	2308
1 = Very good health; 2 = Good health;										
3 = Relative health; 4 = General health;										
5 = Poor health										
Age (years)	34.160***	6.581	76	0	11,903	32.300	6.856	63	0	2308
Education	3.270	2.073	6	0	11,903	3.233	2.306	6	0	2308
0 = Illiterate;										
1 = Primary school;										
2 = Junior high school; 3 = Senior high school or some school;										
4 = College;										
5 = Postgraduate;										
6 = Ph.D. or higher										
Insured	0.907***	0.291	1	0	11,903	0.650	0.477	1	0	2308
1 = Yes; 0 = No										
Smoking	0.011	0.106	1	0	11,903	0.013	0.113	1	0	2308
1 = Yes; 0 = No										
Drinking	0.017*	0.131	1	0	11,903	0.012	0.11	1	0	2308
1 = Yes; 0 = No										
Household characteristics										
Household size (persons)	5.462***	2.113	21	1	14,167	5.158	2.083	19	1	2995
Having elderly	0.220***	0.414	1	0	14,167	0.197	0.398	1	0	2995
≥ 60 years old										
1 = Yes; 0 = No										
Log of (Annual) per capita income	10.934*	1.056	16.248	0	13,980	10.973	1.162	15.618	0	2875

Note: IHE = Impoverishing health expenditure. CHE = Catastrophic health expenditure. SIS = Severe illness shock. S.D. is the standard deviation. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

Source: CFPS in 2016 and 2018 and 2019 Yearbook of China's Poverty Alleviation and Development.

study used a two-sample t-test to obtain P-values and the descriptive statistics revealed a significant difference in mean covariate values between the insured and uninsured groups when other covariates were not controlled. The comparison of maximum and minimum values reveals critical insights into the disparities and effectiveness of insurance programs. Therefore, it is crucial to control for the influence of other factors to mitigate endogeneity problems associated with covariates before assessing the statistical significance of the differences

between groups, so this study developed a model and introduced these covariates into empirical analysis. Furthermore, this study employed the PSM method to evaluate the effectiveness of these covariates.

Estimation and results

Results of baseline regression

Table 2 presents the baseline regression results, revealing the poverty alleviation effect of children's enrollment in social health insurance. Following the statistical methods and results of the descriptive statistics described above, this study considered the incidence of IHE and CHE as dependent variables, and the fixed-effects model was applied in the empirical estimation. Stepwise regression was adopted to enhance the reliability of the regression results. Therefore, all the covariates in Table 1 are controlled for in Table 2. Specifically, in Models 1 and 4, covariates reflecting the individual characteristics of children were added. In Models 2 and 5, covariates reflecting mother characteristics were added. Finally, in Models 3 and 6, covariates reflecting household characteristics were added while controlling for the fixed effects of province and year. According to the regression results in Table 2, when progressively incorporating control variables into the model, the estimation coefficient of $SIS \times SHI$ remains statistically significant and

Table 2 The baseline regression results before PSM: effects of social medical insurance on poverty due to illness

