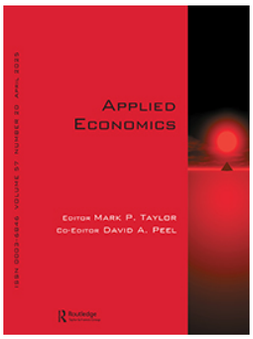

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Parental health shocks, and upward mobility of children's income in China

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ABSTRACT

This study examines the relationship between early parental health shocks and children's future income upward mobility in China. We employ the timing of major acute health events to measure the parental health shocks and use CEM-PS matching to control for potential endogeneity between parental health and children's economic outcomes. We find strong evidence of a negative effect of parental health shocks on children's initial income levels upon entering the workforce. This effect is more pronounced for those from low-income families, families without medical insurance, and those with parents working in the non-public sector. Our results suggest that parental health shocks decrease the probability of children attaining higher education levels. We find that the impact of the father's health shocks is more pronounced than that of mothers, and the upward mobility of female children is more affected than that of male children. This study contributes to the literature on intergenerational impacts of health shocks, human capital transfer, and coping mechanisms in developing countries.

KEYWORDS

Parental health shocks; upward mobility; intergenerational income; China Health and Nutrition Survey

JEL CLASSIFICATION

D31; I13; I14; J18

I. Introduction

Debilitating illnesses can dramatically increase healthcare expenses and reduce income and consumption for resource-limited households in developing countries (Wang et al. 2023). Where market and public insurance provisions are limited, in developing economies, families undertake risk-sharing strategies (K. Liu 2016) that include borrowing, and asset divestiture, to ease the immediate financial burden (Wagstaff and Lindelow 2014). Empirical evidence indicates that such coping mechanisms often force trade-offs between immediate needs and long-term sustainability (Bird and Prowse 2009), including withdrawing children from school (Björklund and Salvanes 2011; Guryan, Hurst, and Kearney 2008; Jacoby and Skoufias 1997) impairing children's future economic prospects (Joergensen, Urhoj, and Andersen 2018; Kristiansen 2021). While studies have examined how parental health shocks affect children's education (Alam 2015; Bratti and Mendola 2014; Dhanaraj 2016; Mendolia, Nguyen, and Yerokhin 2019), evidence on long-term economic impacts across generations remains limited. Using longitudinal data from China, we ask, do parental health shocks influence the labour market outcomes of the younger generation in developing countries? Do these impacts disproportionately affect female children? To what extent do these effects persist? Empirical answers to these questions help understand the costs of family risk-sharing and provide insights into the potential benefits of market and social insurance reforms in developing countries.

Becker and Tomes's (1986) theoretical framework illuminates how parental health shocks influence children's future economic outcomes. Their model posits that in perfect markets, families can separate consumption from investment decisions, with investment choices determined purely by return rates (Jacoby and Skoufias 1997), allowing them to invest optimally in children's education regardless of wealth. However, imperfect markets in low-income countries lack mechanisms to smooth consumption, forcing families to prioritize immediate needs over education when faced with health shocks (Jensen 2000). These health shocks

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impact children's human capital beyond finances. Poor health reduces parental involvement in children's education (Haveman and Wolfe 1995). Parents shift time from childcare to health-related activities (Alam 2015), especially during hospitalization and recovery (Bratti and Mendola 2014). Children, particularly those with ill mothers, often take on more household duties, reducing study time (Dinku, Fielding, and Genç 2018). Additionally, the parent–child bond means children face stress from their parent's illness and treatment (Osborn 2007).

This paper investigates the relationship between parental health shocks and children's income upward mobility. Our objective is to quantify the impact of early-stage diagnoses of major chronic diseases in parents, such as stroke, tumour, and cardiac infarction, which have long-lasting and significant effects on family finances (hereinafter referred to as parental health shocks), on the upward mobility of children's initial income levels upon entering the workforce.

The empirical analysis follows three steps. First, we define parental health shocks as the first occurrence of unexpected acute cardiovascular or cerebrovascular events, such as non-fatal strokes or heart attacks. These events are major causes of disease burden in China (Zhou et al. 2019) and globally (Johnson et al. 2016), and are considered acute emergencies with unpredictable timing (Doyle 2011; Fadlon and Nielsen 2019, 2021). This definition allows us to use the unexpected timing of these events as a source of exogenous variation in health outcomes. Second, we use the CEM-PS algorithm to control for observable heterogeneity among individuals and their families. This ensures comparability between the treatment group (those experiencing the first parental health shock) and the control group (those who never experienced a parental health shock during or before the sample period) in terms of characteristics observable before the parental health shocks. Third, we estimate fixed-effects (FE) models for individuals and survey waves on the matched samples to control for unobserved heterogeneity and potential long-term trends. Overall, the CEM-FE design enables us to estimate the average treatment effect on the treated (ATT) for families experiencing parental health shocks.

We find three main results. First, parental health shocks significantly reduce the likelihood of upward income mobility for children when they first enter the workforce, with father's health shocks having a stronger impact statistically. Second, children from low-income families and those whose parents work in the non-public sector are disproportionately affected by parental health shocks. In contrast, children from high-income families and those with parents in the public sector show resilience against these shocks. Third, our estimates indicate that parental health shocks decrease the likelihood of children securing a place in high school and college by 0.154 and 0.291, respectively.

