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Article

Does Adult Children's Education Increase Parents Longevity in China?

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Abstract: Background: Some developing countries, such as China, population is aging rapidly, meanwhile, the average years of schooling for residents is constantly increasing. However, the question of whether adult children's education has an effect on the longevity of older parents, remains inadequately studied. Methods: This paper uses China Health and Retirement Longitudinal Survey (CHARLS) data to estimate the causal impact of adult children's education on their parents' longevity. Identification is achieved by using the truncated regression model and using historical education data as instrument variables for adult children's education. Results: For every unit increase in adult children's education, the father's and mother's longevity increased by 0.89 years and 0.75 years, respectively. Mechanism analysis shows that adult children's education has a significant positive impact on parents' emotional support, financial support and self-reported health. Further evidence shows that for every unit increase in adult children's education, the father-in-law's and mother-in-law's longevity increased by 0.40 years and 0.46 years, respectively. Conclusions: It is conclusion that improving the level of adult children's education can increase parents' and parents-in-law's longevity. Adult children's education might contribute to the longevity of older parents by three channels that providing emotional, economic support and affecting parents' health.

Keywords: Adult children's education; parental longevity; truncated regression; emotional support

1. Introduction

For a long time, the inter-generational transmission of human capital between parents and children has been regarded as a "one-way street." Economists and sociologists have mainly considered the impact of parents' human capital and economic and social status on their children [1], but is this effect only a one-way street? As children grow, will the human capital of adult children "pay back" their parents? This problem deserves further study. On the one hand, the Chinese population is aging rapidly. It is predicted that the elderly population (over 65 years old) in China will reach its peak between 2030 and 2050 [2]. Along with the aging of the national population, comes the problem of supporting the elderly population. In the Chinese traditional social concept, children are raised with the understanding that they will take care of their parents in the future. In this traditional culture, the role of adult children in supporting their elderly parents cannot be ignored. In addition, children's education is an important way to strengthen the concept of filial piety and increase income, while filial piety and children's earnings directly affect the quality of care for their parents [3]. Therefore, the impact of adult children's educational attainment on their parents' health or longevity cannot be ignored. On the other hand, with the expansion and popularization of the compulsory education system in China, the years of schooling for residents is constantly increasing. In 2020, the average years of education of China's population aged 15 years and above, reached 10.75 years—an increase of 1.08 years over 2010. The illiteracy rate also dropped from 4.08% in 2010 to 1.67% in 2020. Given that the society and family attach importance to their children's education, children receive significantly more schooling than their parents. According to

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the data of the China Health and Retirement Longitudinal Survey [4], the average years of education of parents are 1.31 years. On the other hand, the average number of years of education of children is 5.33 years, 4.02 years higher than that of their parents. The level of education in all countries is increasing. At the same time, the global population is ageing, especially in China and Japan. In this context, analyzing the impact of adult children's education on the longevity of their parents is of great significance with regard to improving the quality of life for the elderly.

Education is an important influencing factor in individual longevity, and a significant body of literature confirms that education affects one's health and the mortality rate of newborns under five years of age [5-6]. Does children's education affect parents' longevity, especially when the parents become older and need more care and affection? There are a few recent studies shedding light on this issue. Most studies examine the effect of children's education on the probability of survival or the risk of death of parents. De Neve and Fink [7] used a comparative analysis before and after the education reform in Tanzania to find that the improvement of children's education level can significantly increase the probability of survival of parents who are over 50 years old. In addition, Torssander [8] compared differences between the longevity of siblings using Swedish data. Results showed that sisters with children who have only received compulsory education were likely to die younger, than sisters with children who had received higher education. Moreover, adult children's education affects their parents' probability of illness and the risk of death after illness. Zimmer et al. [6], using data from Taiwan, showed that children's education has a significant effect on reducing parents' mortality, especially for elderly parents with serious illnesses. Friedman and Mare [9] found that highly educated children increase the lifespan of their parents, especially by reducing the risk of death from chronic respiratory and lung diseases. However, some studies have different conclusions. Lundborg and Majlesi [10], using the instrument variables approach, argue that the implementation of compulsory education increased the years of schooling. But this policy does not significantly increase the life expectancy of parents. The reason is that children's education increases the distance between parents' accommodation and children's residence. That makes it less likely that children will live with their parents, which reduces parents' investment in their own health. Therefore, existing studies have inconsistent conclusions about the effect of adult children's education on parent's risk of death.

