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Adult Children's Education and Older Parents' Chronic Illnesses in Aging China

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ABSTRACT Although intergenerational transmission from parents to children has been widely studied, less is known about human capital spillover from children to parents. Utilizing nationally representative data on both doctor diagnosis and biomarkers, as well as exploiting variations in the implementation of China's Compulsory Education Law, we examine the effects of adult children's education on the prevalence of chronic cardiovascular illnesses among older parents in China and explore potential mechanisms. Instrumental variable estimates indicate that additional years of schooling among adult children decrease the prevalence of hypertension among older parents, whereas no evidence indicates a significant impact on the prevalence of diabetes among the same group. Sons and daughters differentially impact their mothers and fathers. Compared with fathers, mothers benefit more from adult children's education. Although no significant differences are observed in the effects of sons' and daughters' education in urban China, sons' education is more beneficial for parents' health in rural China. Further analyses show that financial support and health support (e.g., diagnosis and management of chronic illnesses and maintenance of health behaviors) are critical pathways for older parents to benefit from their adult children's education.

KEYWORDS Education • Chronic illnesses • Biomarkers • Intergenerational transmission • China

Introduction

It is well established that education is associated with longevity, physical health, and mental health across a wide range of socioeconomic contexts (Goldman and Smith 2011; Grossman 1972, 2015; Montez and Friedman 2015; Smith 2007). Evidence suggests that the effects of education on health persist across generations (Black and Devereux 2011). However, previous studies have largely focused on intergenerational transmission from parents to children (Aizer and Currie 2014). In the context of population aging, intergenerational transmission might work the other way around, from adult children to older parents.

If well-educated adult children provide better old-age support and improve their parents' health, investment in children's education could be a cost-effective means

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to promote population health and alleviate governments' fiscal challenges induced by rising medical expenditures. A small albeit growing literature has documented the positive association between adult children's education and parental mortality in various contexts (De Neve and Fink 2018; Friedman and Mare 2014; Lundborg and Majlesi 2018; Torssander 2013; Yahirun et al. 2017). However, less is known about the effects of adult children's education on parental mortality causes and how gender influences those effects.

This issue is of particular importance in China, which has the largest elderly population and is one of the most rapidly aging societies in the world.[1] As one of the world's largest developing economies, China provides relatively less generous social welfare to its elderly population. Given this inadequate public provision of formal care for China's elderly, informal family support plays an essential role in old-age care provision. Filial piety, which is the core value of traditional Chinese culture, enjoins children to respect and support their parents. In this context, the educational attainment of an adult child may be viewed as a family resource, benefiting not only the adult children but also their old-age parents (Friedman and Mare 2014).

These resources are particularly important now because China's demographic shift is linked to a rapid health/epidemiological transition from infectious to chronic diseases.[2] Cardiovascular diseases remain the leading cause of mortality in China, accounting for 46% and 43% of all deaths in rural and urban China, respectively (National Center for Cardiovascular Diseases 2018). Besides direct costs of medical care and the overall economic burden associated with these conditions, cardiovascular diseases also adversely impact quality of life—for example, through decreased physical functioning, shrunk social networks, and less constructive coping strategies (Megari 2013; Stanton et al. 2007; Tijhuis et al. 1998; Turner and Kelly 2000). Many cardiovascular diseases are preventable, and their risk factors are known and modifiable. However, inadequate awareness and responses among the older population increase their likelihood of developing those diseases and decrease their likelihood of receiving proper disease diagnosis and management afterward.

In this article, by utilizing novel nationally representative data on both doctor diagnosis and biomarkers and by exploiting the differential implementation of the Compulsory Education Law (CEL) between the late 1980s and early 1990s in different provinces across China, we examine the impact of adult children's education on older parents' (aged 50+) cardiovascular health. We focus, in particular, on hypertension and diabetes, two major indicators of cardiovascular health. Hypertension is an important risk factor for angina, heart attack, and stroke. It is regarded by the World Health Organization (WHO) as one of the most modifiable risk factors for premature morbidity and mortality (WHO 2013). It is also the single largest contributor to global disease burden and mortality (Poulter et al. 2015). Diabetes is another important risk factor for cardiovascular disease, and cardiovascular disease is the leading cause of mortality and morbidity among people with diabetes (Dal Canto et al. 2019).

[1] It took the United States 69 years, Sweden 85 years, and France 115 years for the proportion of the population aged 65 or older to double from 7% to 14% (Bhattacharya et al. 2014). In China, the same transition is estimated to have occurred in only 25 years.

[2] Almost 80% of all deaths of people living in China aged 60 or older and 70% of disability-adjusted life-years lost are attributable to chronic noncommunicable diseases (Wang et al. 2005; WHO 2015).

By combining self-reported doctor diagnosis with biomarker information, we can go beyond subjective self-report measures to accurately measure disease prevalence. More importantly, we can investigate the impact on the diagnosis and management of those diseases among older parents.

We also explore how gender influences the effects of adult children's education on parental health. The drastic demographic, economic, and cultural changes in China have shifted traditional patriarchal family structures and may have undermined the gender divide in old-age support from adult children to older parents, especially in urban China (Xie and Zhu 2009). Financial, instrumental, emotional, and health support (e.g., providing better health knowledge and encouraging better health behaviors) may be particularly important mechanisms for adult children to improve parental cardiovascular health.

Background and Hypotheses

Chinese Context

Education System in China

The typical education system in China consists of primary (six years), secondary (three years of junior high and three years of senior high), and tertiary (three/four years of college or more) levels. In 1986, China instituted its nine-year Compulsory Education Law, marking the first time the country used a law to specify nationwide education policy (Fang et al. 2012; Huang 2015).

The CEL had several key features. First, it specified that all children should enroll in school at age 6 and no later than age 7. Second, six years of primary school and three years of junior high school were designated mandatory and free (i.e., nine years of free compulsory education in total).[3] A typical student complying with this law would begin primary education at age 6, complete the nine years of compulsory schooling, and be eligible to leave school at age 15. Those who were under age 15 at the time of the reform, especially those who would not have received the stipulated number of years of education if it were not for the CEL, were likely to obtain more years of schooling than they would have without the CEL. But the extent of educational exposure varied across age-groups. Those who were aged 6 or younger at the time of the reform were fully exposed because they had not begun their education before the reform was introduced. In contrast, those who were aged 7–15 may already have begun their education at the time of the reform and thus were only partially exposed.

Third, the policy made it unlawful for any organization or individual to employ school-age children or adolescents who should be receiving compulsory education (i.e., children under age 15). The government also set the minimum employment age at 16 for the public and private sectors in 1986 and 1988, respectively (State Council

[3] Income per capita was much lower in China than in the United States or the United Kingdom when compulsory schooling laws were implemented. In practice, the "free" aspect of the policy was not strictly enforced immediately after the enactment and was instead set as a longer term goal.

1986, 1988). In principle, a child can enter the labor market only after finishing the nine years of compulsory schooling at age 15. A proportion of children would continue their education for at least one more year, but children aged 16 or older were not bound by either the CEL or the minimum working age and thus were not exposed to the reform.

Finally, the provinces could implement the CEL on different schedules (see Table A1 in the online appendix). Some provinces started as early as 1986, and some postponed implementation until the 1990s. The central government also divided the nation into three categories: (1) economically developed regions and cities, where a considerable proportion of the population had already realized universal junior secondary education and where the government aimed for CEL to be completed by 1990; (2) middle-level developed townships and villages with traditionally lower educational levels, for which the goal was to realize universal primary education first and then complete CEL by 1995; and (3) least developed regions (mainly villages) with the lowest educational level before the reform, for which no rigid timeline was set for CEL implementation (Central Committee of the Communist Party of China 1985).

Old-Age Support in China

Community care, institutional care, and family care are the three main forms of care provision for the elderly. Family care—the informal care provided mainly by adult children or other relatives—is the most important of these forms (Zhao et el. 2019). Family income level is a critical component of this support throughout the country, particularly in rural areas. Family is the most important source of support for rural older parents (Cai et al. 2012).

The norms of filial piety, the most important virtue of Confucianism, require that children provide old-age support to their parents. Such support has also been formalized into law (Standing Committee of the National People's Congress 2012). According to the law, adult children should fulfill their obligations of financial, emotional, and health support and care to their older parents. In particular, adult children should provide timely treatment and care for their sick, older parents and cover medical expenses for older parents with financial difficulties. This obligation is particularly important for elderly people with chronic illnesses because they require constant care and treatment. Although health care conditions in China have generally improved, the distribution of medical resources between urban and rural areas is imbalanced. In 2018, in urban and rural areas (respectively), there were 4.0 versus 1.8 physicians, 5.1 versus 1.8 registered nurses, and 8.7 versus 4.6 beds per 1,000 population.[4] The quality of chronic disease management is far from satisfactory in China. Although hypertension and diabetes are the most common chronic conditions encountered in primary health care settings, the management of these two diseases is characterized by poor awareness and control rates (Li et al. 2020). Only 51.6% of hypertensive and 36.5% of diabetic adults are aware of their conditions, and only 16.8% of hypertensive adults receive treatment and control their blood pressure (National Center for

[4] Authors' calculations from 2019 China Statistical Yearbook (National Bureau of Statistics 2019).

Cardiovascular Diseases 2018). The quality of diagnosis and management of these two diseases in rural China is even worse (Li et al. 2020).