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	IHE			CHE		
SIS × SHI	-0.022*	-0.046***	-0.038***	-0.339***	-0.310***	-0.304***
	(0.012)	(0.013)	(0.012)	(0.018)	(0.020)	(0.018)
SIS	0.056***	0.073***	0.067***	0.427***	0.405***	0.397***
	(0.011)	(0.012)	(0.011)	(0.017)	(0.019)	(0.017)
SHI	-0.005	-0.002	0.005	0.018**	-0.007	0.002
	(0.005)	(0.005)	(0.005)	(0.007)	(0.008)	(0.007)
Child schooling	-0.002	-0.005	-0.003	0.008	0.001	0.008
	(0.004)	(0.004)	(0.004)	(0.007)	(0.007)	(0.006)
Child age	-0.002	0.001	0.002	0.018**	0.027***	0.001
	(0.005)	(0.006)	(0.006)	(0.008)	(0.009)	(0.008)
Child gender	0.038	0.001	0.005	-0.010	-0.003	0.002
	(0.030)	(0.033)	(0.030)	(0.047)	(0.052)	(0.045)
Child residence status	-0.010	0.005	0.004	-0.036***	-0.038***	-0.024**
	(0.008)	(0.008)	(0.008)	(0.012)	(0.013)	(0.012)
Mother health status		0.001	0.002		-0.004	0.001
		(0.002)	(0.002)		(0.003)	(0.002)
Mother age		0.002	0.002		-0.002	-0.001
		(0.002)	(0.002)		(0.003)	(0.003)
Mother education level		0.001	0.001		-0.003**	-0.002**
		(0.001)	(0.001)		(0.001)	(0.001)
Mother covered by medical insurance or not		0.004	0.004		-0.015*	-0.015**
		(0.005)	(0.005)		(0.008)	(0.007)
Mother smoking		-0.023	-0.023		-0.012	-0.018
		(0.021)	(0.019)		(0.032)	(0.028)
Mother drinking		0.012	0.009		-0.017	0.007
		(0.012)	(0.011)		(0.018)	(0.016)
Household size (persons)			0.003*			0.005**
			(0.002)			(0.002)
Having elderly ≥ 60 years old			0.0066*			0.011*
			(0.004)			(0.006)
Log of (Annual) per capita income			-0.059***			-0.014***
			(0.002)			(0.003)
Constant	-0.012	-0.079	0.523***	0.412***	0.364**	0.615***
	(0.075)	(0.098)	(0.092)	(0.118)	(0.153)	(0.139)
Number of samples	17,157	14,209	14,017	17,157	14,209	14,017
R-squared	0.020	0.027	0.194	0.139	0.142	0.173

Note: IHE=Impoverishing health expenditure. CHE=Catastrophic health expenditure. SHI=Social health insurance. S.D. is the standard deviation. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

negative. This indicates that under the impact of severe illness, children's enrollment in social health insurance will significantly reduce the incidence of household poverty due to illness. Additionally, social health insurance for children is critical for guarding against the dilemma of no treatment for illness.

More specifically, based on the results of Model 3 in Table 2, when the dependent variable is assigned as IHE, the estimated coefficient of SIS is statistically significantly positive at a level of 0.01, indicating that the severe illness shock of children is a significant cause of household impoverishment. Furthermore, the estimated coefficient of $SIS \times SHI$ remains statistically significantly negative, indicating that social health insurance for children under severe illness shock will reduce the incidence of IHE by 3.8%. This also demonstrates that social health insurance considerably alleviates poverty. Alternatively, this finding could result from social health insurance focusing on preventing major diseases and covering the costs of severe illness [47]. The estimated results for the other control variables also align with expectations. For example, in Model 3, the larger the household, the higher the incidence of IHE. The existence of senior citizens aged 60 years and over has a similar effect. In contrast, the higher a household's actual income, the lower the incidence of poverty due to illness.

Furthermore, from the perspective of relative poverty due to illness, the effect of social health insurance on the incidence of CHE using Model 6 in Table 2 can be clarified. The empirical results indicate that when an SIS occurs, the incidence of CHE will be reduced by 30.4% for households covered by social health insurance, which explains the prominence of the poverty alleviation effect of social health insurance. Other results were similar to those reported previously. Compared with rural households, the income and resources of urban households are greater and families are capable of bearing additional medical expenses. Therefore, the incidence of CHE is lower in urban households than in rural households. Regarding mother characteristics, the higher the mother's education level, the higher the family income, and the lower the incidence of medical impoverishment (MI). In addition, if the mother is covered by social health insurance, the probability of enrolling children in social health insurance will be higher, reducing the incidence of CHE. When an SIS occurs, social health insurance can relieve the household's financial burden and protect the household from the medical poverty trap.

Diagnostics for PSM

In this study, PSM was performed to address adverse selection issues. As mentioned previously, a balanced panel was constructed by synthesizing the unbalanced panels in 2016 and 2018. The treatment group consisted of children who were not enrolled in social health insurance in 2016 but were enrolled in social health insurance in 2018, whereas the reference group consisted of children who did not enroll in social health insurance in either 2016 or 2018. The balanced panel included 1076 children, with 727 in the treatment group and 349 in the reference group.