Previous studies have explored the impact of children's education on parents' longevity, but they suffer from the following deficiencies. First, there was no consensus regarding the effect of children's education on the longevity of their parents. Second, the analysis of the possible influencing mechanisms was imperfect, and no strict empirical analysis of possible mechanisms was conducted. Third, there was no strict treatment and testing of the possible problem of endogeneity. Based on the above deficiencies, this paper employs the data of the China Health and Retirement Longitudinal Survey (CHARLS) [4] to empirically analyze the effect of children's education on parental longevity. Meanwhile, we also explore possible mechanisms from the perspective of theoretical and empirical evidence.

This study shows that adult children's education has a significant positive effect on parents' longevity, which is still valid in the robustness test and instrumental variables regression. On this basis, the mechanism of adult children's education on parents' longevity is analyzed. Combined with theoretical and empirical analysis, we find that enhancing the level of children's education can increase emotional and economic support to their parents and improve their parents' health. These three channels are critical to prolonging longevity of elderly parents. Heterogeneity analysis indicates that the effect of children's education on parents' longevity is more obvious in rural areas and in families with multiple children. Further analysis shows that increasing the education level of individuals is also beneficial to the extension of the longevity of parents-in-law[①].

[①] Parents-in-law refers to the parents of the married partner.

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Compared with the existing literature, this paper makes the following novel contributions: (1) this paper studies the influence of adult children's education on parents' longevity, which not only helps in understanding the influencing factors of parents' longevity, but also provides a new solution to the problem of supporting the elderly; (2) this paper summarizes and refines three mechanisms of adult children's education affecting parents' life span, and tests them with detailed microdata of China. This provides a solid basis for solving the global problem that whether it is appropriate to support the elderly in the family; (3) this paper further analyzes the influence of adult children's education on parents-in-law's longevity. This provides strong support for reconsidering family relations and promoting family harmony, in the context of an aging population and imperfect social security system in some developing countries like China.

The rest of the paper is arranged as follows. Section 2 outlines the possible channels linking longevity of older parents with adult children's education. Section 3 introduces detailed information about the data, variables, and model used. Section 4 reports the empirical analysis results for parents' longevity and underlying pathways. It also highlights the robustness of the results. Section 5 summarizes and discusses the findings of the paper.

2. Theoretical Analysis

Berkman and Glass [11] point out many ways that social networks affect health, among which three ways may be related to the influence of adult children's education on parents' health. These include social support, social resources, and social influence. On the basis of the current theories, this paper concludes that there are three mechanisms regarding the influence of adult children's education on parents' longevity and summarizes them. The mechanisms can be summarized in the following manner: adult children's education might affect the longevity of older parents by providing emotional support, economic support, and influencing parents' health status.

First, recent studies show that children with greater years of formal schooling may provide more emotional support to their old parents, which improves parents' mental health. For example, it is more likely to increase the frequency of contact with parents and strengthen communication with their parents [12]. They may provide emotional support by protecting their parents from stressful events, supporting the good mental health of the elderly, and strengthening their social class identity [13]. Adult children are more likely to enjoy a more stable production and living environment when they are highly educated, which reduces parents' worries about their children and weakens the negative impact on parents' mental health [14]. However, some studies have highlighted that children with higher education increase the opportunity cost of contact with their parents, so that they may provide less emotional support [15]. Previous researchers arrived at different conclusions on the impact of adult children's education on parents' emotional support. Further research is required on the working of this mechanism in the context of traditional Chinese culture.

Second, the improvement of children's education can increase financial support for their parents. Adult children who have higher education can enhance willingness and ability to support their elderly parents, and improve the quality of care for the old parents through current and long-term intergenerational support [3]. Moreover, in order to compensate for their parents' investment in their education when they are young, adult children with higher education tend to provide more financial support to their elderly parents [16]. In addition, in rural areas, the relationship between parents and adult children's support is characterized by reciprocity. There is a significant positive correlation between parents' investment in their children's education and the old-age return provided by adult children [17]. Investment in children's education in the early stage of the children's lives can improve the quality of life of the parents, once they cross the age of 65. The longer the children's education period, the better the quality of life of the elderly [18]. Moreover, adult children are motivated to help others and tend to share their own resources with their parents. Even if adult children do not live with their

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parents, adult children with higher income or socioeconomic status due to higher education, boost financial support for their parents [8]. Therefore, the higher the level of education of the adult children, the more likely they are to provide more financial support.