Prior Research on Offspring's Education and Parental Health

Studies have documented a positive association between offspring's education and parental health in various contexts. Most of these studies used mortality risk as the main indicator of parental health. Friedman and Mare (2014) showed that in the United States, offspring's higher educational attainment was associated with a lower risk of parents' mortality when controlling for parents' socioeconomic resources. Zimmer et al. (2002, 2007) found that in Taiwan, the educational attainment of a parent's highest-educated child was inversely associated with parents' mortality and severity of functional limitations as they age. Lee (2018) found that children's education was negatively associated with older parents' physiological dysregulation in Taiwan. Sabater and Graham (2016a) found that having children with upper secondary or tertiary education was associated with a reduced risk of mortality in Europe. Using Swedish registry data, Torssander (2013) documented a similar relationship between parental mortality and children's education. Among socioeconomic dimensions of adult children, education seems to be a key factor associated with parental mortality (Torssander 2014). Several recent studies in Europe and the United States have shown that an increase in offspring's schooling was associated with better parental mental health, as assessed via measures of depressive symptoms (Sabater and Graham 2016b; Yahirun et al. 2020).

Similar associations have also been documented in several contexts characterized by limited public support for the elderly. Yahirun et al. (2016, 2017) found that offspring's education in Mexico was not associated with short-term changes in parents' physical functioning but was associated with increased parental longevity. De Neve and Harling (2017) found that a one-year increase in offspring's schooling attainment was associated with 5% and 6% declines in the hazard of maternal and paternal death, respectively, in South Africa. Using Chinese data, Yang et al. (2016) found that the adjusted hazard of parental death for children who received 10 or more years of education was 17% lower than that of children who received 6 or fewer years of education, and Jiang (2019) found that having college-educated children was associated with a 31% decline in the hazard of parental death.

Most of these cited results provide correlational evidence. Four recent studies exploited educational reform policies and used the instrumental variables (IV) approach to estimate the causal effects of children's education on parental health. Using children's exposure to the CEL as the IV, Ma (2019) found that increased children's education led to better cognitive functioning and higher expected survival of older parents in China. Exploiting an educational expansion policy in Mexico in 1993, Ma et al. (2021) found significant beneficial effects of offspring's schooling on older parents' cognition. Two other studies used parental mortality as their main health measure, producing different results. First, exploiting a Swedish compulsory schooling reform that provided exogenous variation in children's schooling, Lundborg and Majlesi (2018) found no significant causal impact of children's education on parental mortality risk broadly. However, they found the marginal impact of children's education to be more prominent in low-resource settings. Second, using the 1974 Tanzania Universal Primary Education policy reform as the IV for children's education, De Neve and Fink (2018) found that each additional year of primary schooling among children led to decreases of 3.7% and 0.8% in the probability of maternal and paternal death, respectively.

How Might Adult Children's Education Affect Parental Health?

Health Spillovers/Behavioral Changes

Adult children's education may affect parental health via several channels. Berkman et al. (2000) highlighted the effects of social networks (including family and friends) on health. The spillover effects of family members' education, particularly that of spouses and siblings, are well documented (Friedman and Mare 2014). Well-educated adult children may help older parents practice better health behaviors (Friedman and Mare 2014; Ram et al. 2020); they may have better health knowledge and thus help older parents avoid harmful health behaviors and choose healthier lifestyles, such as by increasing exercise, improving diet, quitting smoking, and reducing alcohol consumption. Exposure to health-related expertise in the family has even been found to increase preventive health investments, which is critical for long-term health improvement (Chen, Persson et al. 2019).

Financial, Instrumental, and Emotional Support

Better-educated children may have more means to support their old-age parents. Adult children with more education tend to have higher incomes and better health outcomes themselves, increasing their likelihood of providing financial support to their older parents (De Neve and Fink 2018; Jiang and Kaushal 2020).

In addition, adult children's education can have implications for the emotional and instrumental support of older parents. Having more resources and better health themselves, better-educated adult children may be well positioned to care for their older parents (Friedman and Mare 2014). If children's higher educational attainment translates to greater success, it may increase morale or decrease worry among parents (Lundborg and Majlesi 2018). However, in pursuit of better job opportunities and career development, adult children with more education might live farther from their parents, making caring for older parents more costly and potentially negatively impacting parents' health (Torssander 2013). Other studies, though, have found no evidence that geographic proximity and frequency of contact moderate the associations between adult children's education and parental health (e.g., Peng et al. 2019).

Diagnosis and Management of Care

Adult children's education may increase their ability to acquire and process health information and to help older parents navigate the health care system (Friedman and

Mare 2014; Torssander 2013). The rapid development of digital health—including mobile health, health information technology, wearable devices, and personalized medicine—is expected to improve the diagnosis and treatment of disease and enhance health care delivery (Timmermans and Kaufman 2020). However, older adults face various challenges related to digital health, such as decreased familiarity with technology (e.g., internet, computer, and smartphone), issues of trust, and concerns about privacy (Fischer et al. 2014). Equipped with better access to digital health, better-educated adult children may help parents overcome these challenges, obtain a timely diagnosis, and practice better health management once diagnosed (De León and McLaughlin 2018). This support is particularly important because the epidemiological transition in China is characterized by widespread underdiagnosis and low rates of treatment and control of chronic diseases.

In this article, we aim to provide empirical evidence on the effect of children's education on parental health in old age in China. In addition to examining the influence of financial, instrumental, and emotional support, we highlight the roles of health behavior changes and the diagnosis and management of care. Using measures of major behavioral risk factors for cardiovascular diseases (including physical inactivity, diet, smoking, and drinking), we investigate potential behavioral mechanisms. By comparing self-reported doctor diagnosis with objectively measured biomarkers, we test whether adult children's additional years of schooling lead to better diagnosis and management of chronic diseases for older parents.

Mother–Father and Daughter–Son Gender Differences

Adult children's education may affect mothers and fathers differently. The resource substitution theory posits that when resources substitute for one another, the presence of one makes the absence of another less harmful (Ross and Mirowsky 2006). The less there is of one resource, the more important another resource will be. Given that older mothers have fewer socioeconomic resources, such as occupation and earnings, adult children's education may have a larger impact on mothers (Zhao and Zhao 2018). However, if the resources multiply one another's impact, the absence of one makes the presence of another less effective. Conversely, the more there is of one resource, the more important another resource will be. Because older fathers have more socioeconomic resources, they may benefit more from adult children's education. Previous research has found greater benefits of offspring's education on mothers' health in Mexico and Tanzania but greater benefits on fathers' health in South Africa (De Neve and Fink 2018; De Neve and Harling 2017; Yahirun et al. 2017).

In addition, daughters' and sons' education may have different impacts on their older parents. Friedman and Mare (2014) found that in the United States, having daughters was more beneficial for mothers' survival than for fathers', but the effects of sons' and daughters' education did not differ significantly. Torssander (2013) found that in Sweden, daughters' education was no more important for parental mortality than sons' education. Also using Swedish data, Lundborg and Majlesi (2018) showed that daughters' education was more important for fathers' longevity. In the traditional patriarchal Chinese family system, sons are expected to assume the major responsibility of supporting their old-age parents. However, with drastic demographic changes, economic development, and cultural transitions, the traditional gender divide in providing old-age support has been declining. Although the traditional gender patterns in old-age support are more stable in rural China (Lei 2013; Yang 1996), daughters play an increasingly important and sometimes more prominent role in old-age support in urban China (Hu 2017; Whyte 2005; Xie and Zhu 2009).

In this article, we examine gender differences in the effects of adult children's education on parental health at the parent and child levels in urban and rural China.

Data

We use data from the China Health and Retirement Longitudinal Study (CHARLS), which is a biennial and nationally representative panel survey of people aged 45 years or older and their spouses of any age. The CHARLS is part of an international network of longitudinal studies of aging and is closely harmonized with the Health and Retirement Study in the United States and the Survey of Health, Ageing and Retirement in Europe. In this study, we mainly use data from Wave 4 (with the most recent available biomarker data released in 2019).[5] The CHARLS data were collected via computer-aided personal interviewing (CAPI) and a health assessment. For detailed information on the CHARLS sampling, see Zhao et al. (2013).

Using CHARLS for this research offers three advantages. First, CHARLS is publicly available and nationally representative, containing a wide range of information on demographics, health, and socioeconomic circumstances of adults aged 45 or older. Specifically, as one of the first nationally representative surveys in China to include blood biomarkers (Chen, Crimmins et al. 2019), it contains information on doctor diagnosis and biomarkers of hypertension and diabetes, enabling us to accurately characterize the prevalence, diagnosis, and management of those illnesses. Second, CHARLS collects detailed information on respondents' living children.[6] By matching each parent with their children, we can estimate the impact of children's education on older parents' health and explore potential mechanisms. Finally, because some of these children were exposed to the CEL but others were not, we can infer causality. The sample includes children born between 1956 and 1991, who were aged 0–30 when the CEL was implemented. The oldest individuals

[5] Wave 1 data were collected in 2011 and 2012; Waves 2, 3 (the life history wave), and 4 followed in 2013, 2014, and 2015, respectively. However, the health assessment data (blood pressure and blood biomarkers), from which we derive the objective measures of hypertension and diabetes, are available for Waves 1 and 4 only. In addition, implementing a fixed-effects estimation strategy would not account for time-varying unobservable characteristics and, more importantly, would not allow us to recover the effect of adult children's education, which is largely time-invariant. Therefore, for the main analysis, we use a cross-sectional sample with the most recent available biomarker data (Wave 4, released in June 2019) combined with the IV estimation strategy.