As shown in Table 3, the effectiveness of the PSM was evaluated, confirming the balance of the newly matched sample. The covariates controlled for in both waves include child schooling, child age, child gender, child residence status, mother health status, mother age, mother education level, mother covered by medical insurance or not, mother smoking, mother drinking, household size, having elderly, and household income. The summary statistics indicate that the standardized mean difference (SMD) across 11 covariates was less than 5% and the T-values of all the matched sample were not statistically significant at the 10% level. As a result of matching, the systematic differences in covariates between the matched samples became statistically insignificant, and these matched children samples remain largely consistent with the overall population, affirming the validity of the PSM method employed here and the representativeness of children's social health insurance.

Following matching, the impact of children's social health insurance enrollment on household impoverishment due to illness was assessed using the DID approach. As shown in Table 4, the estimated coefficients of $Year \times Insured\,children$ are significantly negative at the 5% level, indicating that PSM-DID effectively handles endogeneity issues. Additionally, a placebo test was conducted by generating 500 "virtual" coefficients, and the results are presented as a scatter plot of P-values versus coefficients (Fig. 3). Most of the coefficients are not statistically significant, supporting the conclusion that severe illness shocks in children contribute to household poverty. Therefore, it can be concluded that children enrolled in social medical insurance can significantly reduce the incidence of IHE and CHE and that social medical insurance can significantly alleviate household poverty due to children's severe illness shocks.

Robustness tests

Using alternative dependent variables

Many proxy variables related to medical impoverishment have been established in previous empirical studies. Therefore, this study validated the regression analysis presented in Table 5 by applying alternative dependent variables. On this basis, health expenditure should be considered impoverishing if it satisfies the following condition. If OOP payments of inpatient care exceed 40% of total household expenditure or OOP expenditure for children accounts for 40% of the annual household

Table 3 The summary statistics of balance test results from pre- and post-matching on covariates

Variable	PSM	Mean		SMD	T-test	
		Treatment group	Reference group	(%)	T-value	*P*-value
Child schooling	Unmatched	0.780	0.559	48.200	6.800	0.000
	Matched	0.775	0.758	3.700	0.680	0.494
Child age	Unmatched	7.896	5.841	46.300	6.440	0.000
	Matched	7.812	7.718	2.100	0.370	0.712
Child gender	Unmatched	0.516	0.544	-5.700	-0.780	0.438
	Matched	0.522	0.501	4.100	0.700	0.483
Child residence status	Unmatched	0.467	0.500	-6.600	-0.890	0.372
	Matched	0.472	0.493	-4.300	-0.730	0.468
Mother health status	Unmatched	2.818	2.678	12.200	1.670	0.095
	Matched	2.800	2.869	-5.900	-1.050	0.295
Mother age	Unmatched	34.281	33.185	16.300	2.250	0.025
	Matched	34.251	34.323	-1.100	-0.190	0.852
Mother education level	Unmatched	3.519	3.459	2.600	0.360	0.719
	Matched	3.539	3.574	-1.500	-0.260	0.794
Mother covered by medical insurance or not	Unmatched	0.887	0.600	69.600	10.320	0.000
	Matched	0.885	0.896	-2.800	-0.630	0.528
Mother smoking	Unmatched	0.010	0.011	-1.000	-0.140	0.890
	Matched	0.009	0.009	-0.700	-0.130	0.897
Mother drinking	Unmatched	0.015	0.004	11.800	1.460	0.146
	Matched	0.002	0.007	-5.200	-1.320	0.188
Household size (persons)	Unmatched	5.017	5.248	-12.000	-1.670	0.096
	Matched	5.036	5.086	-2.600	-0.460	0.648
Elderly	Unmatched	0.188	0.170	4.700	0.630	0.529
	Matched	0.186	0.207	-5.500	-0.900	0.369
Log of (Annual) per capita income	Unmatched	10.996	10.965	2.500	0.360	0.718
	Matched	10.996	11.011	-1.200	-0.220	0.823