Finally, educational attainment of adult children is conducive to improving parents' health. On the one hand, the increase of children's human capital can help parents process health and disease information more correctly [7]. The healthy bonus brought about by improvement of cognitive ability can be shared with parents. Adult children who acquired health knowledge or healthier lifestyles can influence parents' attitudes towards healthy behaviors and daily life habits. These could include, for example, improving the hygiene of the residential environment and reducing smoking and alcohol abuse [19]. It also increases the possibility of parents participating in sports or physical activities [20]. On the other hand, higher education of adult children is beneficial to improving the cognitive ability of elderly parents, preventing the occurrence of Alzheimer's disease, improving the function of the instrumental activities of daily living of elderly parents, reducing the incidence of chronic diseases and enhancing social adaptability [13, 21]. When parents are sick, adult children with higher education can provide better medical resources and care for sick parents, thereby increasing the probability of parents' recovery and improving their health [6]. Therefore, adult children with higher education can help their parents acquire good health concepts, have more positive health behaviors, reduce the probability of illness, and improve parents' health status.

3. Data and Methodology

3.1 Data variables and descriptive analysis.

The main data source of this paper is China Health and Retirement Longitudinal Study (CHARLS). The historical regional data was drawn from the Chinese Research Data Services Platform (CNRDS) and China Urban Statistical Yearbook. CHARLS data baseline survey of this database is 2011, which mainly investigates elderly families and their members aged 45 and above. This database contains abundant information of individuals, families, parents, and children. In addition, it describes in detail the age of the deceased parents, the time of death, the number of children each couple had, and the intergenerational support between children and parents. Therefore, based on the data from 2011, this paper extracts the age of death of parents in the following survey years. In the end, this data is integrated into cross-sectional data which includes the information about parents and children. It includes 10,525 father's observations and 11,344 mother's observations.

Explained variable: The explained variables in this paper are the longevity of father and mother. If parents die, the longevity is the age when they died. If the father or mother is still alive during the year 2018, their age during that year will be used. This is because the survey respondents are over 45 years old in the survey year of 2011. The parents of the respondents who are still alive in 2018 are 72 years old and above. They are still alive as per the most recently conducted survey wave, which means that the parents have a long lifespan; therefore, they are included.

Explanatory variables: The core explanatory variable is adult children's education, which is divided into five levels: illiteracy, primary school, junior high school, high school (and vocational education), junior college and above, with values of 1–5, respectively. The years of education are used in the robustness test. Referring to the assignment of education level by Yang et al. [22], illiteracy, primary school, junior high school, high school (and technical secondary school), junior college, university, postgraduate and doctorate level are assigned 0, 6, 9, 12, 15, 16, 19, and 22 years of schooling, respectively.

The control variables include occupational prestige of father or mother, whether the parents have sons, whether the parents have daughters, the number of children of each couple, whether the respondents own real estate, property value, and whether they live in towns. Occupational reputation refers to the ranking of occupational reputation by Li [23]. This paper sorts the occupations in the questionnaire from low to high and divides them into seven types. From low to high, they are: unemployment (unclassified

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occupation or no occupation), farmers (production personnel in agriculture, forestry, animal husbandry, fishery, and water conservancy industry), workers (production and transportation equipment operators and related personnel), business and service personnel, clerks (clerks and related personnel), professional and technical personnel and managers (heads of state organs, party-mass organizations, enterprises and institutions). The above seven types of occupations are assigned values from 1–7, respectively. The number of children of each couple is assigned values from 1–10, and if the number of children is more than 10, it is merged into 10. Whether the parents have sons or daughters, presence of a child is assigned 1, otherwise it is assigned 0. If the surveyed adult children live in town, they are assigned a value of 1 and if they live in rural areas, they are assigned a value of 0. If the surveyed children have real estate, it is assigned a value of 1 and 0 otherwise. The property value is taken as the logarithm of the current property value in 2011. In order to control the birth cohort effect, the parent birth cohort is divided into six groups, which are before 1900, 1901–1910, 1911–1920, 1921–1930, 1931–1940 and 1941–1950.

The mechanism variables are parents' emotional support, financial support, and health status of father or mother. Emotional support is measured by the frequency of visiting parents, which are: almost never, once a year, once every six months, once every three months, once every month, once every half month, once every week, two to three times a week, almost every day. The values are 1–9, respectively. The higher the value, the higher the frequency of visiting parents. If adult children live with their parents, the value is 9. Financial support to parents is measured by the sum of the value of money and things given to their parents regularly or irregularly. In order to reduce heteroscedasticity, financial support has been taken as the logarithm. The health status of father or mother is self-reported on a scale of 1 to 5. The larger the value, the better the health status. Specific descriptive statistics are shown in Table 1.

