Number of children, Parental Longevity and Health in later life

Hualei Yang
Zhongnan University of Economics and Law
Yuanyang Wu (wuyuanyang97225@163.com)
Zhongnan University of Economics and Law
Jiahui Pang
Zhongnan University of Economics and Law
Shuo Zhang
Zhongnan University of Economics and Law
Siqing Zhang
Zhongnan University of Economics and Law

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Abstract

Background

The trade-off between fertility and longevity stands or falls in China, concerning the realization of the welfare of the parents in later life. With healthy ageing and the implementation of the three-child policy, the policies will always aim to safeguard the welfare of the elderly and increase the level of fertility. Based on Chinese households, whether this trade-off relationship is established or not is of great significance to family fertility orientation and the welfare in later life.

Methods

Based on data from the Chinese Longitudinal Healthy Longevity Survey (CLHLS) from 2008 to 2018, a Cox proportional risk model and an accelerated failure time model were used to examine the impact of the number of children, the number of sons and the number of daughters on longevity.

Results

The study found that the trade-off between childbearing and longevity only existed for those with five or more children, and that for those with fewer than five children, their longevity was not associated with having more children. We further found that having five or more children significantly increased the risk of death for both rural male older adults and urban older adults; and that having a son had a greater negative impact on parental longevity than having a daughter. The timing of childbearing, both too early and late childbearing, adversely affects the longevity of older people.

Conclusions

Based on current policy fertility levels and desire of fertility in family, the negative impact of current fertility patterns on older people's longevity is not present, and promoting fertility and ensuring well-being in later life can be achieved simultaneously. The implications are as follows, firstly, for families, having three children does not affect later life welfare under the three-child policy. Secondly, in terms of fertility support policies, improving fertility services for women while increasing attention to the role of men and fertility services for urban residents; and promoting scientific fertility to avoid the negative effects of unreasonable childbearing behavior.

1 Introduction

The trade-off between childbearing and longevity, that is, the more children one has, the shorter one's life expectancy or the higher one's risk of dying, has been the focus of demographic, sociological and anthropological attention (Kirkwood et al., 1991; Lycett et al., 2000; Dribe, 2004). Data from the seventh census shows that the number of people aged 65 and over in China is 190 million, accounting for 13.50% of the population, further increasing the level of ageing. Based on this, Chinese government is increasingly committed to raising the fertility rate and increasing the number of births in order to maintain a more reasonable population structure and slow down the ageing process. At the same time, the "Healthy China 2030" plan outlines a clear vision that "life expectancy in China will reach 79 years in 2030, with a significant increase in healthy life expectancy per capita", making healthy life expectancy a key

concern for healthy ageing. Guaranteeing the welfare of the elderly and promoting fertility have become two important issues in the context of ageing. On the one hand, in terms of fertility promotion, there is still a gap between the actual fertility level of families and the policy level. How to narrow the gap, guide families to have children and increase the actual level of fertility is the key to achieving the effectiveness of the policy. On the other hand, in terms of safeguarding the welfare of the elderly, there are numerous supportive policies at the national level. However, the realization of welfare in later life cannot be achieved overnight and should be explored from a whole life cycle evolutionary perspective. The question of whether early-life fertility behavior affects later-life welfare from a life-cycle perspective is then relevant to the achievement of fertility policy and the promotion of health in old age. The trade-off between fertility and longevity has been sought after in current studies. However, it is worth considering whether this relationship is valid in China, where there are significant differences in human, social and economic circumstances.