[6] The CHARLS (Wave 4) contains a separate data file on the respondent's child(ren) (Child.dta), from which we obtain the information on adult children. Each child is assigned the same household ID as the respondent. Relying on the unique household ID, we can link each respondent to their child(ren).

affected by the CEL were 15 years old at the time of implementation. Thus, our choice to include individuals who were 0–30 years old at CEL implementation means that roughly half the sample contains children who were fully or partially affected by the CEL, and half the sample contains children who were not affected by the CEL.

For parents with multiple children, we have multiple parent–child records in the data. Following Lundborg and Majlesi (2018), we weight each record proportional to the number of children the parent has. For example, for a parent with two children who thus appears twice in the data, we weight each observation of that parent by one half, leading to a total weight of 1 for that parent. In this way, we give equal weight to each parent in the analysis.

Our sample of parents includes those aged 50 or older. The final analysis sample includes approximately 29,458 adult children in 150 counties in 28 provinces.

Methods

Offspring education might correlate with unobserved factors that are shared between offspring and older parents (e.g., intrinsic abilities and underlying health), and healthier parents might be better able to invest in offspring's education. To address these potential endogeneity issues and infer causality, we employ an IV approach and base our empirical analysis on the following equations:

$$Y_j = \alpha_0 + \alpha_1 S_i + \varphi \mathbf{X}_{c,i} + \gamma \mathbf{X}_{p,j} + \varepsilon_j \quad (1)$$

$$S_i = \beta_0 + \beta_1 Z_i + \theta \mathbf{X}_{c,i} + \delta \mathbf{X}_{p,j} + \mu_i . \quad (2)$$

Y_j denotes the health status of child i's parent j. S_i indicates years of schooling of child i. $\mathbf{X}_{c,i}$ is a vector of control variables for child i's characteristics: age; age squared; and indicators for female, being married, birth order (1st, 2nd, 3rd, and 4th+), and number of siblings. $\mathbf{X}_{p,j}$ is a series of control variables for characteristics of child i's parent j: age; age-squared; and indicators for female, being married, highest educational level (illiterate, primary, junior high, and senior high school or above), and rural household registration (*hukou*) status. Z_i measures CEL exposure and is the IV. ε_j and μ_i are the disturbance terms. We control for both province fixed effects and province-specific birth year linear trends (of the children). We also cluster the standard error at the province children's birth year level.

Older Parents' Chronic Illnesses

Our analysis includes two chronic conditions: hypertension and diabetes. We use information from the CAPI and the health assessment to define prevalence.

We first retain those who both completed questions regarding their medical history of hypertension and had their blood pressure measured during a health assessment. We then define hypertension prevalence as either of the following:

- Diagnosed with hypertension (gathered from the CAPI question, "Has a doctor ever told you that you have high blood pressure or hypertension?").
- Measured hypertensive (from the health assessment, where hypertension is defined as systolic blood pressure ≥ 140 mm Hg and/or diastolic blood pressure ≥ 90 mm Hg).[7]

Following Zhao et el. (2016), we first include individuals who completed questions regarding their medical history related to diabetes and had valid fasting plasma glucose and whole blood HbA1C levels. Diabetes prevalence is then defined as one of the following:

- Diagnosed with diabetes (gathered from the CAPI question, "Has a doctor ever told you that you have diabetes or high blood sugar?").
- A fasting glucose level of 126 mg/dL or higher.
- An HbA1C concentration of 6.5% or higher.[8]

Adult Children's Education

To measure adult children's education, we follow Pischke and von Wachter (2008) and Lundborg and Majlesi (2018) in converting each adult child's highest educational attainment to years of schooling.[9] Because all adult children could potentially affect their older parents' health, and because adult children with different educational levels might differentially influence parental health, we include all adult children's years of schooling in the main analysis. We also adopt alternative measures for adult children's education as robustness checks.

Table 1 presents descriptive statistics for adult children and their older parents, respectively. The total prevalence of hypertension among older parents is 46%, and the total prevalence of diabetes is 20%. There are evident differences in educational attainment between adult children and their older parents. Whereas nearly half of the older parents are illiterate and 22% obtained only primary education, the average years of schooling for adult children is approximately 8.3 years.

[7] In the health assessment, systolic and diastolic pressure are measured three times. The mean values of these three readings are calculated (Lei et al. 2014).

[8] Ten milliliters of fresh whole blood (three tubes of venous blood) was collected for each respondent during health assessment; 2 ml was used for complete blood count analysis at local health centers immediately after the collection. A 6-ml tube of whole blood was kept under 4°C until the specimens were centrifuged to obtain plasma and buffy coat at local hospitals. Plasma and buffy coat for each respondent were then stored in separate cryovials and immediately stored frozen at −20°C. A 2-ml tube of whole blood for the HbA1C was stored at 4°C in local hospitals. The plasma, buffy coat, and whole blood for HbA1C were then shipped to the study headquarters and placed in storage at −80°C, and then assayed. More details can be found in Chen, Crimmins et al. (2019).

[9] We convert the highest educational attainment to years of schooling as follows: 0 = no formal education, 4 = did not finish primary school, 6 = primary school, 9 = junior high school, 12 = senior high school/vocational school, 14.5 = two/three years of college, 16 = four years of college, 19 = master's degree, and 22 = doctoral degree. Because the CHARLS does not contain information on exact years of schooling, we use the same cohorts from another nationally representative survey, the China Family Panel Studies. We thus calculate the average years of schooling for those with fewer than six years of schooling and assign that number (i.e., 4) to the group who did not finish primary school.

Table 1 Descriptive statistics

Variable	Mean	SD	*N*
A. Adult Children			
Years of schooling	8.324	3.927	29,458
Junior high school or above	.580	.494	29,458
Female	.478	.500	29,458
Age	39.123	7.349	29,458
Married	.870	.336	29,458
Number of siblings	3.588	1.578	29,458
Birth order			
1st	.372	.483	29,458
2nd	.292	.455	29,458
3rd	.176	.381	29,458
4th+	.161	.367	29,458
B. Older Parents			
Hypertension	.461	.499	11,082
Diabetes	.202	.402	8,106
Female	.533	.499	11,398
Age	63.646	8.268	11,398
Married	.816	.387	11,398
Education level			
Illiterate	.483	.500	11,398
Primary school	.221	.415	11,398
Junior high school	.189	.391	11,398
Senior high school or above	.107	.309	11,398
Rural (*hukou*)	.746	.435	11,398

The Instrumental Variable and Its Validity

We use CEL exposure as the IV for children's schooling. Compulsory schooling laws have been used as exogenous shocks in estimating the effects of education on various outcomes across the economic, health, and social domains (Grossman 2015; Oreopoulos et al. 2008). The CEL took effect in different years across provinces. Using information on the CEL effective year and adult children's birth year, and using province of parental residence as a proxy for the province in which adult children received compulsory education, we calculate adult children's ages when the CEL was implemented. On the basis of those ages, we further divide adult children's CEL exposure into three types: full, partial, and none. Because children begin schooling at age 6 (no later than age 7) and compulsory education lasts for nine years, we classified individuals aged 6 or younger at the time of CEL implementation as fully exposed, those aged 7–15 as partially exposed, and those aged 16 or older as not exposed. Therefore, Z_i equals 1 if child *i* was fully exposed to the CEL (i.e., aged 6 or younger at CEL implementation) and 0 if child *i* was unexposed (i.e., aged 16 or older at CEL implementation). For those aged 7–15 when the CEL was implemented, we assume that their exposure to the law followed a linear function, as shown in Figure 1.

The identification assumption is that although children's CEL exposure must have a sufficiently strong impact on adult children's schooling, it affects parental health

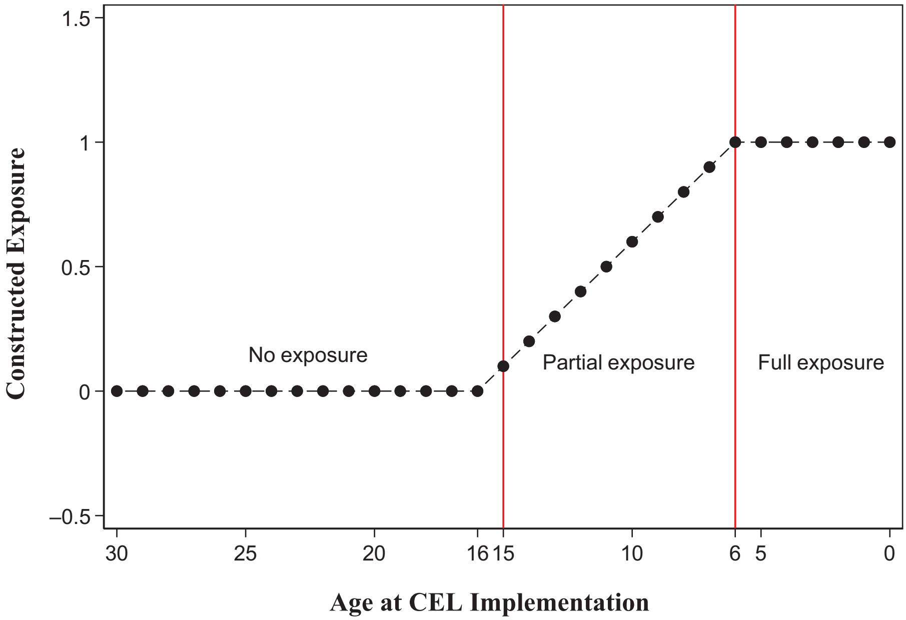

Fig. 1 Constructed exposure to the CEL. The left red rule indicates age 15 at CEL implementation, and the right red rule indicates age 6 at CEL implementation.

only through its impact on adult children's schooling, conditional on the fixed effects, trends, and covariates for which we control. We first check the predictive power of the IV. Figure 2 shows the average years of schooling by age at CEL implementation. The average number of years of schooling is lower for those aged 16 or older at CEL implementation than for those who were younger at CEL implementation. The effects of CEL exposure on adult children's years of schooling are reported in panel C in Table 2. The CEL increased adult children's years of schooling by approximately one year—a finding consistent with results from previous studies (Fang et al. 2012). The Kleibergen–Paap F statistic for the weak identification test is above 10, indicating that the IV is sufficiently strong.