Table 1 Descriptive statistics of variables

Variable	Variable definition	Observations	Mean	Standard deviation
Father's longevity	Father’s length of life	10525	71.904	13.557
Mother's longevity	Mather’s length of life	11344	75	13.354
Father's education	Father's education level	10525	0.472	0.745
Mother's education	Mother's education level	11344	0.467	0.751
Father's year of birth	The year of father's birth	10525	1921.608	13.039
Mother's year of birth	The year of mother's birth	11344	1923.993	12.654
Children’s education	Education level of respondents	11344	1.213	1
Father's occupation prestige	Father's occupation prestige ranking	11344	2.793	1.669
Mother's occupation prestige	Mothers' occupation prestige ranking	11344	2.101	0.803
Real estate	Whether respondents own real estate	11344	0.902	0.297
Property value	Natural logarithms of property value of respondents	11344	1.932	1.574
Number of children of parents	Number of children of parents	11344	3.604	2.398
Whether parents have boys	Are there any males among children of parents	11344	0.935	0.246
Whether parents have girls	Are there any women among children of parents	11344	0.932	0.252
Towns	Whether respondents live in towns	11344	0.398	0.489
Emotional support	Frequency of visiting parents	3220	6.069	2.262
Economic support	Natural logarithms of the amount of transfer payment to parents	3220	3.205	2.971
Mother's health status	Mother self-report health status at year 2011	2708	2.811	0.963

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Father's health status	Father self-report health status at year 2011	2243	2.959	0.985
Per capita number of Jinshi	Per capita number of Jinshi in each city of Qing Dynasty (per 10,000)	8002	1.98	3.183

Note: The respondent is the identifying ID basis of the data, which refers to one of the parents' children. Jinshi was a successful scholar in the Qing Dynasty of Chinese history.

3.2 Truncated regression model

The theme of this study is the influence of adult children's education on parents' longevity. The dependent variables are father's longevity and mother's longevity. Parents' age should be 40 years and above. Parents can obtain effective contributions from their children, if and only if, they are at least 40 years of age and above when they die. The range of dependent variables is limited. In order to avoid the deviation caused by OLS model estimation, MLE estimation is adopted in this paper. The truncated regression model is used to estimate the data. The model is set as follows:

$$longevity_i^* = \alpha_0 + \alpha_1 edu_i + \delta X_i + cohort_i + community_i + \varepsilon_i \quad (1)$$

$$longevity_i = \begin{cases} longevity_i^*, & \text{if } longevity_i^* \geq 40 \\ 40 & , \text{ if } longevity_i^* < 40 \end{cases}$$

In equation (1), $longevity_i^*$ is the longevity of the father or mother of individual i. When the longevity is greater than or equal to 40 years, it can be observed, and when the longevity is less than 40 years, there is no information about this observation. The variable edu_i is the education level of individual i, $cohort_i$ is the fixed effect of birth cohort, $community_i$ is the fixed effect of community and ε_i is the random disturbance term. X_i includes control variables such as parents' personal, family characteristics, and respondents' family characteristics.

3.3 Cox proportional hazard model

Cox proportional hazard model is used to estimate father's death risk. Cox proportional hazard model is most commonly used in survival analysis, which adopts semi-parametric estimation and does not make fixed restrictive assumptions on benchmark risk function. The model is set as follows:

$$h(t) = h_0(t)e^{(\beta X)} \quad (2)$$

In equation (2), h(t) indicates probability of death at t years old under the condition that the individual has survived t-1 years old; $h_0(t)$ is the individual's benchmark death risk function when there is no covariate, and X is the variable affecting the longevity of parents, that is all independent variables in equation (1). β are the parameters to be estimated for each covariate. The explained variable is the death of father (or mother). If father or mother survive to age t-1 and die at the age of t, the father or mother is considered dead.

4. Results

4.1 Father's longevity

Table 2 shows the results of the impact of adult children's education on father's longevity, estimated using the truncated regression model. Column 1 in Table 2 shows that adult children's education has a significant positive impact on father's longevity. After adding father's education and occupational reputation in column 3, the results show that father's own education level has a significant positive impact on their longevity. The improvement of one's own education can not only increase one's own resources, but also improve the productivity of one's own health investment, which has a positive impact on individual longevity. Father's occupational prestige has a significant positive impact on longevity. Increasing occupational prestige is conducive to improving their own income and social capital, which is beneficial to prolonging lifespan. Column 5 shows that

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children with real estate can significantly increase their father's lifespan at the 10% level. The results of the marginal effect estimation in column 6 show that father's longevity increases by 0.89 years on average when their adult children's education increases by one unit.