Note: S.M.D. represents the standardized mean difference between the treatment and reference groups. The T-statistics are used to test the significance of differences between the treatment and the reference groups

Table 4 Estimated outcomes of PSM-DID note: the dependent variables are IHE and CHE, respectively. "Insured children" represents the treatment group. *p, **p, ***p

Variable	Model 7	Model 8
	IHE	CHE
Year	0.027***	0.054**
	(0.010)	(0.025)
Insured children	-0.008	0.042*
	(0.009)	(0.023)
Year× Insured children	-0.026**	-0.159***
	(0.013)	(0.032)
Constant	0.020***	0.143***
	(0.007)	(0.018)
Covariates	yes	yes
Year fixed effects	yes	yes
Provincial fixed effects	yes	yes
Number of samples	1,962	1,962
R-squared	0.010	0.018

income per capita, then the value will be coded as one. Otherwise, the value will be coded as zero [87]. Table 5 presents the alternative variables in columns (1) and (2). The estimated coefficient of $SIS \times SHI$ is significantly negative. The incidence of household MI is statistically significantly reduced by 29.2% and 28.4%, in columns (1) and (2), respectively. Under these conditions, households have their children covered by social health insurance and the empirical results prove robust.

Taking the impact of commercial health insurance into account

A previous study [77] found that commercial health insurance supplements social health insurance to protect households from MI. To exclude the interference of commercial medical insurance and ensure the comparability of the research objects, this study excluded children with commercial health insurance (CHI) from the empirical analysis. The results are listed in columns (3) and (4) in Table 5. One can see that the incidences of IHE and CHE in households with children insured are significantly reduced by 9.0% and 8.9%, respectively, compared with households with children uninsured suffering severe illness. Therefore, the conclusions are robust.