One concern is that the CEL implementation might be associated with provincial economic and developmental conditions. We include province fixed effects to account for the time-invariant provincial characteristics and province-specific adult children's birth year linear trends to control for observed and unobserved province cohort–specific characteristics.[10]

Another concern is that individuals might migrate across provinces for compulsory education in a systematic way. However, because of the rigid household registration system, migration was sharply restricted until the late 1980s, and cross-province

[10] To account for the possibility that changes in provincial economic and social conditions may not be linear in time or cohort and to allow for more flexible changes in provincial economic and social conditions, we add province-specific quadratic trends in adult children's birth year as a robustness check. These results, shown in Table A2 in the online appendix, are similar to the main results.

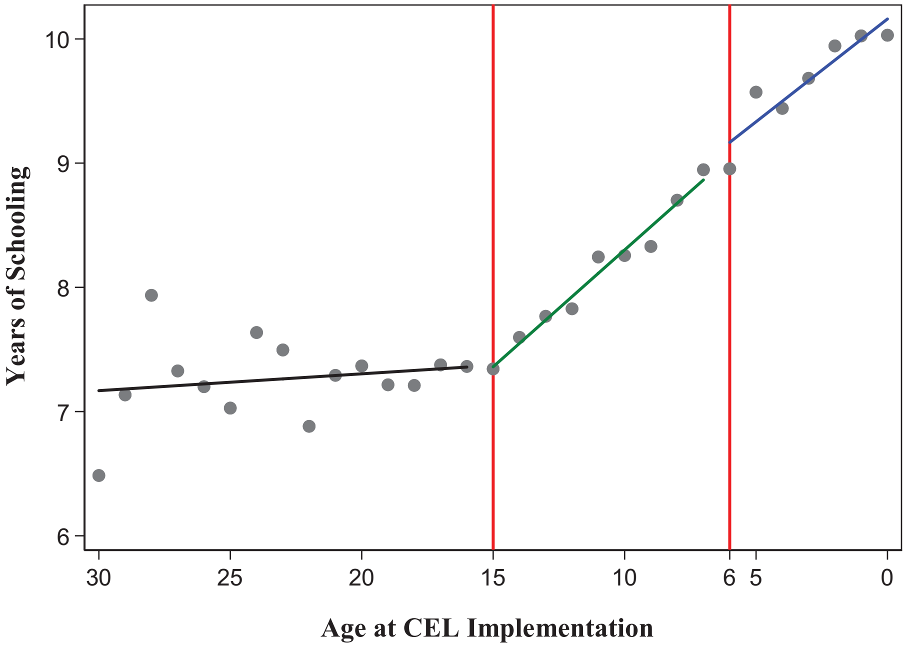

Fig. 2 Adult children's years of schooling by age at CEL implementation. The left red rule indicates age 15 at CEL implementation, and the right red rule indicates age 6 at CEL implementation.

migration was rare in the 1980s and 1990s (Cui et al. 2019; Fan 2005). Less than 10% of CHARLS respondents have lived in a province other than their current province for more than six months. The rate would be much lower for a stay longer than six months. In addition, major disincentives made it difficult for young children to migrate: they were denied benefits of local *hukou*, including access to public schools (Chen and Feng 2013). Less than 5% of children covered in the CHARLS lived away from their parents for more than six months before age 16.

Empirical Results

Main Results

Panels A and B in Table 2 present the ordinary least squares (OLS) and two-stage least squares (2SLS) estimates of the effects of adult children's education on the prevalence of hypertension and diabetes among older parents, respectively. The 2SLS estimation results indicate that an additional year of adult children's schooling, induced by the CEL, decreases the probability of having hypertension by approximately 5 percentage points. Given that the total prevalence of hypertension among older parents is 46%, this finding suggests that an additional year of adult children's schooling could decrease the total prevalence of hypertension among older parents by approximately 11%. We find no evidence of a significant impact of adult children's education on diabetes prevalence among older parents.

Table 2 OLS and 2SLS estimates of the effects of adult children's education on older parents' chronic illnesses

	Hypertension (1)	Diabetes (2)
A. OLS Estimation		
Adult children's years of schooling	–0.002†	0.001
	(0.001)	(0.001)
B. 2SLS Estimation		
Adult children's years of schooling	–0.051*	0.018
	(0.023)	(0.019)
C. First Stage (Y = adult children's years of schooling)		
CEL exposure	1.054**	1.085**
	(0.223)	(0.256)
Kleibergen–Paap F Statistic for Weak Identification	22.262	18.010
R^2	.309	.298
Number of Observations	28,636	20,965

Notes: All regressions include controls for adult children's characteristics (age; age squared; and indicators for female, being married, birth order [1st, 2nd, 3rd, and 4th+], and number of siblings) and controls for parents' characteristics (age; age squared; and indicators for female, being married, highest educational attainment [illiterate, primary, junior high, and senior high school or above], and rural *hukou*). Province fixed effects and province-specific adult children's birth year linear trends are also included. Standard errors, clustered at the province children's birth year level, are shown in parentheses.

†$p < .10$; *$p < .05$; **$p < .01$

The different results for the prevalence of hypertension and diabetes among older parents might be due to different progression rates of the two diseases. Compared with hypertension, diabetes has earlier antecedents, which are less susceptible to change given diabetes' earlier onset (e.g., type 1 diabetes and obesity in early life).[11] Therefore, adult children's education may have a larger impact on hypertension prevalence among older parents. Type 1 diabetes begins most often in childhood and young adulthood and lasts for life.[12] Type 2 diabetes is the most common kind of diabetes and occurs most often in middle age and older adulthood; hypertension is common among older adults.[13] In addition, overweight and obese children are more likely to remain obese into adulthood and to develop diabetes in adulthood.[14] Although the older parents in our sample (who were 50 or older in 2015) were less likely to experience childhood obesity, they experienced rapid urbanization in China when they were younger, which was characterized by increased obesity (from excess calorie intake and sedentary lifestyle) and environmental pollutants.

[11] Older age and family history are correlated with higher chance of having hypertension and diabetes.

[12] We do not exclude type 1 diabetes in our main analysis. As a robustness check, because respondents were not explicitly asked what type of diabetes they had been diagnosed with, we exclude those parents who were diagnosed with diabetes before the age of 40 and who were on insulin therapy at the time of interview, owing to the suspicion that they may have type 1 diabetes. The results are similar.

[13] See https://www.nia.nih.gov/health/diabetes-older-people and https://www.nia.nih.gov/health/high-blood-pressure.

[14] See https://www.who.int/news-room/questions-and-answers/item/noncommunicable-diseases-childhood-overweight-and-obesity.

Because urbanization, obesity, and inflammation from environmental pollutants are the main drivers of diabetes in China (Zhao et al. 2016), older parents' diabetes prevalence is probably more related to their own experiences when they were younger than to their adult children's education.[15] Our findings are similar to those reported from Mexico, another middle-income developing country (Smith and Goldman 2007).

The 2SLS estimates are larger in magnitude than the OLS estimates. Two potential explanations for this difference can be identified. First, the disparity could reflect an attenuation bias driven by measurement error in reported schooling (De Neve and Fink 2018). Second, OLS estimates show that the positive association between adult children's years of schooling and parental health is obtained in general, including both the lower and upper parts of the education distribution. The IV estimates identify the local average treatment effect for those who change their schooling attainment as a result of the CEL, reflecting variations at the lower part of the education distribution (Angrist and Pischke 2009). Those "compliers" are more likely to be from a lower socioeconomic background, where old-age parents are more dependent on their children for support and care.

Robustness Checks

In this section, we conduct sensitivity tests to check the robustness of our results. First, we check whether differences in defining adult children's education could affect results. Second, we use the CHARLS biomarker weights to account for the possibility that respondents who participated in the health assessment might differ from those who did not. Third, we test whether the CEL had a bigger impact in provinces with traditionally lower educational levels before the reform and use alternative IVs. Finally, we impose further sample restrictions to see whether the main results are robust to sample choices.