Table 2 Estimation of children's education on father's longevity

Variables	Coefficient	Marginal effect	Coefficient	Marginal effect	Coefficient	Marginal effect
	(1)	(2)	(3)	(4)	(5)	(6)
Children's education	1.081***	1.017***	0.975***	0.917***	0.943***	0.887***
	(0.152)	(0.142)	(0.152)	(0.142)	(0.152)	(0.143)
Father's education			0.888***	0.835***	0.887***	0.834***
			(0.214)	(0.201)	(0.214)	(0.201)
Father's occupation prestige			0.276***	0.259***	0.266***	0.250***
			(0.089)	(0.084)	(0.089)	(0.084)
Father's year of birth			-0.158***	-0.148***	-0.161***	-0.151***
			(0.040)	(0.037)	(0.040)	(0.037)
Number of children					0.093	0.087
					(0.063)	(0.059)
Whether parents have boys					0.277	0.260
					(0.614)	(0.577)
Whether parents have girls					0.702	0.661
					(0.544)	(0.512)
Towns					1.473***	1.386***
					(0.362)	(0.341)
Real estate					0.973*	0.915*
					(0.529)	(0.498)
Property value					0.160	0.150
					(0.116)	(0.109)
Constants	70.88***		369.67***		373.05***	
	(0.560)		(75.186)		(74.900)	
Cohort fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Community fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10525	10525	10525	10525	10525	10525

Note: The data in brackets are standard deviation, and *, *, * * are significant at 10%, 5%, and 1% levels, respectively; columns 1, 3, 5, and 7 represent the estimation coefficients of the truncated regression model, and columns 2, 4, 6, and 8 represent the average marginal effect.

4.2 Mother's longevity

Table 3 shows that the estimated results of mothers' longevity by using the same truncated regression model. After adding cohort and community fixed effect, the results in column 1 of Table 3 shows that adult children's education can significantly increase the longevity of their mothers. Control variables of mother, parental family and children characteristics are successively added in columns 3 and 5. The results still show that adult children's education can significantly increase mother's longevity. Column 5 shows that mother's own education and occupation prestige have a significant positive impact on their longevity. An increase in the number of children, and the presence of boys as well as girls, has a positive impact on mother's longevity. The marginal effect analysis in column 6 shows that, on average, a one-level increase in adult children's education increases a mother's longevity by 0.75 years. Tables 2 and 3 both show that children's education has a positive spillover effect on parents' longevity.

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Table 3 Estimated results of children's education on mother's longevity

Variables	Coefficient	Marginal effect	Coefficient	Marginal effect	Coefficient	Marginal effect
	(1)	(2)	(3)	(4)	(5)	(6)
Children's education	0.822***	0.797***	0.828***	0.803***	0.774***	0.751***
	(0.143)	(0.138)	(0.142)	(0.138)	(0.143)	(0.139)
Mother's education			0.470*	0.456*	0.488*	0.474*
			(0.257)	(0.250)	(0.257)	(0.249)
Mother's occupation prestige			0.317*	0.307*	0.325**	0.315**
			(0.162)	(0.157)	(0.163)	(0.158)
Mother's year of birth			-0.152***	-0.147***	-0.158***	-0.153***
			(0.040)	(0.039)	(0.040)	(0.039)
Number of children					0.198***	0.192***
					(0.055)	(0.054)
Whether parents have boys					1.726***	1.674***
					(0.579)	(0.562)
Whether parents have girls					1.497***	1.453***
					(0.554)	(0.537)
Towns					3.919***	3.803***
					(0.259)	(0.252)
Real estate					-0.200	-0.194
					(0.494)	(0.479)
Property value					0.185*	0.179*
					(0.098)	(0.095)
Constants	73.526***		360.585***		369.142***	
	(0.610)		(75.768)		(75.861)	
Cohort fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Community fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11344	11344	11344	11344	11344	11344

Note: The data in brackets are standard deviation, and *, *, and * * are significant at the 10%, 5%, and 1% levels respectively; columns 1, 3, 5, and 7 represent the estimation coefficients of the truncated regression model, and columns 2, 4, 6 and 8 represent the average marginal effect.