This paper contributes to the literature in three ways. First, existing studies in developing countries primarily focus on household consumption and income-related outcomes (e.g. Ghatak and Madheswaran 2011; Wagstaff 2007). Former research has examined the long-term consequences of parental loss during the American Civil War on children's occupational and economic trajectories (Dupraz and Ferrara 2023), the effects of early-life famine experiences on subsequent family commercial insurance demand (Wang et al. 2023), and the impacts of parental unemployment on intergenerational mobility, highlighting nuanced influences on educational decisions and future income potential (Hilger 2016). To our knowledge, this study is the first to use panel data with individual fixed effects to investigate the impact of early paternal health shocks on the future economic outcomes of offspring. By analysing parental health shocks in a representative sample of Chinese families, our findings reveal the long-term causal effects of parental health shocks on younger generation's income upward mobility and environments in China and other developing countries with similar healthcare systems.

Second, we contribute to the literature on the intergenerational transfer of human capital. Previous research has shown that parents' socioeconomic status affects children's health, which in turn hinders their future educational and labour market outcomes, thereby impacting their socioeconomic status (Case and Paxson 2011; Currie 2009). Here, we explore a different channel: we examine whether parents' health (partially determined by their

socioeconomic status) affects children's future economic outcomes. This paper also adds to the literature on consumption smoothing and coping mechanisms employed by families facing shocks (Feng et al. 2020; K. Liu 2016). Our findings suggest that families reduce children's schooling to mitigate the impact of parental health shocks. It should be noted that while this paper and previous literature mainly focus on the education channel, parental health shocks may also affect upward mobility through other channels, such as children's psychological distress and lack of parental supervision, making educational investment less worthwhile for families (Aaskoven, Kjær, and Gyrd-Hansen 2022).

Finally, due to data limitations, research on health shocks in developing countries predominantly relies on self-assessed health status, all-cause hospitalization, or rare events such as family member deaths as metrics, using cross-sectional differences to evaluate the relationship between health status and labour market outcomes. P. Gertler and Gruber (2002) found that in Indonesia, deteriorating health of the head of household reduced labour supply and income. Wagstaff (2007) and Mitra et al. (2016) provided evidence from Vietnam showing that health shocks significantly reduced consumption, income, and labour supply, especially in uninsured families. Ghatak and Madheswaran (2011) documented that health issues in India led to an average 21.6% decrease in annual household income, with the rural poor being particularly affected. Here, we advance the existing literature by focusing on a series of acute and unforeseen health shocks, using their first occurrence as an indicator of health changes. We employ nationally representative longitudinal data from the China Health and Nutrition Survey (CHNS) from 1989 to 2015, which records and tracks the detailed medical histories of family members. This enables us to track the occurrence of parental health shocks and observe changes in various family socioeconomic and health outcomes. We also employ CEM-PS Matching with individual fixed effect methods to control for both observable and unobservable heterogeneity among patients and households. This approach allows us to isolate the impact of adverse health events on economic outcomes from other potential long-term trends and address the potential endogeneity of self-reported health status to economic conditions.

The remainder of this paper is organized as follows: In Section II we briefly introduce the medical insurance system and the difference in household economic status between urban and rural areas in China. Section III discusses the identification strategy used to evaluate the effect of the parental health shocks on upward mobility. In Section IV we describe the data. Section V presents regression results. Section VI briefly concludes this research.

II. Coping with health shocks in China (1989–2015)

Medical insurance system

Access to medical insurance serves to protect families from the negative financial effects of health shocks. In China, the medical insurance system was initially established in the 1950s, and by the end of the 1970s, nearly all households in urban areas and over 85% of rural households had access to universal health insurance through the Cooperative Medical Scheme (CMS). However, due to inadequate public funding, the CMS collapsed, leaving around 90% of rural households uninsured by 1989 (Yip and Hsiao 2008). The National Medical Service Survey also revealed a decline in urban medical insurance coverage from 54% in 1993 to 39% in 1998.

During our sample period, there have been efforts to expand the coverage and efficiency of China's medical insurance system. The government has increased subsidies, with a focus on providing larger subsidies for underdeveloped regions in central and western China. In 1998, a basic medical insurance system for employees was established, and in 2003, rural areas began implementing the 'new rural cooperative medical insurance' system, with the goal of covering all Chinese rural counties by 2008. In 2007, the basic medical insurance system for urban residents was introduced, with funding sources roughly farmers: urban residents: corporate employees = 1:2:8 (Wenjiong 2014).

Despite these efforts, China's medical insurance system has low reimbursement rates and limited coverage (Lixiang, Lu-An, and Xiao-Ou 2017).

Patients meet most of medical expenses, with no significant difference in medical expenditures between urban and rural areas, but a lower level of rural funding. This exacerbates the negative impact of health shocks on disadvantaged groups, particularly rural residents.