Alternative Measures for Adult Children's Education

First, we use an indicator for junior high school or above to measure adult children's education. The CEL requires nine years of free compulsory education (six-year primary and three-year junior high education). Thus, instead of having a uniform effect increasing years of schooling by approximately one year across the population, the CEL may have a particularly strong effect on the likelihood of completing junior high school. We run the analysis using this alternative measure and report the 2SLS results in panel A of Table 3. Results show significant impact of

[15] Zhao et al. (2016) found higher diabetes prevalence for Chinese with urban *hukou*, especially those living in the better-off coastal regions. Using older parents' body mass index calculated from weight and height information collected in the CHARLS health assessment, we test whether adult children's education affects the probability of being overweight or obese for older parents. We find no significant impact (results are available upon request). We further explore the major behavioral risk factors in the Potential Mechanisms section.

Table 3 Robustness checks I: Alternative measures for adult children's education

	Hypertension (1)	Diabetes (2)	Hypertension (with weights) (3)	Diabetes (with weights) (4)
A. Junior High School or Above	–0.313*	0.123		
	(0.129)	(0.133)		
Number of observations	28,636	20,965		
B. Highest-Educated Child's Schooling	–0.111**	0.018	–0.152†	0.105
	(0.043)	(0.029)	(0.086)	(0.077)
Number of observations	10,187	7,480	10,187	7,480
C. Average Years of Schooling of All Children	–0.050**	–0.001	–0.055*	0.021
	(0.015)	(0.015)	(0.023)	(0.025)
Number of observations	10,094	7,438	10,094	7,438

Notes: The highest-educated child's CEL exposure is used as the instrumental variable for the highest-educated child's education in the 2SLS estimation in panel B. The average of all children's CEL exposure is used as the instrumental variable for the average years of schooling of all children in the 2SLS estimation in panel C. In panels A and B, all regressions include controls for adult children's characteristics (age; age squared; and indicators for female, being married, birth order [1st, 2nd, 3rd, and 4th+], and number of siblings) and controls for parents' characteristics (age; age squared; and indicators for female, being married, highest educational attainment [illiterate, primary, junior high, and senior high school or above], and rural *hukou*). Province fixed effects and province-specific adult children's birth year linear trends are also included. Standard errors, clustered at the province children's birth year level, are shown in parentheses. In panel C, all regressions include controls for parents' characteristics (age; age squared; and indicators for female, being married, highest educational attainment [illiterate, primary, junior high, and senior high school or above], rural *hukou*, and number of living children). Province fixed effects are also included. Standard errors, clustered at the household level, are shown in parentheses.

†$p<.10$; *$p<.05$; **$p<.01$

adult children's education on the prevalence of hypertension among older parents. The magnitude of the impact is larger than for the main results in Table 2, which aligns with expectations, because completing junior high school requires nine years of schooling.

Second, and in contrast to the main analysis and previous robustness checks in which we include all children from the same family, we use only the highest-educated child's years of schooling as our measure of offspring education. The highest-educated child's CEL exposure is used as the IV in the 2SLS estimation. Results are shown in panel B of Table 3.

Third, we use the average years of schooling of all children in a family to measure offspring education. The average of all children's CEL exposure is used as the IV in the 2SLS estimation. Results are shown in panel C of Table 3.

As shown in panels B and C of Table 3, using the latter two alternative measures for adult children's education does not change the main results: additional years of schooling of adult children lead to lower prevalence of hypertension for older parents, but we find no significant impact for diabetes prevalence. Although we find similar magnitudes of impact when using average years of schooling across all children in a family, we find larger magnitudes when using the highest-educated child's education.

Using CHARLS Sampling Weights

We address the possibility that older parents who participated in the health assessment differ from those who did not. Because the number of children serves as a weight when all children's education levels are included, we use two alternative measures of children's education, noted in previous robustness checks (i.e., the highest-educated child's education and average years of schooling across all children), with the CHARLS biomarker weights. To account for the fact that a smaller number of respondents had their blood taken in the health assessment, we use CHARLS blood weights for diabetes regressions. The results, reported in columns 3 and 4 in Table 3, are very similar to those obtained without sampling weights.

Alternative Instrumental Variables

To test whether CEL had a bigger impact in provinces with traditionally lower educational levels before the reform, we first calculate the average years of schooling within the unaffected cohorts in each province as a proxy for education levels in that province before the reform. On the basis of this measure, we divide the sample into three groups—low-level, middle-level, and high-level schooling areas—and rerun the schooling regression. The results, reported in Table A3 of the online appendix, show that the effects of exposure to compulsory education on years of schooling are larger in provinces with lower schooling levels before the reform. To further account for this issue, we interact the average years of schooling within the unaffected cohorts in each province with the CEL exposure to obtain an additional IV. The results, shown in panel A in Table 4, are very similar to the main results.

Alternative Samples

First, we remove adult children who may be too young or too old to care for their parents and further restrict the child cohorts to (1960,1990). Second, to help address the issue of survivor bias, we remove parents aged 80 years or older from the sample. Third, we remove adult children who were partially exposed to the reform (i.e., those aged 7–15 at CEL implementation) and perform a "doughnut" regression. Finally, to capitalize on the longitudinal power of the data set, we retain older parents who were not hypertensive (diabetic) in Wave 1 and test whether adult children's education has an impact on the onset of hypertension (diabetes) by Wave 4 for older parents. The results, shown in panels B–E of Table 4, suggest that the main results are robust to those four alternative sample choices.

Heterogeneous Effects

Sons and daughters may impact their mothers and fathers differently (Friedman and Mare 2014). Gender-specific heterogeneous effects may also be different in urban and rural China. In this section, we first test whether fathers' and mothers' health

Table 4 Robustness checks II: Alternative instrument variables (panel A) and alternative samples (panels B–E)

	Hypertension (1)	Diabetes (2)
A. Alternative Instrument Variables		
Adult children's years of schooling	−0.042†	0.016
	(0.022)	(0.019)
Kleibergen–Paap *F* statistic for weak identification	11.839	9.483
p value of Hansen *J* statistic	0.010	0.220
Number of observations	28,636	20,965
B. Adult Children's Birth Year ∈ (1960,1990)		
Adult children's years of schooling	−0.041*	0.010
	(0.020)	(0.018)
Number of observations	27,962	20,521
C: Exclude Parents Aged 80+		
Adult children's years of schooling	−0.059*	0.016
	(0.025)	(0.021)
Number of observations	27,072	19,974
D: Exclude Adult Children Partially Exposed to CEL		
Adult children's years of schooling	−0.053†	0.014
	(0.029)	(0.021)
Number of observations	17,294	12,532
E. Exclude Hypertensive (diabetic) Parents in Wave 1		
Adult children's years of schooling	−0.079*	0.041
	(0.032)	(0.027)
Number of observations	12,162	10,286

Notes: All regressions include controls for adult children's characteristics (age; age squared; and indicators for female, being married, birth order [1st, 2nd, 3rd, and 4th+], and number of siblings) and controls for parents' characteristics (age; age squared; and indicators for female, being married, highest educational attainment [illiterate, primary, junior high, and senior high school or above], and rural *hukou*). Province fixed effects and province-specific adult children's birth year linear trends are also included. Standard errors, clustered at the province children's birth year level, are shown in parentheses.

†$p < .10$; *$p < .05$

exhibit the same benefits from adult children's education in urban and rural China. Then, we test whether sons' or daughters' education is more beneficial for older parents' health in urban or rural areas.

Parent's Gender

To explore the heterogeneous effects by parental gender, we interact adult children's years of schooling with parents' status (urban father, urban mother, rural father, and rural mother) in the model.[16] The results are shown in panel A in Table 5. Compared with

[16] Similar to Fruehwirth et al. (2019) and Balli and Sørensen (2013), we use the interaction terms of adult children's CEL exposure and indicators for parents' status as the IVs for the interaction terms of adult children's years of schooling and indicators for parents' status.

Table 5 Heterogeneous effects by gender and urban/rural residence

	Hypertension (1)	Diabetes (2)
A. By Parent's Gender		
Years of schooling × urban father	–0.043†	0.022
	(0.023)	(0.020)
Years of schooling × urban mother	–0.106**	–0.022
	(0.035)	(0.026)
Years of schooling × rural father	–0.037	0.030
	(0.024)	(0.021)
Years of schooling × rural mother	–0.062**	0.012
	(0.024)	(0.019)
Number of observations	28,636	20,965
B. By Child's Gender		
Years of schooling × urban son	–0.061*	0.008
	(0.028)	(0.024)
Years of schooling × urban daughter	–0.067**	–0.006
	(0.023)	(0.020)
Years of schooling × rural son	–0.058*	0.028
	(0.027)	(0.024)
Years of schooling × rural daughter	–0.035*	0.015
	(0.017)	(0.015)
Number of observations	28,636	20,965

Notes: "Years of schooling" refers to adult children's years of schooling. All regressions include controls for adult children's characteristics (age; age squared; and indicators for female, being married, birth order [1st, 2nd, 3rd, and 4th+], and number of siblings) and controls for parents' characteristics (age; age squared; and indicators for female, being married, highest educational attainment [illiterate, primary, junior high, and senior high school or above], and rural *hukou*). Indicators for parents' status (urban father, urban mother, rural father, and rural mother) are included as additional control variables in panel A. Indicators for children' status (urban son, urban daughter, rural son, and rural daughter) are included as additional control variables in panel B. Province fixed effects and province-specific children's birth year linear trends are also included. Standard errors, clustered at the province children's birth year level, are shown in parentheses.