4.3 Instrumental variables

There may be endogenous problems in the above estimation. First, there may be a problem due to missing variables. Factors affecting longevity, besides the factors contained in the above regression equation, could also be present. These include factors such as genes, parents' eating habits, family harmony and so on, which cannot be controlled in this paper. On the other hand, it may have a reverse causality problem. The longer the life expectancy of parents, the more likely they are to invest in their children's education and improve their children's human capital, in order to get more support from their adult children when they are old. In order to deal with possible endogenous problems, this paper uses instrumental variables. Taking the example of the estimation of instrumental variables by Chen et al. [24], the per capita number of Jinshi in the Qing Dynasty is used as the instrumental variable of adult children's education. Historically, the greater the per capita number of Jinshi in cities, the more local citizens pay attention to the investment in children's education, which affects their children's access to education. However, the number of Jinshi in cities do not have a direct impact on residents' longevity. Limited to the availability of data, the total population of the corresponding city in 1984 is used to substitute for total population of cities in the Qing Dynasty. The number of Jinshi per capita is obtained by dividing the number of Jinshi by total population in this region. The two-stage least squares (2SLS) method is used to estimate instrumental variables. Hausman test shows that adult children's education has

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been rejected as an exogenous variable at the 1% level. The estimated results are shown in Table 4. The one-stage regression results in columns 1 and 3 of Table 4 show that the per capita number of Jinshi in the Qing Dynasty has a significant positive impact on the level of adult children's education. The more the per capita number of Jinshi in regional history, the higher the level of adult children's education, which meets the correlation requirements of instrumental variables. Column 2 and column 4 in Table 4 show that in the regression with father's and mother's longevity as the dependent variable and controlling variables of parents' characteristics and family characteristics, 2SLS shows that adult children's education has a significant positive impact on parents' longevity. The regression results of dealing with endogeneity still support that adult children's education has a significant positive effect in promoting parents' longevity.

Table 4 Estimated results of instrumental variables

Variable	Father		Mother	
	One-stage	Two-stage	One-stage	Two-stage
	(1)	(2)	(3)	(4)
Per capita number of Jinshi	0.171***		0.297***	
	（0.015）		（0.024）	
Children's education		8.117**		10.183***
		(3.949)		(3.948)
Control variable	control	control	control	control
Cohort fixed effect	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes
Observations	7426	7426	8002	8002

Note: The data in brackets are standard deviation, and *, ** and *** are significant at 10%, 5%, and 1% levels respectively. Columns 1-4 represent the average marginal effect. Other control variables and constants in regression results are not reported in this table. Interested readers can ask the author for them.

4.4 Robustness

In order to test the robustness of the above results, bootstrapping, cox proportional hazard model, multiple linear regression, and the measurement method of changing core variables are used. First, the method of bootstrap was used to choose the sample 500 times randomly in all observations, and then we use the truncated regression model to fit parent's longevity. Columns 1 and 7 in Table 5 show that after using the bootstrap method, the results still support the fact that adult children's education significantly improves parents' longevity. Columns 2 and 8 are estimated by multiple linear regression, and the results still support the above outcomes. Another measure of longevity is the mortality risk. The lower the mortality risk, the greater the longevity of individuals. Therefore, in order to estimate the influence of adult children's education on father's mortality risk, columns 3 and 9 use the Cox proportional hazards model. The result shows that an increase in every unit of adult children's education reduces the risk of father's death by 0.058 times and the risk of mother's death by 0.062 times. The result shows that an increase in adult children's education can significantly reduce the risk of parents' death.

To estimate the impact of adult children's education on parent's longevity more accurately, excluding parents who are alive in 2018, the data only contains dead parents, and the result is shown in columns 4 and 10 in Table 5. The results of columns 4 and 10 show that after controlling for the characteristics of parent and children, joining birth cohort, and community fixed effect, adult children's education still has a significant positive impact on parents' longevity. The marginal effect analysis shows that, on average, an increase in every unit of adult children's education increases father's longevity by 0.65 and mother's longevity by 0.64 years. In columns 5 and 11, according to the current education system, the degree of adult children education is converted into years of

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education. The marginal effect analysis shows that, on average, increasing each year of adult children's education, the longevity of the father's life increases by 0.27 years and that of the mother's increases by 0.20 years. In columns 6 and 12, the degree of adult children's education is replaced by the highest degree of education among parents' children. The result still supports our main conclusions. All in all, after using OLS, bootstrap, and the Cox proportional hazards model, the results of the truncated regression model are robust. After replacing the core independent variables and core dependent variable with other measurement methods, the results still support the conclusion that adult children's education has a significant positive impact on parents' longevity.