Furthermore, working in the public sector in China offers more protection from health shocks and greater access to the medical insurance system (Ma 2018). This difference becomes particularly pronounced when the family faces health shocks.[1] Shiu (2014) identifies job mobility in relation to the availability of employer-provided health insurance. Meanwhile, Devkota and Upadhyay (2015) unpack health disparity dynamics in four developing countries, uncovering that health disparity is dependent significantly on income differences. Finally, C. Liu and Eriksson (2023) point out that maternal educational improvement, inspired by a legislative change, positively impacts child health and nutrition. In contrast, Zhu and Yu (2023) note that increasing education expenditure dampens Chinese households' subjective well-being due to an education 'arms race'.

In conclusion, the issue of parental health shocks and their impact on upward mobility in China highlights the need for a comprehensive approach that addresses not only access to medical care but also the financial protection provided by insurance. Without adequate protection, families are at risk of falling into poverty and being unable to achieve upward mobility.

Household economic status, urban and rural areas

Formal insurance and credit markets in China are less developed, leading to low or non-existent health insurance coverage for low-income households. In a nationally representative sample of Chinese households, Wang et al. (2023) found that out-of-pocket medical expenses average 31% of annual household income, a much higher percentage than in developed countries (2.6% in the United States, Dobkin et al. 2018). This indicates that ordinary Chinese families are particularly vulnerable to the financial impacts of major illnesses. Mommaerts, Raza, and Zheng (2020) found that, in a sample of Chinese elderly (aged 50 to 59), direct out-of-pocket hospitalization expenses increased by a staggering 93% after admission, a figure significantly higher than in the United States (2.9%) and European countries (1.5%). To mitigate the negative effects of health shocks, these households deplete savings, sell assets, borrow from informal financial markets, or rely on family support (Del Valle 2021). Risk-sharing mechanisms, such as health insurance, can help prevent families from falling into a poverty trap.

Family savings play a critical role in providing a safety net against health shocks (Ren, Rammohan, and Wu 2014; Wagstaff and Lindelow 2008). However, higher income individuals and households generally have a stronger ability to resist risks and accumulate health capital, making them less vulnerable to health shocks compared to low-income groups (Yingfeng and Wei 2013). In addition to income disparities, the dual economic structure of urban and rural areas in China also creates significant differences in the income levels and social security systems of households in these areas.[2] Health care systems in rural areas are often less developed and less accessible compared to those in urban areas (Deng et al. 2021). This further exacerbates the vulnerability of rural households to health shocks and the financial burden they may face.

In conclusion, the lack of access to formal insurance and credit markets, combined with income disparities and the dual economic structure of urban and rural areas in China, can make low-income households particularly vulnerable to the negative effects of health shocks. To mitigate these risks, it is crucial to expand access to health insurance and risk-sharing mechanisms, particularly for low-income households. This can help prevent families from falling into poverty traps and ensure they have the necessary financial protection to smooth consumption in case of health shocks.

III. Methods

Theoretical framework

To motivate our empirical strategy, we use a simple conceptual framework following Becker (1981) and

[1]The public sector is defined as government agencies, state-owned institutions and research institutes, state-owned enterprises, big collectively owned factories (county-owned, municipal, provincial).
[2]SeeLixiang, Lu-An, and Xiao-Ou (2017) for differences in health system support.

Bratti and Mendola (2014). Becker theorizes that household resource allocation decisions are made jointly by members based on their bargaining power. Parents make collective decisions about children's human capital investments while maximizing household welfare under constraints. Parental health status affects these investments through both financial and time resources. Bratti and Mendola's (2014) extend this by emphasizing how parental health shocks can affect the intergenerational transmission of economic opportunities. Their model suggests that parental investments in children's quality, particularly in terms of 'money' and 'time' investments, are shaped by the family's resources and the parents' health status. Building on these frameworks, we argue that parental health shocks, significantly affect both financial and time-based investments in children. While much of the literature focuses on schooling outcomes (Heckman 2007), we investigate the broader implications of parental health shocks on children's upward income mobility, considering not just educational attainment, but also long-term economic outcomes.

To operationalize this framework, we start by considering the relationship between parental health shocks and children's income mobility. The key hypothesis is that parental health shocks reduce both the financial and time investments in children's education, which in turn hampers their potential for upward income mobility. We specify this relationship as follows:

$$Y_{it} = f(F_{it}, S_{it}, SX_{it}) + \varepsilon_{it} \tag{1}$$

where i and t are individual and time identifiers; Y_{it} is a discrete variable which represents the income mobility of children's income. $Y_{it} = 1$ if children's income moves upward, and 0 otherwise; F_{it} is the investment by parents on their children; S_{it} is the human capital of child i in period t; SX_{it} includes the information of children's characteristic; ε_{it} is a stochastic disturbance term.