$^{\dagger}p<.10$; $^{*}p<.05$; $^{**}p<.01$

fathers, mothers benefit more from adult children's education—a pattern also found in other developing contexts (De Neve and Fink 2018; Yahirun et al. 2017). In urban China, an additional year of adult children's schooling, induced by the CEL, decreases fathers' probability of having hypertension by 4.3 percentage points and mothers' by 10.6 percentage points. The difference between the two coefficients is statistically different from zero (the p value, calculated via t test, is .001). In rural China, the decrease in the probability of having hypertension is 2.5 percentage points (–0.062 + 0.037) larger for mothers than for fathers. This difference is also statistically different from zero ($p = .000$).

Child's Gender

To explore the heterogeneous effects by child's gender, we interact adult children's years of schooling with children's status (urban son, urban daughter, rural son, and rural daughter) in the model.[17] The results are shown in panel B in Table 5. In urban China, we find no significant differences in the effects of sons' and daughters' education ($p = .711$). However, in rural China, sons' education is more beneficial for parents' health than daughters' education. An additional year of sons' schooling decreases the probability of having hypertension by 5.8 percentage points for older parents, while an additional year of daughters' schooling decreases this probability by 3.5 percentage points. This difference is statistically different from zero ($p = .064$) and may be due to son preference and high coresidency rates among older parents and adult sons.

Potential Mechanisms

Health Spillovers/Behavioral Changes

Well-educated adult children may help older parents avoid harmful health behaviors and choose healthier lifestyles. In the life history wave (Wave 3) of the CHARLS, each respondent was asked the following question: "During your life, have you ever engaged in any of the following activities for at least a year?" Four behavioral changes were then listed: increasing physical activity, improving diet, quitting smoking, and reducing alcohol consumption. If the respondent had engaged in at least one behavioral change for at least a year, then a follow-up question was asked to identify their specific age when they engaged in the behavioral change: 0–15, 16–25, 26–40, 41–55, 56–65, 66–75, or above 75.

These retrospective questions can provide different perspectives than the questions on contemporaneous behavior changes. First, we focus on behavior changes that last for at least one year because longer term adherence to healthy behavior changes has a greater impact on health, especially on chronic cardiovascular health. Second, we focus on older parents' behavior change(s) since age 56. Most parents in our sample are older than 55, and their children are likely to have finished their education.

On the basis of these two questions, we first derive four dummy variables indicating that older parents have increased physical activity, improved diet, stopped smoking, or reduced alcohol consumption for at least one year since age 56. We then derive a fifth dummy variable indicating that older parents have engaged in at least one behavior change for at least one year since age 56. The 2SLS estimation results are reported in Table 6. Although we find no significant impact for the full sample, we find different results for fathers and mothers. We find a significant positive impact of adult children's education on major behavioral risk factors for cardiovascular diseases for mothers but not for fathers. Adult children's education is more likely to improve mothers' health behaviors. This result provides one possible explanation for our finding that compared with paternal health, maternal health benefits more from offspring's education.

[17] We use the interaction terms of adult children's CEL exposure and indicators for children's status as the IVs for the interaction terms of adult children's years of schooling and indicators for children's status.

Table 6 Potential mechanisms I: 2SLS estimates of the effects of adult children's education on older parents' health behavior changes

	At Least One Healthy Behavioral Change (1)	Increased Physical Activity (2)	Improved Diet (3)	Stopped Smoking (4)	Reduced Alcohol Consumption (5)
A. General Effects					
Years of schooling	0.025	0.001	–0.005	0.003	0.013
	(0.020)	(0.015)	(0.015)	(0.012)	(0.013)
Number of observations	26,838	26,838	26,838	26,838	26,838
B. Heterogeneous Effects by Parent's Gender					
Years of schooling	–0.0004	–0.004	–0.002	–0.019	–0.010
	(0.020)	(0.015)	(0.014)	(0.012)	(0.013)
Years of schooling × mother	0.049**	0.010**	–0.006	0.043**	0.045**
	(0.006)	(0.004)	(0.004)	(0.005)	(0.005)
Number of observations	26,838	26,838	26,838	26,838	26,838

Notes: "Years of schooling" refers to adult children's years of schooling. All regressions include controls for adult children's characteristics (age; age squared; and indicators for female, being married, birth order [1st, 2nd, 3rd, and 4th+], and number of siblings) and controls for parents' characteristics (age; age squared; and indicators for female, being married, highest educational attainment [illiterate, primary, junior high, and senior high school or above], and rural *hukou*). Province fixed effects and province-specific adult children's birth year linear trends are also included. Standard errors, clustered at the province children's birth year level, are shown in parentheses.

$^{**}p < .01$

Financial, Instrumental, and Emotional Support

Better-educated adult children might earn more and have better health, thereby being better positioned to support their old-age parents. To test this mechanism, we examine the impact of adult children's education on the net cash transfer from adult children to parents, parental living arrangements, and visiting/contact frequency. We obtain the net cash transfer from adult children to parents by subtracting cash transfers from parents to adult children from transfers in the opposite direction (from adult children to parents).[18] The results are reported in panel A of Table 7. We find no significant impact of visiting/contact frequency and living arrangements. However, adult children's additional years of schooling lead to a greater net cash transfer from adult children to parents; this result is consistent with that found in another developing context, Tanzania (De Neve and Fink 2018).

[18] This variable is measured at the household level. For households in which only one (mainly separated/divorced or widowed) older parent participates in the CHARLS, the household level net cash transfer is regarded as the transfer received by the older parent. For households in which both older parents participate in the CHARLS, we assign the net cash transfer at the household level equally to each parent.

Table 7 Potential mechanisms II: Net cash transfer, parental living arrangements, visiting/contact frequency, and diagnosis and management of care

	Net Cash Transfer	Living in the Same Home	Living in the Same Village	Visiting Frequency	Contact Frequency	
A. Financial, Instrumental, and Emotional Support						
Adult children's years of schooling	439.102*	0.014	–0.031	–0.517	–0.116	
	(192.445)	(0.025)	(0.029)	(0.648)	(0.422)	
Number of observations	28,232	27,366	27,366	28,069	28,503	
	Undiagnosed Hypertension	**Undiagnosed Diabetes**	**Undiagnosed Dyslipidemia**	**Controlled Hypertension**	**Controlled Diabetes**	**Controlled Dyslipidemia**
B. Diagnosis and Management of Care						
Adult children's years of schooling	–0.091*	0.021	–0.029†	–0.002	–0.006	0.017*
	(0.038)	(0.044)	(0.016)	(0.029)	(0.029)	(0.009)
Number of observations	12,396	3,508	14,478	12,396	3,508	14,478

Notes: All regressions include controls for adult children's characteristics (age; age squared; and indicators for female, being married, birth order [1st, 2nd, 3rd, and 4th+], and number of siblings) and controls for parents' characteristics (age; age squared; and indicators for female, being married, highest educational attainment [illiterate, primary, junior high, and senior high school or above], and rural *hukou*). Province fixed effects and province-specific adult children's birth year linear trends are also included. Standard errors, clustered at the province children's birth year level, are shown in parentheses.

† $p < .10$; * $p < .05$

Diagnosis and Management of Care

Well-educated children might have better health knowledge and greater ability to navigate the health care system, thereby providing better health support to their older parents. Diagnosis and management of diseases is a case in point. By comparing self-reported doctor diagnosis and objectively measured biomarkers, we can test whether adult children's additional years of schooling lead to better diagnosis and management of diseases for older parents.

We first derive indicators for undiagnosed hypertension, diabetes, and dyslipidemia.[19] Dyslipidemia refers to abnormal levels of lipids (e.g., cholesterol, fat) in the blood and is recognized as a prominent risk factor for cardiovascular disease. Among older parents who are hypertensive, those who have not received a doctor's diagnosis of hypertension are defined as having *undiagnosed hypertension*. We similarly derive indicators for the other two conditions—*undiagnosed diabetes* and *undiagnosed dyslipidemia*—among those who have each disease. Estimates shown in panel B of Table 7 indicate that an additional year of adult children's schooling decreases parental undiagnosed hypertension and dyslipidemia by 9 and 3 percentage points, respectively. The effect on undiagnosed diabetes is not statistically significant. Given that the undiagnosed hypertension and undiagnosed dyslipidemia rates are 39.7% and 84.1%, respectively, these are sizable effects.

We also derive indicators for controlled hypertension, diabetes, and dyslipidemia. Controlled hypertension refers to a situation in which hypertensive older parents were normotensive in the health assessment. We similarly derive indicators for the other two conditions—*controlled diabetes* and *controlled dyslipidemia*. Estimates in panel B of Table 7 suggest that an additional year of adult children's schooling increases parental controlled dyslipidemia by 1.7 percentage points.

Discussion and Conclusions

In this article, we use nationally representative data on doctor diagnosis and biomarkers to provide new evidence on the causal impact of adult children's education on older parents' cardiovascular health in China.