Table 5 Estimated results of robustness test

Variable	Panel A: Father					
	Bootstrap	OLS	Cox	Truncation		
	(1)	(2)	(3)	(4)	(5)	(6)
Children's education	0.943***	0.893***	-0.059***	0.698***		
	(0.170)	(0.151)	(0.012)	(0.162)		
Years of Children's education					0.265***	
					(0.038)	
The highest degree of education among parents' children						0.875***
						(0.145)
Control variable	control	control	control	control	control	control
Cohort fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Community fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10525	10522	10525	9236	10525	10188
	Panel B: Mother					
Variable	Bootstrap	OLS	Cox	Truncation		
	(7)	(8)	(9)	(10)	(11)	(12)
Children's education	0.774***	0.779***	-0.060***	0.675***		
	(0.139)	(0.137)	(0.012)	(0.172)		
Years of Children's education					0.196***	
					(0.036)	
The highest degree of education among parents' children						0.852***
						(0.132)
Control variable	control	control	control	control	control	control
Cohort fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Community fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	11344	11344	11344	8360	10500	10977

Note: The data in brackets are standard deviation, and *, ** and *** are significant at 10%, 5%, and 1% levels, respectively. Columns 4, 5, 6, 10, 11, 12 represent the average marginal effect. Other control variables and constants in regression results are not reported in this table. Interested readers can ask the author for them.

4.5 Mechanism

According to the theoretical analysis above, emotional support to parents, economic support to parents, and parents' health status are used as the mechanism variables. We use data to verify the three mechanisms, the estimated results of the mediation effect are shown in Table 6.

Columns 1 and 4 of Table 6 show that adult children's education has a significant positive impact on parents' emotional support. It indicates that the higher the degree of adult children's education, the higher the frequency of contacting parents. Columns 2 and

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5 show that the degree of adult children's education increases economic support to their parents at a confidence level of 5%. It demonstrates that the higher the adult education, the more willing they are to provide financial or material help to their parents. Column 6 shows that the increase in adult children's years of schooling significantly improves mothers' self-reported health status. In conclusion, emotional support, economic support, and the parents' health status, partly play a channel role. The adult children's education influence parents' longevity by giving parents more mental and material help and improving parents' health status.

Table 6 Analysis of the mechanism

Variables	Father sample			Mother sample		
	Emotional support	Economic support	Father's health status	Emotional support	Economic support	Mother's health status
	(1)	(2)	(3)	(4)	(5)	(6)
Children's education	0.602***	0.325**	0.016	0.207***	0.241***	0.032*
	(0.078)	(0.159)	(0.021)	(0.046)	(0.085)	(0.019)
Control variables	Control	Control	Control	Control	Control	Control
Cohort fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Community fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2243	2243	2243	3220	3220	2708

Note: The data in brackets are standard deviation, and *, ** and *** are significant at the 10%, 5%, and 1% levels, respectively.

4.6 Heterogeneity analysis

As there are great differences among individuals, families, and regions, our study analyzes the heterogeneity of different groups. Our sample has been divided into whether they live in towns and the number of children more than two. Between urban and rural areas, there are differences in accessibility and abundance of medical resources. Meanwhile, the two areas of health knowledge and health concepts are not completely consistent. Therefore, adult children can provide different resources to their parents. This paper analyzes the heterogeneity between urban and rural areas. On the one hand, the more children older parents have, the more support they have. On the other hand, for supporting the elderly and filial relatives, it is likely that a greater number of children could lead to them shifting blame on each other. The resultant effect should be verified based on the background of Chinese culture.

All control variables were added to the regressions, along with birth cohort and community fixed effect in Table 7. Column 1 shows that the cross-multiplication term between towns and adult children's education is significantly less than 0, which indicates that adult children's education in rural areas have a more positive impact on father's longevity than those in urban areas. For children with higher education levels in rural areas, the health spillover effect is higher. There are many left-behind elderly people in rural areas of China. Increasing adult children's education is also beneficial to prolonging the longevity of parents. Columns 2 and 4 show that the cross-multiplication term between the number of children and their education is significantly positive. It indicates that when the number of children is greater than 2, the probability of adult children contacting their parents rises. In that time, the number of parents receiving financial or emotional support from their adult children will rise. The raising of support can increase older parents' lifespan. Therefore, the positive influence of adult children's education on parents' longevity is greater for those who have more children and whose adult children live in rural areas.