F_{it} arises out of the optimal parental decision (Becker 1981), and closely relates to the health status of parents. When the parents are in poor physical condition, family expenditure on health care increases reducing resources for human capital investment on children (Frankenberg, Smith, and Thomas 2003). Often, children are forced to drop out of school or work to fill the debt gap caused by parental incapacity (Jacoby and Skoufias 1997). H_{it} represents the health status of the father or the mother, w_{it} stands for paternal characteristics that change over time (income and occupation), and p_i be the time-invariant parent characteristics (gender and education), so F_{it} can be represented as:

$$F_{it} = F(H_{it}, p_i, w_{it}) \tag{2}$$

We can differentiate F_{it} from 'money investment' and 'time investment'. M_{it} is the money that parents invest; T_{it} represents the time invested; a_i and ρ_i are the unobservable factors, standing for the child's inherited ability and the parents' intertemporal discount rates (Luca and Bloom 2018), then we have:

$$M_{it} = M\left(F_{it}, H_{it}, p_i, w_{it}, \alpha_i, \rho_i\right) \tag{3}$$

$$T_{it} = T\left(F_{it}, H_{it}, p_i, w_{it}, \alpha_i, \rho_i\right) \tag{4}$$

S_{it} is determined by human capital input $F_{it}(M_{it}, T_{it})$ accumulated in the past and individual characteristics of the children SX_{it}, which yields:

$$S_{it} = S(M_{it}, T_{it}, SX_{it}) + \varepsilon_{it} \tag{5}$$

ε_{it} is the random term. H_{it} depends on the individual characteristics of parents as well as factors that affect how much parents invest in their health, like the discount rate, education, and income levels (Lleras-Muney 2005). So, we have:

$$H_{it} = H\left(p_i, w_{it}, \rho_i\right) + \mu_{it} \tag{6}$$

Where μ_{it} is a random term. Based on (2) to (5), Equation (1) can be represented more concisely as:

$$Y_{it} = f(H_{it}, SX_{it}) + \acute{\alpha}_i \acute{\rho}_i \varepsilon_{it} \tag{7}$$

It should be noted that, assuming $f(.)$ is a linear function, and α_i and ρ_i are respectively linear functions in child ability and the intertemporal discount rate, the error term becomes $\delta_{it} = \acute{\alpha}_i \acute{\rho}_i \varepsilon_{it}$. So H_{it} is correlated with the error term and endogenously related to unobservable factors. In order to effectively analyse this issue, it is necessary to employ robust and nuanced methodological approaches. One key aspect of this is to incorporate the individual fixed effect of children in the estimation process. This allows for the elimination of any time-invariant, unobserved factors that may

confound the analysis. A probability model based on Equation (7), as outlined in Equation (8), is established to estimate the impact of parental health shocks on the upward mobility of children's income:

$$upward_i = \alpha_0 + \beta shock_i + \delta_c + \delta_t + \mu_i + \varepsilon_{it} \quad (8)$$

Where $upward_i$ represents the upward mobility (1 = yes, 0 = no), μ_i is the individual fixed effects of children, δ_c and δ_t are the regional fixed effects and time fixed effects, and ε_{it} is the random term. $shock_i$ = 1 for households in the treatment group, $shock_i = 0$ for households in the control group.

CEM-PS matching

To handle potential bias from parental characteristics, such as income level, behavioural habits, and education level, we combine Coarsened Exact Matching (CEM) and Propensity Score (PS) estimation. This controls for factors correlating with parental health shocks, removing endogeneity bias. We use CEM to construct matched groups, coarsening variables into strata and weighting households based on health shock exposure. To preserve information, we add PSM using numerical covariates (parents' income, education, age) as proposed by Pohl, Neilson, and Parro (2014), dividing scores into five portions for a second CEM round.

Our three-stage matching process unfolds as follows: First, base CEM matching using categorical variables (public sector employment, insurance, Hukou status). Second, PSM using numerical covariates to estimate health shock propensity. Third, we combine PS with initial CEM covariates for secondary matching. Unmatched samples are removed. Table 1 details the matching variables. The specifics regarding the weights of the CEM-PS matching will be presented in the Appendix.

The CEM-PS matching process leads to a significant decrease in the overall imbalance of covariates in the treated and control groups. This reduction, quantified by the L1 statistic (Iacus, King, and Porro 2012), falls from 0.25 to 0.06 for categorical covariates and from 0.29 to 0.04 for the propensity score of numerical covariates. Detailed information about the entire sample before and after matching with weights generated by the CEM-PS algorithm can be found in Table 2.

IV. Data source and variable definition

Data source

This study uses the China Health and Nutrition Survey (CHNS), which provides detailed health

Table 1. Covariate preprocessing of the CEM-PS matching.

Covariates	Explanation	Coarsening procedure
Education.	Education has a significant impact on the health of individuals. For example, education level will affect their health literacy, including basic knowledge and idea of health and healthy lifestyle and behaviour, etc., which affects the health of the individual.	We cod the education level according to the discretization of years of education in the educational system in China, which corresponds to 0=never been to school; 1=elementary school; 2 =middle school; 3=high school;4 =technical school; 5=college; 6=graduate and above, and we input the education level of the parents as covariates of the PSM.
Age.	With the increase of age, all aspects of the body's function gradually degenerate, and the health status of residents will decline with age especially for middle-aged and elderly people.	input as covariates of the PSM
Income.	Economic status and income also affect health, specifically in the two aspects of prevention and treatment: in terms of prevention, high-income people are more likely to obtain good nutrition and form a healthy lifestyle, and they have easier access to quality medical and health services in the treatment aspect.	input as covariates of the PSM
Institutional factors.	In China, the difference between the nature of the work unit will also affect individual health status. The labour force of state-owned units (public sector) in China has a better health status than those in non-state-owned units (non-public sector) (Ma 2018)). This may be explained by the difference of the free insurance and other benefits like less expensive healthcare. Besides, we also include the information of individual medical insurance (with or without) and the types of jobs (white collar, blue collar and others). Studies show that there is a wide gap between the urban and rural places in the provision and quality of medical services and other local public goods in China, which might lead to the difference in health status. And we consider this according to one's Hukou.	The nature of a person's employment is coded as: working in the public sector = 1; working in the non-public sector = 0. The information of individual medical insurance: with medical insurance = 1; without = 0. Different types of jobs: white collar = 1; blue collar = 2; others = 3. Hukou: city = 1; rural = 0.