Throughout the research available, studies on fertility and parental longevity in China are still very limited in terms of sample size, especially those based on people aged 65 years and older. Most studies have selected older adults as the sample, such as, Zeng and Jin (2004) and Zhu et al. (2001). The selection effect of older adults' own health can weaken the association between fertility and longevity, showing a bias in sample selection. Secondly, on the selection of fertility variables, most studies only selected the total number of births or the total number of children, including Li and Zhang (2017). However, based on the differences in intergenerational support from children in China, gender differences in offspring should be taken into account when examining the relationship between fertility and parental longevity. Finally, in terms of research methodology, this paper further incorporates an Accelerate Failure Time model to overcome the estimation validity problem compared to the Cox model or discrete-time logit model used in most studies. Considering the shortcomings of the above studies, the Cox proportional risk model and the accelerate failure time model were used to examine the effects of the total number of children, the number of sons and the number of daughters on the longevity of older adults aged 65 and above in China, based on the Chinese Longitudinal Healthy Longevity Survey (CLHLS) from 2008 to 2018. The paper examines the effects of total number of children, number of sons and number of daughters on the longevity of parents aged 65 years and further explores the effects of early and late childbearing behaviors on longevity by urban-rural and male-female differences. Combined with the Chinese context, the paper seeks to demonstrate the applicability of the trade-off hypothesis to the Chinese sample, expanding the explanatory scope of the theory and advancing its development. The answer to this question is, of course, also conducive to improving health intervention policies for the elderly, can provide an empirical basis for the formulation of active fertility policies in low-fertility countries, and has practical implications in terms of health promotion and poverty reduction.

2 Literature Review And Research Hypothesis

Scholars carried out relevant research on the trade-off between fertility and longevity. In terms of number of births, most studies supported the negative relationship between number of births and longevity (Kitagawa and Hauser 1975. Beral 1985. Kvale et al. 1994. Green et al. 1988. Lund et al. 1990. Friedlander 1996). Bourg (2007) used complete cohort data to study that under natural fertility conditions, when the number of births increased, longevity would not decrease, but in the modern population, when women had more than five children, the mortality risk may increase. In order to overcome the direct consequences of pregnancy on death, Westendorp and Kirkwood (1998) limited the sample to postmenopausal women. They still found that the number of births was negatively correlated with women's longevity in women aged 60 and over, and a similar correlation was obtained when the sample was expanded to the age group of 50. Similar findings were also found in the study of Chinese samples. Based on the data of China Hainan centenarian cohort study, Zhu et al., (2021) found that compared with women aged 80–99, women over 100 had significantly fewer children, and there was also a negative correlation between female fertility

and longevity in China's elderly population. However, due to the influence of population, social and economic level, the trade-off relationship between fertility and longevity was becoming more and more complex.

The mechanism of the trade-off relationship between fertility and longevity was as follows: first, in the gestational stage, there was a replacement relationship between the resources required for fertility and the resources used to maintain life (Kirkwood, 1977). A large number of reproductive activities exhausted the resources that could have been used to maintain life. Among them, Disposable Soma Theory (DST) believed that organisms need to invest more resources to maintain the integrity of somatic cells in order to live longer, but fertility consumed a large proportion of resources, resulting in the reduction of resources used to maintain somatic cells. The extension of longevity was at the cost of reducing reproductive behavior. We must reduce reproductive behavior in order to live longer. On the contrary, the more births, the shorter longevity. Second, in the stage of childbirth and parenting, reproductive behavior brought long-term negative cumulative effects to health through physiological or socio-economic factors. Multiple pregnancies and childbirth worsened women's health, increased the pressure of child care, and made men have greater economic pressure and excessive labor participation. From the perspective of health, the biological reaction brought by childbirth behavior increased the risk of coronary heart disease and obesity in the later stage for women (Bastian et al, 2005). Repeated pregnancy may also affect the metabolism of lipid and glucose for a long time, resulting in health problems such as obesity and arteriosclerosis (Skilton et al., 2009). In the long run, pregnancy and childbirth had a direct impact on women's health, especially the health status of high parity women was worse than that of low parity or non-fertility women, and high parity women faced higher risks of chronic diseases such as cardiovascular diseases, endocrine diseases and some cancers (Peters et al., 2016). The damage of fertility to physical health also existed in man groups. In some male animals, mating was usually dangerous, even suicidal mating. After mating, males died, such as mantis, salmon and bag shrew. From the perspective of social economy, life course theory held that health was a dynamic process that developed over time and was the result of the accumulation of a variety of risks and protective factors in the life process. Major events experienced by individuals in their life course, such as childbirth and abortion, may have a cumulative impact on health in old age (Liu et al., 2019). Among them, fertility was not only limited to women's physiological behavior, but also an important change for men and women to enter a new role in the life process, which changed the whole family structure. Accompanying fertility may bring about changes in individual social roles, social networks and social participation, which had a cumulative or even negative impact on the health of the elderly. According to the health production theory of Grossman (1972), health was not only a kind of consumer goods, but also an investment goods. Apart from the time of illness, part of the remaining time needed to be used for work to produce other goods, and the other part was used for leisure. Health can be produced only when work and leisure were matched together. When the mother had more children, she spent more time on child care and housework, which occupied the mother's leisure time and family resources, resulting in the mother not having too much time for health production. At the same time, having too many children required more social labor in exchange for parenting resources. According to the gender roles of parents within the family, men often engaged in more social labor. The more children and the more parenting resources they need, they needed to participate in more social labor. Excessive labor participation was detrimental to the health level, which caused negative accumulation of growth in their later years of health and life. The Hypothesis 1 was formulated accordingly:

Hypothesis 1

There is a trade-off between the number of children and parental life expectancy in later life, with an increase in the number of children having a negative impact on life expectancy in later life.

When analyzing the relationship between fertility and longevity, the gender of children was also an important factor to be considered. Having sons and daughters may have different effects on parents' longevity. Boys grew faster during pregnancy and had a heavier average weight at birth (Loos et al., 2001. Marsal et al., 1996), larger body size may have higher lactation needs. The birth interval of women after giving birth to sons was often longer than that after giving birth to daughters (Mace and sear, 1997), and the mother may become more exhausted due to the production of male offspring. Helle et al., (2002) found that having a son brought a higher relative survival cost for the mother than having a daughter. The son shortened the life of the mother, while the daughter not. Van De Putte et al., (2003) found a similar conclusion in the study of a Flemish agricultural village in the 18th-20th century. The Hypothesis 2 was formulated accordingly:

Hypothesis 2

Increases in the number of boys have a more pronounced negative impact on parental longevity in later life than the number of girls.

In addition, childbearing time also had an impact on parents' longevity, but this impact was adjusted by region and gender. In terms of regional differences, Doblhammer (2000) found that the mortality of women giving birth before the age of 20 was higher than that of women giving birth for the first time after the age of 20, and the mortality of late motherhood mothers was lower than that of young mothers. Westendorp and Kirkwood (1998) conducted a study on female samples from British noble families and found that there was a significant negative correlation between the time of giving birth and longevity, but there was a significant positive correlation between the age of first birth and longevity. Zeng and Jin(2004) also believed that late motherhood was significantly related to the health and longevity of the elderly in China. Hank (2010), based on the data of the German Socio-Economic Panel, found that in West Germany, early motherhood was accompanied by poor physical health, while in East Germany, late motherhood was accompanied by poor mental health. In terms of gender differences, early motherhood reduced the survival time of elderly women (Li and Zhang, 2017), and late motherhood was only related to women's longevity, but not for men (McArdle et al., 2006). The Hypothesis 3 was formulated accordingly:

Hypothesis 3

The effect of the number of children on parental longevity is differentiated by gender, urban/rural and timing of childbearing.

3 Methods

3.1 Study sample

Data were obtained from the Chinese Longitudinal Healthy Longevity Survey (CLHLS)[1]. The CLHLS study was approved by the Research Ethics Committees of Duke University and Peking University. The CLHLS was initiated in 1998 and follow-up surveys were conducted in 2000, 2002, 2005, 2008, 2011, 2014 and 2018. CLHLS randomly selected about half of the counties and cities in 23 provinces, cities, autonomous regions in China for tracking investigation, and had accumulated 113,000 visits to the households. This database included micro data of physical health, mental health, social participation, behavior, diet and nutrition, living habits, socio-economic status, family structure, intergenerational relationship, elderly family care needs, care costs and other data of the living elderly, as well as data of health status, care costs and quality of life of the dead elderly before death. The data quality of CLHLS was generally recognized by scholars in China and abroad.

This paper selected the follow-up survey data of 2008, 2011, 2014 and 2018, mainly considering: first, the timeliness of the data. The latest follow-up survey was the information of 2226 elderly people collected from 2017 to 2018, which had a short time span to now and was representative. Second, the cumulative tracking samples of the four surveys reached 16954. After excluding the missing persons and the missing values of key variables, the final sample size was 10938, which was of large sample and suitable for empirical analysis.