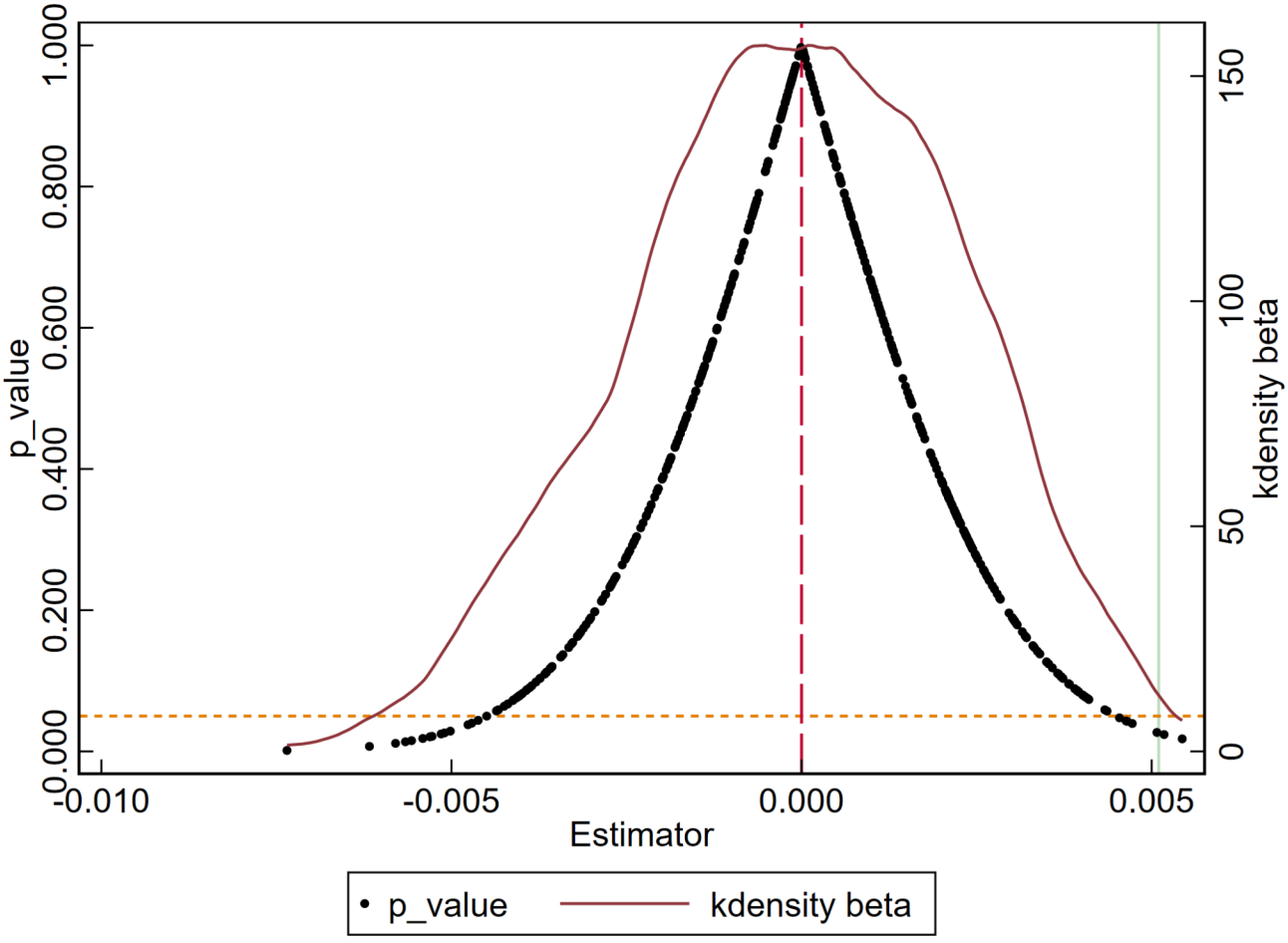

Fig. 3 Placebo test

Excluding the impact of other family members

To ensure robustness, additional tests were conducted on one-child families and households without elderly members or adults with compromised health [32, 65]. This approach aims to exclude the influence of child participants with the same household characteristics and adults' illness severity in the data. The results, presented in Column (5) of Table 5, indicate that one-child families are more likely to experience significant health shocks. Under these conditions, children's enrollment in social health insurance significantly reduces the incidence of CHE by 24.7%. Additionally, excluding households with elderly members and adults with compromised health who have a higher risk of severe illness, as shown in columns (6) and (7), demonstrates that children's enrollment in SHI lowers the incidence of CHE by 30.5% and 28.5%, respectively. These findings affirm the robustness of the conclusions.

Analysis of the poverty alleviation mechanism transmitted by SHI

An empirical model and robustness tests were executed to prove that children enrolling in social health insurance would significantly reduce the incidence of household CHE. Specifically, households with insured children should be less likely to experience impoverishment due to severe illnesses than those without insurance.

Which poverty alleviation mechanisms are facilitated by children's enrollment in social health insurance? As shown in Fig. 1, the mechanism of poverty alleviation is straightforward. When children are covered by social health insurance, a portion of their medical expenses are reimbursed by the healthcare system [88]. This reimbursement allows households to allocate additional resources to health expenditures relative to their permanent CTP, thereby reducing the incidence of CHE. Social health insurance primarily covers inpatient care costs resulting from severe illness [47], indicating that households suffering from high OOP payments for children's inpatient care are more vulnerable to health shocks. This, in turn, examines the importance of children's social

Table 5 The empirical test results: poverty alleviation effect of social medical insurance