Table 2. Imbalance checking for the matching.

			Univariate imbalance						
		Multivariate L1 distance		L1	mean	min	25%	50%	75%	max
Categorial covariates	Before Matching	0.25334717	Working in Public sector (Parent)	0.08345	0.08345	0	0	0	0	0
			Medical insurance (Parent)	0.20497	0.20497	0	0	1	0	0
			City (Hukou)	0.09934	−0.09934	0	−1	0	0	0
			Type of job (Parent)	0.14465	−0.25731	0	0	−1	0	0
	After Matching	0.06010652	Working in Public sector (Parent)	0.02821	0.02821	0	0	0	0	0
			Medical insurance (Parent)	0.04347	0.04347	0	0	0	0	0
			City (Hukou)	0.01873	−0.01873	0	0	0	0	0
			Type of job (Parent)	0.04003	−0.07605	0	0	0	0	0
P-score for numerical covariates	Before Matching	0.28649558	P-score	0.2865	0.89623	0	1	1	1	0
	After Matching	0.03901626	P-score	0.03902	0.11973	0	0	0	0	0
Numerical covariates	Before Matching	0.72322749	Parents's age	0.34964	9.8218	3	9	11	11	−4
			Parents's income	0.20254	0.61686	1.832	0.471	0.55	0.52	−1.1485
			Parents's education	0.09449	0.17859	0	0	0	0	0
	After Matching	0.55516292	Parents's age	0.10575	1.209	5	3	1	0	−8
			Parents's income	0.06342	0.1957	2.89	0.104	0.14	0.06	−0.2149
			Parents's education	0.04887	0.07616	0	0	0	0	0

and medical information, income status and other social-demographics characteristics of household members, as well as follow-up surveys conducted in 1989, 1991, 1993, 1997, 2000, 2004, 2006, 2009, 2011, and 2015. The surveys covered nine provinces (Heilongjiang, Liaoning, Shandong, Henan, Jiangsu, Hubei, Guizhou, Hunan, and Guangxi), covering provinces in eastern, central, and western regions of China, including urban, rural areas, and suburbs of different development levels. The sample is highly representative, providing a sound database for the investigation of the intergenerational impact of parental health shocks.

Despite its comprehensiveness, the CHNS has limitations including missing observations, measurement errors, and potential recall bias. In pursuit of a robust analysis, we process the data in several steps. We included only samples where the age gap between parents and children ranged from 18 to 40 years to avoid skewness from households with unusual age gaps. In the treatment group, which includes households that have experienced parental health shocks, we used the affected parents' individual information. For the control group, we leveraged the 'head of the household' information as a proxy for parental data, thus ensuring clear parental representation. We removed samples with ambiguous or missing information to ensure the integrity of our data, and the education of the parents and children was recoded for more granular analysis.

Parental health shocks

The diverse definitions of health shocks in the literature include catastrophic household expenditure (Islam and Maitra 2012), changes in self-rated health status (Hafner and Lochner 2022), modifications in activities of daily living (M. Gertler and Trigari 2009), and bifurcating health shocks into acute and chronic categories (Del Valle 2021). Each of these measurements brings its unique challenges. For instance, the self-rated health status is prone to measurement inaccuracies and can be distorted by personal bias, resulting in skewed estimates. Additionally, there is a body of literature that suggests certain health shocks, such as family member mortality or injuries due to accidents, can exhibit unpredictable patterns and may be regarded as exogenous (Alam 2015).

In light of these considerations, this study adopts a definition of health shocks as unanticipated, significant illnesses including stroke, tumour, and cardiac infarction that exert long-lasting, considerable effects on family finances. This operationalization is corroborated by scholarly consensus (Pohl, Neilson, and Parro 2014) and provides a clear demarcation of health shocks that exact a substantial toll on both the individual and household units. We use data from two survey question sets to capture parental health shocks. The first set asks whether an individual has ever been diagnosed with

diabetes, myocardial infarction, tumour, or stroke. If yes, a second set records the diagnosis age for each condition. Combining birth year and earliest diagnosis age determines the first year of severe illness, consistently available for respondents 18 or older across all waves. The specifics regarding the construction of the household-level parental health shock will be presented in the Appendix.

Income construction and earnings distribution

In this study, *Individual income* combines all income sources for a single household member, including business, farming, fishing, gardening, livestock, wages, and retirement income. This excludes household-level income like subsidies. All values are adjusted to 2015 Yuan. *Adult children's income* represents their average annual earnings during their first decade of employment, adjusted to 2015 Yuan. *Parental income* for shock-affected cases uses the average annual income from 10 years before the shock, in 2015 Yuan. For unaffected cases, we used average income between ages 24–35.