3.2 Variables

The survival time of respondents during the observation period was selected as the explanatory variable of this paper. If the interviewee died during the observation period, that is, the event of concern (death) occurred, the survival time was from the time of visit in 2008 to the time of death. If the respondents were still alive at the time of 2018 survey, their survival time was from the beginning of the interview event in 2008 to the end of the survey event in 2018, and was defined as censored. In the total sample, the proportion of death occurred during the observation period was about 65%, and the proportion of censored was about 35%.

This paper used the number of births, sons and daughters to investigate the impact of the number of children on parents' longevity. The number of births was measured by one question: “How many children, including those who have died, do you have?” Considering the sample size and policy level, 1 and 2 children born were combined as the reference group (assigned as 0), and the dummy variables of 3 children, 4 children, 5 children and 6 or more children were generated respectively. If the respondent had 3, 4, 5 or 6 or more children, the value is 1. In addition, due to the existence of gender differences, the number of sons and daughters may have different effects on parents' longevity, and further generated variables of the number of sons and daughters. The dummy variables of the number of sons born include 1 son (vs 0 son), 2 sons (vs 0/1 son) and 3 or more sons (vs 0/1 son). The dummy variables of the number of daughters born include 1 daughter (vs 0 daughter), 2 daughters (vs 0/1 daughter) and 3 or more daughters (vs 0/1 daughter).

In addition to the core explanatory variables, the model also included a series of demographic characteristics, living habits and health status of respondents as control variables. In terms of demographic characteristics, it mainly included the respondents' age, gender, marital status, urban and rural status and education. In terms of living habits, including smoking, drinking and daily exercise. In terms of health status, including respondents' disability and self-rated health status. In addition, there were variables of living with children and family annual income. Among them, gender, marital status, urban and rural status, education, smoking, drinking, daily exercise, disability and living with children were set as dummy variables, age and family annual income were set as continuous variables, and self-rated health status was an orderly multi classification variable. See Table 1 for specific settings.

3.3 Statistical Methods

Cox Proportional Hazards Model

The Cox proportional hazards model, established by British statistician D.R. Cox in 1972, was the classic model for dealing with survival analysis problems and was widely used in medicine, biology and the social sciences. Cox PH model did not make any restrictive assumptions about the distribution form of baseline hazard. It was a semi-parametric estimation model. When the correct parameter model was unknown, the results obtained by using Cox PH model were relatively robust. The hazard function was set as follows:

$$h(t, X) = h_0(t)\exp(\beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_m X_m)$$

1

Where, $h(t, X)$represented the hazards function about the X at the time t ,$h_0(t)$ was the baseline hazard at the time t, X was the hazard factor, representing the number of births, number of sons and number of daughters.β was coefficient of hazard factors, indicating the impact of hazard factors. It should be noted that the important assumption of Cox PH model was proportional hazards assumption. Therefore, Schoenfeld residuals tests were used here when estimating Cox PH model.

Accelerate Failure Time Model

In the process of using Cox PH model, there may be some variables that cannot meet the proportional hazards, which may cause some estimation bias. Referring to the study of Li and Zhang (2017), the Accelerate Failure Time model was used to carry robustness test. AFT model was an effective parameter estimation, which can directly estimate the impact of hazard factors on survival time. The specific settings of the model were as follows:

$$\ln T = X_m\beta + \mu$$

2

$$T = \exp(X_m\beta + \mu) = \exp(X_m\beta) \times \exp(\mu)$$

3

$$\exp(\mu) = T \times \exp(-X_m\beta)$$

4

Where, $\ln T$was the logarithm of survival time, β was the coefficient of covariates X_m,X_m was the number of births, number of sons, number of daughters and other variables, μ was random error term.

[1] This research used data from Chinese Longitudinal Healthy Longevity Survey (CLHLS), a program carried out by Peking University. The data file was available on https://opendata.pku.edu.cn/dataset.xhtml?persistentId=doi:10.18170/DVN/WBO7LK

4 Results

4.1 Descriptive analysis

As shown in the Table 1, descriptive analysis was carried out for each variable by male and female. In the sample, the distribution of men and women was relatively balanced, with men accounting for about 45% and women accounting for 55%. In terms of survival status, during the observation period, the death toll of women was slightly higher than that of men, but the overall difference was small, and the mean difference was about 0.016. Most of the number of births (about 91%) was concentrated in 7 or less, and most of the number of sons and daughters (about 92% and 93%) were concentrated in 4 or less, which was consistent with the characteristics before the implementation of family planning.