Variable	Alternative Dependent Variables				Household characteristics			Poverty Alleviation Mechanism		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	OOP	OOP	CHI	CHI	One-child	Without elderly	With healthy adults	Reimburse ratio	OOP ratio	OOP ratio
SIS × SHI	-0.292***	-0.284***	-0.090***	-0.089***	-0.247***	-0.305***	-0.285***			-0.080***
	(0.014)	(0.012)	(0.017)	(0.024)	(0.032)	(0.026)	(0.030)			(0.029)
SIS	0.354***	0.346***	0.124***	0.194***	0.390***	0.429***	0.401***			-0.020*
	(0.013)	(0.012)	(0.016)	(0.022)	(0.030)	(0.024)	(0.028)			(0.011)
SHI	-0.001	-0.003	0.007	0.008	-0.025**	-0.017*	-0.009	0.037***	-0.036***	-0.020*
	(0.005)	(0.005)	(0.006)	(0.008)	(0.012)	(0.010)	(0.011)	(0.011)	(0.011)	(0.011)
constant	0.900***	0.461***	0.610***	0.137	0.804***	0.686***	0.621***	-0.431*	1.192***	1.038***
	(0.106)	(0.094)	(0.137)	(0.194)	(0.263)	(0.162)	(0.156)	(0.225)	(0.323)	(0.303)
Covariates	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Provincial fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	14,017	14,017	12,150	12,150	10,990	13,453	10,427	14,017	11,059	11,059
R-squared	0.251	0.245	0.227	0.067	0.130	0.128	0.132	0.012	0.008	0.126

Note: IHE = Impoverishing health expenditure. CHE = Catastrophic health expenditure. SIS = Social health insurance. CHI = commercial health insurance. OOP = Out-of-pocket medical payments. S.D. is the standard deviation. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

health insurance in ensuring reimbursed medical services that are provided to transcend economic crises.

To verify this transmission mechanism, this study calculated the amount of children's hospitalization reimbursement and OOP ratio for the past year, and clarified the role of social health insurance in using Medicare and relieving the financial burden of OOP medical payments. The empirical results are presented in Table 5. The estimated coefficient for children with social health insurance in Column (8) is statistically significantly positive at the 1% level, indicating a positive impact of children's social health insurance on hospitalization reimbursement. With the backstop guarantee of social health insurance to help those most in need, the utilization of healthcare services for children is significantly increased. When comparing columns (9) and (10), one can see that children's enrollment in social health insurance can significantly reduce the household OOP ratio for medical expenses. Under the influence of a severe illness shock in Column (10), the reduction in the OOP ratio for children's medical expenses is even more pronounced, indicating the existence of a cost compensation mechanism associated with social health insurance in the younger children's division. Overall, the effect of the backstop guarantee is prominent.

Heterogeneity analysis

Heterogeneity analysis based on urban and rural areas

Compared with urban areas, the incidence of no treatment for minor illnesses and weak treatment for severe illnesses is higher in rural areas [42, 67]. A critical reason for the incidence of illness-induced poverty and poverty due to illness is the relatively high rate of OOP medical payments [36, 88]. Therefore, the poverty alleviation effect of children's health insurance may vary between urban and rural areas in China. To address heterogeneity, this study divided the sample of households into rural and urban households according to the place of household registration. The regression results for each group are presented in columns (1) and (2) in Table 6. Under severe illness shock, the results indicate that the poverty alleviation effect of social health insurance mainly exists in rural families. In other words, the effect is more significant in rural areas. As a result of backward medical systems and services, the household financial burden of severe illness can be effectively relieved when children in rural areas are covered by social health insurance. In contrast, households in urban areas with relatively higher incomes and better medical resources are more capable of bearing medical expenses, which can be considered a counteracting factor for the poverty alleviation effect.

Heterogeneity analysis based on household income

Regarding potential heterogeneity in the income distribution, the sample that included households with children interviewed was separated into low-income and middle-high-income groups according to the per capita annual income of each household. As shown in columns (3) and (4) in Table 6, low-income households comprised 32% of the sample, whereas middle-high-income households