To calculate the *Relative Position of Income* for both adult children and parents, we compared each individual's income to the average income of their peers, defined as those born within a five-year range of their birth year. The relative income position (z-score) was computed by subtracting the peer group mean from the individual's income and dividing by the peer group's standard deviation. For adult children, this measure is based on income during their first decade in the workforce, while for parents, it is based on income 10-years prior to the health shock (or between ages 24–35 for the control group). Detailed information about the process of income calculation and the distribution of income variables can be found in the appendix.

Upward income mobility

We define *upward income mobility* of adult children as the situation where the relative position of adult children 's income exceeds that of their parent's income. More specifically, the relative income position of the adult children refers to the decadal average income of the offspring in the first 10 years of entering the labour market, positioned in the income distribution of the birth cohort (those born within 5 years before and after the offspring's birth year). The parent's relative income position, on the other hand, is defined by the decadal average annual income in the 10 years before the parent experienced a health shock (for the treatment group) or the average annual income when the parent was between the ages of 25 and 34 (for the control group). This is then situated in the income distribution of their birth cohort (those born within 5 years before and after the parent's birth year) for either the 10 years preceding the health shock (treatment group) or when the parent was 25–34 years old (control group).

If the child's relative income position, denoted as Z_i in the corresponding income distribution is located higher than the parents' ($Z_i > Z_j$), we defined it as upward mobility, that is, upward_{it} is coded as 1, otherwise, it is coded as 0. The mathematical representation of this is given by:

$$\text{upward}_i = \begin{cases} 1, & \text{if } \Pr(Z_i - Z_j > 0) > 0 \\ 0, & \text{if } \Pr(Z_i - Z_j > 0) = 0 \end{cases} \quad (9)$$

The descriptive statistics of the main variables are presented in Table 3. The results show that 35.5% of the children have achieved income upward mobility, and 54% of the families in our sample suffered from parental health shocks. 3.2% of the children are white-collar workers, 53.1% of them are blue-collar workers, and 43.7% of them are without fixed occupation type. While 8.6% of the parents are white-collar workers, 30.9% of them are blue-collar workers, and 60.5% of them are without fixed occupation type. The sample is geographically balanced, with households in eastern, central, and western regions are 30.1%, 46.3% and 23.6%, and the ratio of individuals in eastern, central, and western regions of China is about 3:4:3.

V. Empirical analysis

The impact of health shocks on the upward mobility of children

We estimate a probit regression Equation (8) controlling for region fixed effects and time

Table 3. Descriptive statistics of main variables.

Variable	Obs	Mean	Std. Dev.	Min	Max
Parental health shock	7362	0.54	0.498	0	1
Children upward Mobility	7362	0.355	0.479	0	1
Parents' income	7362	5589.037	7477.184	−18815.691	132873.14
Children's income	7362	13467.451	28474.68	−417285.34	581609.19
Z-score for Parents' income	7362	0.047	0.931	−3.485	14.863
Z-score for Children's income	7362	0.029	0.991	−8.037	20.223
Parents' birthyear	7362	1952.764	10.929	1918	1975
Children's birthyear	7362	1980.649	8.033	1963	1999
Children's sex(0 = girl, 1 = boy)	7362	0.633	0.482	0	1
Parents' education	7339	2.001	1.147	0	6
Children's education	7348	2.744	1.257	0	6
White-collar worker(parents)	7335	0.086	0.28	0	1
Blue-collar worker(parents)	7335	0.309	0.462	0	1
No fixed occupation(parents)	7335	0.605	0.489	0	1
White-collar worker(children)	5042	0.032	0.175	0	1
Blue-collar worker(children)	5042	0.531	0.499	0	1
No fixed occupation(children)	5042	0.437	0.496	0	1
Working in the public(parents)	7362	0.212	0.409	0	1
Medical inurance(parents)	7362	0.324	0.468	0	1
Hukou(1 = city,0 = rural)	7362	0.295	0.456	0	1
East area(household)	7362	0.301	0.459	0	1
Central Region(household)	7362	0.463	0.499	0	1
Western Region(household)	7362	0.236	0.425	0	1
Survey year 1989	7362	0.606	0.489	0	1
Survey year 1991	7362	0.643	0.479	0	1
Survey year 1993	7362	0.739	0.439	0	1
Survey year 1997	7362	0.733	0.442	0	1
Survey year 2000	7362	0.781	0.414	0	1
Survey year 2004	7362	0.504	0.5	0	1
Survey year 2006	7362	0.418	0.493	0	1
Survey year 2009	7362	0.434	0.496	0	1
Survey year 2011	7362	0.37	0.483	0	1
Survey year 2015	7362	0.436	0.496	0	1

Table 4. Basic regression results of marginal effects.

Variable	Full sample	Father	Mother	Boy	Girl
Health shock	−0.251***	−0.126***	−0.395***	−0.238***	−0.272***
	(0.009)	(0.013)	(0.011)	(0.012)	(0.015)
Time fixed effect	YES	YES	YES	YES	YES
Region fixed effect	YES	YES	YES	YES	YES
Sample size	7,362	5,284	5,464	4,657	2,705

Standard errors in parenthesis.

fixed effects. The parameters shown are the marginal effects. Table 4 presents the regression results. Column 1 shows results from using the full sample, and it indicates that parental health shocks have a significant negative effect on the income upward mobility of children, reducing the children's upward mobility by 25.1%. We then divided the full samples into subsamples where parental health shocks are received by the father and received by the mother. Columns 2 and 3 present the estimation results from these two subsamples. The results show that the fathers' health shocks reduce the probability of upward mobility of children by 12.6%, lower than that of the mothers' (39.5%), and where parental health shocks are received by the mother are not significant.