Exploiting the exogenous variations in the timing of CEL implementation and using the IV approach, we find that adult children's additional years of schooling lead to lower hypertension prevalence among older parents. An additional year of schooling, induced by the CEL, decreases the probability of having hypertension by approximately 5 percentage points. We find no evidence of a significant impact of adult children's education on diabetes prevalence among older parents. The results hold in several robustness checks, including alternative measures for adult children's education, alternative IVs, and various alternative subsamples. There were 222 million

[19] We use data from the first health assessment conducted in Wave 1. Utilizing information from both CAPI and health assessment, we define dyslipidemia prevalence as either diagnosed with dyslipidemia (gathered from the CAPI question, "Has a doctor ever told you that you have dyslipidemia?") or measured dyslipidemic (taken from the health assessment; total cholesterol ≥ 200 mg/dl, triglyceride ≥ 150 mg/dl, high-density lipoprotein cholesterol < 40 mg/dl, or low-density lipoprotein cholesterol ≥ 130 mg/dl).

Chinese people aged 60 and older in 2015 (National Bureau of Statistics 2015), and 53.6% of the age 60+ Chinese population (119 million) are hypertensive (Zhao et al. 2019). Hypertension-related health expenditures totaled 210.6 billion RMB (approximately US$34 billion) in 2013 (National Center for Cardiovascular Diseases 2018). A back-of-the-envelope calculation suggests that an additional year of adult children's schooling is associated with 5.95 million fewer hypertension cases and 10.53 billion RMB less in hypertension-related health expenditures. Adult children's education can decrease hypertension prevalence and related health expenditures and improve older parents' health and well-being.

Heterogeneous analyses show that sons and daughters have differential impacts on their mothers and fathers. Compared with fathers, mothers benefit more from adult children's education in both urban and rural China. One possible reason for this disparity is that adult children are more likely to improve mothers' health behaviors. Although we find no significant differences in the effects of sons' and daughters' education in urban China, sons are more beneficial in rural China than daughters. Analyses on potential mechanisms show that financial and health support are critical pathways through which adult children's education affects older parents' health. Adult children's additional years of schooling lead to more financial support, better diagnosis and management of chronic illnesses, and better maintenance of health behaviors for older parents.

Health is multidimensional. Our findings suggest that the impact of adult children's education can be concentrated on certain health outcomes but not others. Hypertension and diabetes have different causes and rates of progression. The literature highlights that an increasingly Westernized diet and the large amount of refined rice intake in the traditional Chinese diet are linked to diabetes risks in China (Ma et al. 2014). Among the four major behavioral risk factors examined in the analyses, we find no significant impact on improving diet. It is important to acknowledge the differences among various health outcomes and to distinguish different pathways of influence among them.

One limitation of this study is that we focus on compulsory education reform, which mainly affects primary and secondary education levels. The enrollment rate from primary school to junior high school increased from 68.4% in 1985 to 94.9% in 2000 in China (Liang and Dong 2019). As education expansion continues and an increasingly high proportion of Chinese people receive tertiary education, future research should explore how greater educational attainment affects family health outcomes.

The other limitation is that by using the IV approach, we estimate the average treatment effect among those who alter their status because they react to the policy change (Imbens and Angrist 1994). The education reform has greatly increased school completion rates across all of China, but it is children from areas with lower levels of schooling (mostly poorer inland areas) who benefit the most and potentially pass on the health benefits to their older parents. However, educational inequality still exists across regions. For example, among the children exposed to the CEL in our analytic sample, the proportion of children who completed compulsory education is 70.5%, 64.7%, and 55.1% for areas with high, middle, and low levels of schooling, respectively, before the reform. In that sense, further investment in children's education, particularly targeted at children from lower socioeconomic status backgrounds, may benefit multiple generations, helping promote healthy aging and reducing social and health inequalities.

Most health policy and research has focused on individual interventions. The current national public health service project, which aims to provide free basic public health services to both rural and urban residents in China, covers annual blood pressure examinations for those aged 35 years or older and more comprehensive physical examinations for those aged 65 years or older. Yet, the awareness and management of chronic cardiovascular diseases are far from satisfactory. We provide an upward intergenerational perspective (i.e., from adult children to older parents). The education reform in China not only increased levels of schooling among cohorts of individuals who were affected but also had longer term beneficial effects on their parents' health two decades later. ■

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References

Aizer, A., & Currie, J. (2014). The intergenerational transmission of inequality: Maternal disadvantage and health at birth. *Science, 344,* 856–861.

Angrist, J. D., & Pischke, J. S. (2009). *Mostly harmless econometrics: An empiricist's companion*. Princeton, NJ: Princeton University Press.

Balli, H. O., & Sørensen, B. E. (2013). Interaction effects in econometrics. *Empirical Economics, 45,* 583–603.

Berkman, L. F., Glass, T., Brissette, I., & Seeman, T. E. (2000). From social integration to health: Durkheim in the new millennium. *Social Science & Medicine, 51,* 843–857.

Bhattacharya, J., Hyde, T., & Tu, P. (2014). *Health economics*. London, UK: Palgrave Macmillan.

Black, S. E., & Devereux, P. J. (2011). Recent developments in intergenerational mobility. In D. Card & O. Ashenfelter (Eds.), *Handbook of labor economics* (pp. 1487–1541). Amsterdam, the Netherlands: Elsevier.

Cai, F., Giles, J., O'Keefe, P., & Wang, D. (2012). *The elderly and old age support in rural China: Challenges and prospects*. Washington, DC: World Bank.

Central Committee of the Communist Party of China. (1985). Decisions on the education system reform. *Gazette of the State Council of the People's Republic of China, 15,* 467–477. (in Chinese)

Chen, X., Crimmins, E., Hu, P., Kim, J. K., Meng, Q., Strauss, J., . . . Zhao, Y. (2019). Venous blood-based biomarkers in the China Health and Retirement Longitudinal Study: Rationale, design, and results from the 2015 wave. *American Journal of Epidemiology, 188,* 1871–1877.

Chen, Y., & Feng, S. (2013). Access to public schools and the education of migrant children in China. *China Economic Review, 26,* 75–88.

Chen, Y., Persson, P., & Polyakova, M. (2019). *The roots of health inequality and the value of intra-family expertise* (NBER Working Paper 25618). Cambridge, MA: National Bureau of Economic Research.

Cui, Y., Liu, H., & Zhao, L. (2019). Mother's education and child development: Evidence from the compulsory school reform in China. *Journal of Comparative Economics, 47,* 669–692.

Dal Canto, E., Ceriello, A., Rydén, L., Ferrini, M., Hansen, T. B., Schnell, O., . . . Beulens, J. W. J. (2019). Diabetes as a cardiovascular risk factor: An overview of global trends of macro and micro vascular complications. *European Journal of Preventive Cardiology, 26*(Suppl. 2), 25–32.

De León, W., & McLaughlin, S. (2018). Adult children's education and parents' diabetes self-care behaviors in Mexico. *Innovation in Aging, 2,* 271. https://doi.org/10.1093/geroni/igy023.1003

De Neve, J. W., & Fink, G. (2018). Children's education and parental old age survival—Quasi-experimental evidence on the intergenerational effects of human capital investment. *Journal of Health Economics, 58,* 76–89.

De Neve, J. W., & Harling, G. (2017). Offspring schooling associated with increased parental survival in rural KwaZulu-Natal, South Africa. *Social Science & Medicine, 176,* 149–157.

Fan, C. C. (2005). Interprovincial migration, population redistribution, and regional development in China: 1990 and 2000 census comparisons. *Professional Geographer, 57,* 295–311.

Fang, H., Eggleston, K. N., Rizzo, J. A., Rozelle, S., & Zeckhauser, R. J. (2012). *The returns to education in China: Evidence from the 1986 compulsory education law* (NBER Working Paper 18189). Cambridge, MA: National Bureau of Economic Research.

Fischer, S. H., David, D., Crotty, B. H., Dierks, M., & Safran, C. (2014). Acceptance and use of health information technology by community-dwelling elders. *International Journal of Medical Informatics, 83,* 624–635.

Friedman, E. M., & Mare, R. D. (2014). The schooling of offspring and the survival of parents. *Demography, 51,* 1271–1293.

Fruehwirth, J. C., Iyer, S., & Zhang, A. (2019). Religion and depression in adolescence. *Journal of Political Economy, 127,* 1178–1209.

Goldman, D., & Smith, J. P. (2011). The increasing value of education to health. *Social Science & Medicine, 72,* 1728–1737.

Grossman, M. (1972). On the concept of health capital and the demand for health. *Journal of Political Economy, 80,* 223–255.

Grossman, M. (2015). The relationship between health and schooling: What's new? *Nordic Journal of Health Economics, 3*(1), 7–17.

Hu, A. (2017). Providing more but receiving less: Daughters in intergenerational exchange in mainland China. *Journal of Marriage and Family, 79,* 739–757.

Huang, W. (2015). *Understanding the effects of education on health: Evidence from China* (IZA Discussion Paper No. 9225). Bonn, Germany: Institute for the Study of Labor.

Imbens, G. W., & Angrist, J. D. (1994). Identification and estimation of local average treatment effects. *Econometrica, 62,* 467–475.

Jiang, N. (2019). Adult children's education and later-life health of parents in China: The intergenerational effects of human capital investment. *Social Indicators Research, 145,* 257–278.

Jiang, N., & Kaushal, N. (2020). How children's education affects caregiving: Evidence from parent's past years of life. *Economics & Human Biology, 38,* 100875. https://doi.org/10.1016/j.ehb.2020.100875

Lee, C. (2018). Adult children's education and physiological dysregulation among older parents. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 73,* 1143–1154.