Table 7 Heterogeneity analysis results

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	Father		Mother	
Variable	（1）	（2）	（3）	（4）
Children's education	1.409***	0.654***	1.040***	0.641***
	(0.205)	(0.178)	(0.201)	(0.166)
Towns × children's education	-0.930***		-0.442	
	(0.290)		(0.283)	
Number of children × children's education		0.761***		0.480**
		(0.235)		(0.223)
Control variables	control	control	control	control
Cohort fixed effect	Yes	Yes	Yes	Yes
Community fixed effect	Yes	Yes	Yes	Yes
Observations	10525	10525	11344	11344

Note: The data in brackets are standard deviation. *, ** and *** are significant 10%, 5%, and 1% levels respectively. Columns 1-4 represent the average marginal effect. Other control variables and constants in regression results are not reported in this table. Interested readers can ask the author for them; "×" indicates the cross-multiplication term of the two variables before and after.

4.7 Parents-in-law-longevity

Guan [25] finds that "mother-in-law is not mother", which refers to the fact that the feeling of daughters-in-law or sons-in-law towards her/his parents-in-law, are different from that toward their biological parents. We further analyze the influence of adult children's education on the longevity of their in-laws. The columns 1 and 2 of Table 8 estimate the longevity of the father-in-law. The results show that, on average, improvement in one unit of adult children's education can increase the longevity of fathers-in-law by 0.37 years. The columns 3 and 4 of Table 8 estimate the longevity of the mother-in-law, showing that, on average, improvement in one unit of adult children's education can increase the longevity of mothers-in-law by 0.4 years. The improvement of children's education not only has a positive spillover effect on their parents' longevity, but also has a positive spillover effect on their spouse's parents.

Table 8 Parents-in-law longevity estimate results

Variables	Father-in-Law		Mother-in-Law	
	（1）	（2）	（3）	（4）
Children's Education	0.467***	0.399**	0.453***	0.460***
	(0.165)	(0.164)	(0.162)	(0.161)
Father-in-law education		1.151***		
		(0.228)		
Mother-in-law education				0.851**
				(0.343)
Control variable	control	control	control	control
Cohort fixed effect	Yes	Yes	Yes	Yes
Community fixed effect	Yes	Yes	Yes	Yes
Observations	7503	7503	7399	7399

Note: The data in brackets are standard deviation, and *, ** and *** are significant at the 10%, 5%, and 1% levels, respectively. Columns 1-4 represent the average marginal effect. Other control variables and constants in regression results are not reported in this table. Interested readers can ask the author for them.

5. Conclusions

In the process of aging, the intergenerational transfer between children and parents does not flow unidirectionally; improving the degree of children's education can not only

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benefit children, but also benefit their parents. Using CHARLS data, this paper studies the effect of adult children's education on parents' longevity by using the truncated regression model, Cox proportional hazards model, instrumental variables estimation, mediation effect test, and related robustness test. The results show that: (1) Improving the level of adult children's education has a positive spillover effect on parents' longevity. Increasing every unit of adult children's education can significantly increase the father's longevity by 0.89 years and the mother's longevity by 0.75 years. After dealing with the endogenous problems, the results are still robust; (2) The spillover effect of adult children's education on parents' longevity is realized through three ways. Adult children with higher education increase emotional and economic support to their parents and improve their parents' health condition. Well-educated adult children can increase the frequency of contact with their parents, improve their parents' mental and physical health, and use their resources to provide high-quality medical services for older parents. This behavior can prolong their parents' longevity; (3) The positive influence of adult children's education on parents' longevity is greater in rural areas and for families with more children; (4) The improvement of adult children's education is also beneficial with regard to extending the longevity of parents-in-law.

The results of this study have strong policy implications. First, adult children's education is an important factor affecting their parents' longevity. A culture in which parents value their children's education should be promoted. Cultivating a culture of higher education for children, children are more likely to be willing to take on the responsibility of supporting their parents. This can not only reduce endowment insurance pressure of China, but also improve the quality of parents' lives when they become old. Second, we should promote family harmony and create a good family atmosphere. Adult children's education can not only be beneficial to their parent's longevity, but also be beneficial to their spouse's parents' longevity. Parents were more likely to follow their children's advice to increase their own healthy behaviors, instead of following the advice of other relatives. Therefore, family harmony should be advocated to increase the emotional connection between children and their parents. Finally, the elderly should be given training and support regarding the use of mobile Internet. In the context of global aging, in order to reduce the gap between rural and urban life expectancy and improve the quality of life among the left-behind elderly, the access and usage of the Internet is important. We should improve the left-behind elderly's ability to use the internet. Increasing network use training for the elderly ensures that migrant children and left-behind elderly can communicate via video when they are unable to meet frequently. Therefore, children increasing the emotional support to their parents helps in improving the physical and mental health of the elderly.

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