To further explore the difference in the effect of parental health shocks by gender of the children, we also estimate the effect on boys and girls separately. Columns 4 and 5 show the estimation results for the effect on boys and girls respectively. The results indicate that parental health shocks reduce the upward mobility of the female child (27.2%), lower than that of the male child (23.8%).

These results provide evidence of the negative impact of parental health shocks on the upward mobility of children in China, and suggest that the effect varies by the gender of the parent experiencing the health shock and the gender of the child.

Differences in the impact of health shocks on different household samples

One of the key considerations in this study is the fact that different households have different abilities to absorb risks. To account for this, we estimate the regression Equation (8) for different subsamples of households based on their location, type of work of the head of household, and whether the household is covered by medical insurance. Table 5 presents the estimation results for these subsamples. Theoretically, households with more complete social and medical security (such as those living in urban areas, covered by medical insurance) are expected to have a stronger ability to absorb health shocks and therefore a smaller negative impact of health shocks on upward mobility. The results in Table 3 support this hypothesis.

For urban and rural households, there are large differences in the income levels and the social security system of urban and rural households. However, when medical insurance and working in the public sector are controlled, as shown in Columns 1 and 2, parental health shocks reduce the probability of upward mobility of children by 24.2% in the rural households, while the estimation for the urban households is 21.8%. This discrepancy is consistent with the idea that the Hukou system – by providing more comprehensive social and medical benefits to urban-registered families – could partly explain why rural households are more vulnerable.[3]

There are different benefits in the social and medical insurance system for the public sector and the non-public sector in China (Zhichao and Li 2009). Columns 3 and 4 are estimation results from the two subsamples. It shows that parental health shocks reduce the probability of upward mobility of children by 25.4% in the households where the head of the household works in the non-public sector, while for public sector households is 18.5%. The results highlight one of the benefits of working in the public sector, which may provide greater social and medical security for households.

Medical insurance aims to share the risk of illness and improve social equity. Columns 5 and 6 are estimation results from the subsamples with and without the medical insurance coverage. It shows that parental health shocks reduce the probability of upward mobility of children by 25.8% in the households without medical insurance coverage, higher than that of the households with medical insurance coverage (22.4%). These results suggest that households with medical insurance coverage may have a stronger ability to absorb health shocks and mitigate the negative impact on upward mobility.

Overall, these results provide a more nuanced understanding of the impact of parental health shocks on upward mobility in China, by taking into account the different abilities of households to absorb risks. They suggest that households with more complete social and medical security, such as those living in urban areas, working in the public sector, and covered by medical insurance, have a stronger ability to absorb health shocks.[4]

Robustness checks

To ensure the robustness of our findings, we conduct a battery of robustness checks. First, we adopt different measures for the dependent variable of income upward mobility. Specifically, we introduce two distinctive definitions of upward mobility for children: (1) We define upward mobility (UP1) as

Table 5. Heterogeneity analysis of marginal effects.

Variable	Urban	Rural	Public	Non-public	Medical insurance	No medical insurance
Health shock	−0.218***	−0.242***	−0.185***	−0.254***	−0.224***	−0.258***
	(0.024)	(0.014)	(0.025)	(0.014)	(0.022)	(0.015)
Time fixed effect	YES	YES	YES	YES	YES	YES
Region fixed effect	YES	YES	YES	YES	YES	YES
Sample size	2,170	5,191	1,562	5,799	2,386	4,976

Standard errors in parenthesis.

[3]While our evidence points to institutional barriers (such as the Hukou system) as an important factor, we have not conducted a general-equilibrium analysis that would capture the full range of economic and administrative implications of abolishing or substantially reforming the Hukou system.
[4]In the supplementary material, we report the results of robustness tests that further support our findings.

a situation where a child's income relative position surpasses that of their parents, and the child's relative position exceeds the average level of the comparable group. If these conditions are met, upward mobility is categorized as 1, otherwise, it is identified as 0. (2) In our second definition, we consider not only the direction but also the magnitude of upward mobility. We define upward mobility (UP2) as the difference in z-scores between the child's income and the parent's income.[5]

Subsequently, we change the sample matching method. In our analysis, both CEM and PSM are used to reduce the sample selection bias. To avoid the biased estimates resulting from sample matching, we adopt the samples only after the first step of the CEM match (UP3).

Table 6 presents the results of these robustness checks. After controlling for regional fixed effect and time fixed effects, we find that the negative impact of parental health shocks on children's upward mobility is robust, regardless of the measure of income upward mobility, the definition of upward mobility or the sample matching method used. Detailed information about the construction of the upward income mobility calculation and the distribution of income variables can be found in the appendix.