Lei, L. (2013). Sons, daughters, and intergenerational support in China. *Chinese Sociological Review, 45*(3), 26–52.

Lei, X., Sun, X., Strauss, J., Zhao, Y., Yang, G., Hu, P., . . . Yin, X. (2014). Health outcomes and socio-economic status among the mid-aged and elderly in China: Evidence from the CHARLS national baseline data. *Journal of the Economics of Ageing, 3,* 29–43.

Li, X., Krumholz, H. M., Yip, W., Cheng, K. K., De Maeseneer, J., Meng, Q., . . . Zhang, Q. (2020). Quality of primary health care in China: Challenges and recommendations. *Lancet, 395,* 1802–1812.

Liang, Y., & Dong, Z. (2019). Has education led to secularization? Based on the study of compulsory education law in China. *China Economic Review, 54,* 324–336.

Lundborg, P., & Majlesi, K. (2018). Intergenerational transmission of human capital: Is it a one-way street? *Journal of Health Economics, 57,* 206–220.

Ma, M. (2019). Does children's education matter for parents' health and cognition? Evidence from China. *Journal of Health Economics, 66,* 222–240.

Ma, M., Yahirun, J., Saenz, J., & Sheehan, C. (2021). Offspring educational attainment and older parents' cognition in Mexico. *Demography, 58,* 75–109.

Ma, R. C., Lin, X., & Jia, W. (2014). Causes of type 2 diabetes in China. *Lancet Diabetes Endocrinology, 2,* 980–991.

Megari, K. (2013). Quality of life in chronic disease patients. *Health Psychology Research, 1,* 141–148.

Montez, J. K., & Friedman, E. M. (2015). Educational attainment and adult health: Under what conditions is the association causal? *Social Science & Medicine, 127,* 1–7.

National Bureau of Statistics (People's Republic of China). (2015). *National economic and social development statistical bulletin*. Retrieved from http://www.stats.gov.cn/tjsj/zxfb/201602/t20160229_1323991.html (in Chinese)
National Bureau of Statistics (People's Republic of China). (2019). *China national statistical yearbook 2019*. Beijing: China Statistics Press. (in Chinese)
National Center for Cardiovascular Diseases. (2018). *Report on cardiovascular diseases in China 2018*. Beijing: Encyclopedia of China Publishing House.
Oreopoulos, P., Stabile, M., Walld, R., & Roos, L. L. (2008). Short-, medium-, and long-term consequences of poor infant health: An analysis using siblings and twins. *Journal of Human Resources, 43,* 88–138.
Peng, S., Bauldry, S., Gilligan, M., & Suitor, J. J. (2019). Older mother's health and adult children's education: Conceptualization of adult children's education and mother–child relationships. *SSM–Population Health, 7,* 100390. https://doi.org/10.1016/j.ssmph.2019.100390
Pischke, J. S., & von Wachter, T. (2008). Zero returns to compulsory schooling in Germany: Evidence and interpretation. *Review of Economics and Statistics, 90,* 592–598.
Poulter, N. R., Prabhakaran, D., & Caulfield, M. (2015). Hypertension. *Lancet, 386,* 801–812.
Ram, A., Dave, S. S., Lancki, N., Moran, M., Puri-Taneja, A., Mammen, S., . . . Kandula, N. R. (2020). Social influence of adult children on parental health behavior among South Asian immigrants: Findings from the MASALA (Mediators of Atherosclerosis in South Asians Living in America) study. *Ethnicity & Health*. Advance online publication. https://doi.org/10.1080/13557858.2020.1734779
Ross, C. E., & Mirowsky, J. (2006). Sex differences in the effect of education on depression: Resource multiplication or resource substitution? *Social Science & Medicine, 63,* 1400–1413.
Sabater, A., & Graham, E. (2016a). *Intergenerational exchanges, children's education and parents' longevity in Europe* (Working Paper No. 77). Southampton, UK: ESRC Centre for Population Change.
Sabater, A., & Graham, E. (2016b). The role of children's education for the mental health of aging migrants in Europe. *GeroPsych, 29,* 81–92.
Smith, J. P. (2007). The impact of socioeconomic status on health over the life-course. *Journal of Human Resources, 42,* 739–764.
Smith, K. V., & Goldman, N. (2007). Socioeconomic differences in health among older adults in Mexico. *Social Science & Medicine, 65,* 1372–1385.
Standing Committee of the National People's Congress (People's Republic of China). (2012). *Law on protection of the rights and interests of the elderly.* Retrieved from http://www.npc.gov.cn/zgrdw/huiyi/cwh/1130/2012-12/29/content_1749760.htm (in Chinese)
Stanton, A. L., Revenson, T. A., & Tennen, H. (2007). Health psychology: Psychological adjustment to chronic disease. *Annual Review of Psychology, 58,* 565–592.
State Council (People's Republic of China). (1986). Temporary provisions on state business employing staff. *Gazette of the State Council of the People's Republic of China, 25,* 744–745. (in Chinese)
State Council (People's Republic of China). (1988). Provisional regulations of the People's Republic of China on private enterprises. *Gazette of the State Council of the People's Republic of China, 15,* 483–489. (in Chinese)
Tijhuis, M. A., Flap, H. D., Foets, M., & Groenewegen, P. P. (1998). Selection in the social network: Effects of chronic diseases. *European Journal of Public Health, 8,* 286–293.
Timmermans, S., & Kaufman, R. (2020). Technologies and health inequities. *Annual Review of Sociology, 46,* 583–602.
Torssander, J. (2013). From child to parent? The significance of children's education for their parents' longevity. *Demography, 50,* 637–659.
Torssander, J. (2014). Adult children's socioeconomic positions and their parents' mortality: A comparison of education, occupational class, and income. *Social Science & Medicine, 122,* 148–156.
Turner, J., & Kelly, B. (2000). Emotional dimensions of chronic disease. *Western Journal of Medicine, 172,* 124–127.
Wang, L., Kong, L., Wu, F., Bai, Y., & Burton, R. (2005). Preventing chronic diseases in China. *Lancet, 366,* 1821–1824.
Whyte, M. K. (2005). Continuity and change in urban Chinese family life. *China Journal, 53,* 9–33.
World Health Organization. (2013). *A global brief on hypertension: Silent killer, global public health crisis* (Report). Retrieved from https://apps.who.int/iris/rest/bitstreams/195800/retrieve
World Health Organization. (2015). *China country assessment report on ageing and health*. Retrieved from https://apps.who.int/iris/bitstream/handle/10665/194271/9789241509312_eng.pdf

Xie, Y., & Zhu, H. (2009). Do sons or daughters give more money to parents in urban China? *Journal of Marriage and Family, 71,* 174–186.

Yahirun, J. J., Sheehan, C. M., & Hayward, M. D. (2016). Adult children's education and parents' functional limitations in Mexico. *Research on Aging, 38,* 322–345.

Yahirun, J. J., Sheehan, C. M., & Hayward, M. D. (2017). Adult children's education and changes to parents' physical health in Mexico. *Social Science & Medicine, 181,* 93–101.

Yahirun, J. J., Sheehan, C. M., & Mossakowski, K. N. (2020). Depression in later life: The role of adult children's college education for older parents' mental health in the United States. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 75,* 389–402.

Yang, H. (1996). The distributive norm of monetary support to older parents: A look at a township in China. *Journal of Marriage and the Family, 58,* 404–415.

Yang, L., Martikainen, P., & Silventoinen, K. (2016). Effects of individual, spousal, and offspring socioeconomic status on mortality among elderly people in China. *Journal of Epidemiology, 26,* 602–609.

Zhao, R., & Zhao, Y. (2018). The gender pension gap in China. *Feminist Economics, 24*(2), 218–239.

Zhao, Y., Crimmins, E. M., Hu, P., Shen, Y., Smith, J., Strauss, P., . . . Zhang, Y. (2016). Prevalence, diagnosis, and management of diabetes mellitus among older Chinese: Results from the China Health and Retirement Longitudinal Study. *International Journal of Public Health, 61,* 347–356.

Zhao, Y., Strauss, J., Yang, G., Giles, J., Hu, P., Hu, Y., . . . Wang, Y. (2013). *China Health and Retirement Longitudinal Study—2011–2012 national baseline users' guide*. Beijing, China: National School of Development, Peking University. Retrieved from http://charls.pku.edu.cn/Public/ashelf/public/uploads/document/2011-charls-wave1/application/CHARLS_nationalbaseline_users_guide.pdf

Zhao, Y., Wang, Y., Chen, X., Meng, Q., Tang, Y., Zhang, T., . . . Bo, H. (2019). *Report on health and aging in China: China Health and Retirement Longitudinal Study*. Retrieved from http://charls.pku.edu.cn/Public/ashelf/public/uploads/document/public_documents/application/china-health-retirement-report.pdf (in Chinese)

Zimmer, Z., Hermalin, A. I., & Lin, H.-S. (2002). Whose education counts? The added impact of adult-child education on physical functioning of older Taiwanese. *Journals of Gerontology, Series B: Psychological Sciences and Social Sciences, 57,* S23–S32.

Zimmer, Z., Martin, L. G., Ofstedal, M. B., & Chuang, Y. L. (2007). Education of adult children and mortality of their elderly parents in Taiwan. *Demography, 44,* 289–305.

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