Table 6 Results of the heterogeneity analysis

Categorical variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Urban	Rural	Low-income	Middle-high income	Left-behind	No-left-behind	Infancy	Early childhood	Adolescence
SIS × SHI	-0.011	-0.056***	-0.165***	0.004	-0.024	-0.068***	-0.115***	-0.007	0.032
	(0.015)	(0.020)	(0.043)	(0.006)	(0.042)	(0.017)	(0.028)	(0.035)	(0.026)
SIS	0.022	0.103***	0.251***	0.004	0.073*	0.090***	0.144***	0.014	0.0149
	(0.014)	(0.018)	(0.040)	(0.005)	(0.040)	(0.016)	(0.025)	(0.033)	(0.025)
Children insured	0.001	0.009	0.024	0.002	0.018	0.001	0.033**	0.0119	-0.001
	(0.005)	(0.008)	(0.017)	(0.002)	(0.015)	(0.006)	(0.014)	(0.017)	(0.007)
Constant	0.521***	0.617***	1.090***	0.009	0.490**	0.525***	0.635***	0.960***	0.588***
	(0.089)	(0.179)	(0.237)	(0.050)	(0.219)	(0.147)	(0.227)	(0.366)	(0.151)
Covariates	yes	yes	yes	yes	yes	yes	yes	yes	yes
Year fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Provincial fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	6,089	7,928	4,449	9,567	3,249	10,631	3,604	3,050	7,333
R-squared	0.205	0.209	0.383	0.010	0.152	0.236	0.250	0.145	0.233

Note: The dependent variable is impoverishing health expenditure in this analysis from the perspective of extreme poverty. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

comprised 68%. Children's enrolment in social health insurance has a poverty-reducing effect on low-income families when a severe illness shock occurs. However, this effect is not significant in middle-to-high-income families. One possible explanation for this heterogeneity is that high medical expenditure is a heavy burden for low-income households and they are more prone to be caught in the trap of poverty due to illness, and relatively low-income households can recoup most medical expenses through social health insurance, which may enhance the risk tolerance of severe illness for such households.

Heterogeneity analysis based on left-behind children

With the advancement of urbanization in China, many rural laborers have moved across regions, resulting in a large number of left-behind children. In previous studies, left-behind children were found to be associated with higher health risks and lack of parental care [62]. To examine the heterogeneity between left-behind and non-left-behind children, this study presents results for these groups in columns (5) and (6) in Table 6, respectively. Under a severe illness shock, the poverty-reducing effect of social health insurance is not notably reflected in the left-behind children group. Possible explanations for this result are as follows. Left-behind children are generally taken care of by their grandparents, and grandparents are relatively less concerned about their grandchildren's health, which may lead to severe illness risks for left-behind children. Additionally, grandparents of left-behind children are generally uneducated, which leads to insufficient medical utilization and a low rate of insured children. The role of social health insurance in terms of compensation costs is also restricted.

Heterogeneity analysis based on different age groups

This study conducted a heterogeneous analysis to examine the impact of children's participation in social medical insurance across different age groups. Children were categorized into three age groups based on UNICEF developmental stages: infancy (0 to 3 years), early childhood (4 to 6 years), and adolescence (7 to 15 years). The results of this analysis are detailed in columns (7) to (9) in Table 6. Infants were found to be the most significantly affected by social medical insurance coverage among the age groups, which is consistent with the findings from related research [86]. Infancy is the most fragile growth period for children with frequent healthcare needs and high medical expenses. Early enrollment in social medical insurance helps households mitigate financial strain and avoid falling into a medical poverty trap. Families with infants often face significant financial adjustments, making them particularly vulnerable to economic hardships and health-related shocks. As children grow older, families become better equipped to manage medical costs, health service utilization, and the opportunity costs of time lost from school and work [90]. Therefore, prioritizing the social insurance system for younger children can result in long-term benefits such as better health status, improved education outcomes, and increased future earnings [68, 85, 91, 92].

Discussion and conclusion

The results of the above analysis indicate that children's participation in social health insurance significantly reduces the likelihood of families falling into poverty because of illness. Without severe illness, the impact of children's social health insurance on IHE and CHE is limited. However, in cases of severe illness, the incidence rates of these two expenditures are reduced by

3.8% and 30.4%, respectively. These findings demonstrate the poverty alleviation effect of social health insurance for children. Additionally, a series of robustness tests confirmed the credibility of these results. Mechanism analysis revealed that children's social health insurance is more likely to reimburse inpatient expenses, substantially reducing the OOP ratio of medical expenses. Heterogeneity analysis indicated that the poverty alleviation effect varies across regions, households, and individuals. Notably, children's social health insurance is most effective for rural areas, low-income families, non-left-behind children, and infants.