Further analysis

In this part, we examine the role of education as a mechanism through which parents' health shock affects children's earnings. We begin by defining different treatment groups according to the education stage of the children when parental health shocks occurred: treatment 1 = 1 for a parental health shock when the child was at elementary school; treatment 2 = 1 for a parental health shock when the child was at middle school; treatment 3 = 1 for a parental health shock when the child was at high school. The control groups are defined accordingly: treatment 1 = 0 if there is no parental health shock (during the whole sample time) and the max education level (during the whole sample time) of the children is at least elementary school; treatment 2 = 0 if there is no parental health shock (during the whole sample time) and the max education level (during the whole sample time) of the children is at least middle school; treatment 3 = 0 if there is no parental health shock (during the whole sample time) and the max education level (during the whole sample time) of the children is at least high school;

We then examine the impact of parental health shocks on children's educational attainment by looking at (1) the effect of parental health shocks when the children were at elementary school against whether the children get into middle school. (2) The effect of parental health shocks when the children were at middle school against whether the children get into high school. (3) The effect of parental health shocks when the children were at high school against

Table 6. Alternative measures of upward mobility.

	Variable	Full sample	Father	Mother	Boy	Girl
UP1	Health shock	−0.248***	−0.123***	−0.393***	−0.237***	−0.267***
		(0.009)	(0.013)	(0.011)	(0.012)	(0.015)
	Time fixed effect	YES	YES	YES	YES	YES
	Region fixed effect	YES	YES	YES	YES	YES
	Sample size	7,362	5,284	5,464	4,657	2,705
UP2	Health shock	−0.920***	−0.925***	−0.909***	−0.765***	−1.148***
		(0.083)	(0.96)	(0.138)	(0.125)	(0.073)
	Time fixed effect	YES	YES	YES	YES	YES
	Region fixed effect	YES	YES	YES	YES	YES
	Sample size	6,763	6,248	5,336	4,275	2,488
UP3	Health shock	−0.247***	−0.127***	−0.379***	−0.245***	−0.251***
		(0.009)	(0.014)	(0.011)	(0.012)	(0.015)
	Time fixed effect	YES	YES	YES	YES	YES
	Region fixed effect	YES	YES	YES	YES	YES
	Sample size	7,494	5,400	5,596	4,735	2,759

Standard errors in parenthesis.

[5]The construction of the relative position of each adult child is explained fully in the Appendix.

Table 7. Impact of health shocks on the educational attainment of children.

Variable	get into middle school	get into high school	get into college
treatment1	−0.013		
	(0.011)		
treatment2		−0.054***	
		(0.019)	
treatment3			−0.297***
			(0.049)
Time fixed effect	YES	YES	YES
Region fixed effect	YES	YES	YES
Sample size	3,956	3,894	1,182

Standard errors in parenthesis.

whether the children get into college. Table 7 shows that parental health shocks significantly impair children's educational outcomes, especially at higher levels. Shocks during elementary school do not affect progression to middle school, likely due to China's compulsory nine-year education policy. However, shocks during middle school reduce the likelihood of entering high school by 5.4%, and those during high school lower college matriculation by 29.7%. By limiting educational attainment, these shocks constrain children's upward income mobility.

VI. Conclusions and discussion

We have found that parental health shocks have a significant negative impact on the upward income mobility of children, particularly for low-income households, households in rural areas, and households without medical insurance coverage or whose head of family works in the non-public sector. Our study provides new insights into the negative impact of parental health shocks on children's upward mobility in China. Our findings suggest that policies aimed at improving the overall level of health care in China, as well as addressing inequalities in access to medical services between urban and rural residents, would have a positive impact on the upward mobility of children from low-income households.

Our results also show that the negative impact of parental health shocks on children's upward mobility is more significant for females than males and the role of education as a mediating factor. Our findings suggest that policies aimed at improving educational opportunities for children affected by parental health shocks may be an effective way to mitigate the negative effects of health shocks on intergenerational mobility.

Overall, our results give rise to three broad policy conclusions relating to the theme of 'common prosperity' proposed by the Chinese government. First, an increase in health expenditure strikes at the capacity of low-income families in China to invest in human capital accumulation enabling children to migrate to higher income levels. There remains a wide gap between China and developed countries in health expenditure. Data from 'World Health Statistics 2015' show that China's government health expenditure in 2012 accounted for 14.9% of total government expenditure, lower than that of the United States (20%), Japan (20%), Germany (19.3%), Australia (17.8%) and other developed countries. Government health expenditure per capita on a PPP basis are respectively $323 and $180 dollars, far lower than the world's average level of $676 and $615. Well-being and greater income mobility of the low-income households are not the only outcomes of higher investment in health, but recent empirical findings suggest that investment in health (and education) promotes long term growth (Luintel et al. 2020).

Second, the convergence of basic medical services and narrowing the gap between urban and rural areas. The heterogeneity of the negative impact of health shocks on urban and rural residents highlights the inequality of urban and rural medical services in China. 'Common prosperity' necessitates the convergence of the provision of public medical services between rural and urban areas.

Third, the improvement in the design of the critical illness insurance system can play a role in mitigating the adverse impact of family health shocks on children. Critical illness medical insurance in China started late, and the experimental work of the critical illness insurance for urban and rural residents did not officially start until 2012. A public-private critical illness insurance partnership could provide broad medical security for her citizens.

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Data availability statement

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