Policies aimed at enhancing children's health insurance coverage are essential for alleviating illness-related poverty. First, expanding childre's health insurance coverage could help eliminate poverty due to illness. Studies have shown that a considerable proportion of uninsured children, including preschool children, children of low-education parents, and children without household registration, have substantial health risks [55]. Perspectives on poverty alleviation strategies targeting these marginalized groups and areas would enrich current insurance studies in China. Measures such as targeted Medicare policy advocacy, automatic Medicare coverage for children whose parents are insured, and allowing children to be covered without household registration restrictions should be adopted to expand health insurance coverage. In the long term, formulating a child-oriented Medicare plan to meet the needs of children in rural households is crucial. Direct financial assistance through children's social health insurance and health services may guarantee health security.

Social health insurance positively impacts households by reducing health expenditure as it increases the reimbursement for hospitalization and reduces OOP medical expenses. Therefore, optimization of social health insurance coverage modes is recommended. Such optimization includes extending the scope of reimbursable medical care, such as upgrading medical assistance from inpatient to outpatient care on a pooled basis, improving the current level of benefits packages for Medicare, and increasing the current percentage of reimbursement. Specific proposals include increasing child health check-up items, the frequency of children's illness screening, and reimbursement ratios while reducing related inspection fees to protect families from the vicious cycle of illness-poverty-illness.

Considering the heterogeneous effects of social health insurance on poverty alleviation, a "common but differentiated" principle should guide policy recommendations. In other words, greater policy attention should be devoted to left-behind children and infants. Specifically, government subsidies should be further increased to support left-behind children and infants, including contributing direct financial assistance through children's health insurance, optimizing reimbursement system in terms of lowering the payable benefit standard, maximizing the capping standard, improving the amount of reimbursement granted for inpatient and partial outpatient care, and providing regular health checkups to reduce household health risks. These policy proposals are crucial for reducing poverty among left-behind children and infants. Furthermore, perspectives on poverty-alleviation strategies of social health insurance primarily focus on younger children. Future research should broaden its scope to include other vulnerable populations. This entails targeting broader demographics, conducting longitudinal analyses, and incorporating diverse socio-economic variables to ensure the equity and efficiency of health system reforms, which ultimately benefits all individuals when sharing the fruits of reform and development.

Abbreviations

AHE	Annual health expenditure
AHI	Annual household income
ATE	Average treatment effect
CMS	Centers for Medicare & Medicaid Services
CHE	Catastrophic health expenditure
CHIP	Children's Health Insurance Program
CFPS	China Family Panel Studies
URBMI	China's Urban Resident Basic Medical Insurance
NRCMS	China's New Rural Cooperative Medical Scheme
IHE	Impoverishing health expenditure
ISSS	Institute of Social Science Survey
IPRCC	International Poverty Reduction Center in China
NMCES	National Medical Care Expenditure Survey
NMES	National Medical Expenditure Survey
MI	Medical impoverishment
NHS	National Health Service
NCMS	New Cooperative Medical Scheme
NHB	Non-health budget
PSM-DID	Propensity Score Matching with difference-in-differences
SIS	Severe illness shock
SHI	Social health insurance
SMD	Standardized mean difference
OOP	Share of out-of-pocket
UEBMI	Urban Employee Basic Medical Insurance
WHO	World Health Organization

Acknowledgements

The data used in this study is from the China Family Panel Surveys (CFPS) organized and managed by the Institute of Social Science Survey (ISSS) of Peking University. The authors are thankful to the institution for the shared data.

Author contributions

Jiali Zhou and Sijie Chen wrote the main manuscript; Jiali Zhou reviewed the draft and made contributions to the interpretation of data; Yong Zhan was responsible for funding acquisition and supervised the main manuscript; Huashuai Chen supervised the main manuscript and original data curation. All authors reviewed the manuscript.

Funding

The authors gratefully acknowledge funding from the National Social Science Found of China for the key project 'Research on Optimization of the Social Security System for Chinese Retired Soldiers in the New Era' (grant number 21AJY009 & 23AZD074).

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 31 March 2024 / Accepted: 9 September 2024
Published online: 30 September 2024

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