In terms of age distribution, about 90% of the samples were aged 100 and below, and the average age of women was 87.3 years, which was slightly higher than that of men by about 4 years. The proportion of men in marriage was about 35.6%, and the proportion of divorced, widowed or never married was about 64.4%. The proportion of men in marriage was significantly higher than that of women. In the urban-rural distribution, most samples came from rural areas, about 63.4%, and the sample in urban areas was about 36.6%. Most of the parents lived with their children.

About half of the parents rated their health as good or very good. 19% of the parents now smoked and drank, and 71% of the sample did not participate in daily exercise. In terms of disability, 15.8% of the samples was disabled, and the number of disabled women was about twice that of men. About 40% of parents were educated, and the logarithm of total family income was mainly distributed between 4.4 and 11.5.

Table 1
Descriptive Analysis

Variable	Definition	Male		Female		Mean-diff
		N	Mean	N	Mean	
Survival Status	Death=,Censored = 0	4927	0.641	6011	0.657	-0.016*
Number of births	Number of children never born	4927	4.460	6011	4.736	-0.277***
Age	Real age	4927	82.974	6011	87.344	-4.370***
Marriage Status	Inmarriage = 1,divorce,Widowhood or never married = 0	4927	0.531	6011	0.210	0.320***
Region	rural = 1,urban = 0	4927	0.627	6011	0.634	-0.007
Live with Children	With children = 1,not with = 0	4927	0.857	6011	0.824	0.033***
Self-rated Health	Relatively unhealthy = 1,very healthy = 5	4927	3.498	6011	3.417	0.081***
Smoke	Smoke = 1,not smoke = 0	4927	0.343	6011	0.060	0.282***
Drink	Drink = 1,Not Drink = 0	4927	0.310	6011	0.088	0.223***
Exercise	Do exercise = 1,not = 0	4927	0.361	6011	0.231	0.130***
Disability	Disabled = 1, not disabled = 0	4927	0.112	6011	0.196	-0.084***
Educated	Educated = 1,illiteracy = 0	4927	0.659	6011	0.194	0.466***
Household income	Logarithm of household income	4927	9.277	6011	9.285	-0.008

4.2 The results of Cox PH model

As shown in Table 2, Cox PH model was carried to estimate the impact of number of births on the mortality risk of the elderly. In the model 1 and model 2, compared to the elderly who had one or two children, having three or four children would increase the mortality risk of people over 65 years old, but this relationship was not statistically supported. Further, models 3 and 4 gave us meaningful results. When having 5 or 6 and more children, the mortality risk of people over 65 years old increased significantly, and their survival time and longevity reduced. The results from model 3 and model 4 supported the Trade-off relationship between fertility and longevity for Chinese older people. Similarly, Dribe (2004) found that compared with women who have fewer children, giving birth to four or more children increased women's mortality by 30% ~ 50% and shortened women's life expectancy by 3.5 years based on Historical micro-level data of high quality for southern Sweden.

In addition, demographic characteristics, living habits and health status also affected the mortality in old age. Age growth was associated with disability and weakness, which affected the quality of life and longevity in old age. There was a difference of mortality in gender. Compared with men, the mortality risk of female elderly was significantly lower, which was consistent with the average life expectancy of China's population. In 2015, the average life expectancy of men was 73.64 years, women were 79.43 years, and women lived longer. The elderly in marital status showed a significantly lower risk of mortality. The elderly with better marital status would not feel lonely. Loneliness, as a psychological distress, would affect their health in their later years. Compared with the urban elderly, the mortality risk of the rural elderly showed a higher death risk, which may be related to the differences in socio-economic development and medical conditions caused by the urban-rural dual system. The elderly who chose to live with their children and had disability symptoms had a significantly higher risk of mortality. Better self-rated health status, participation in daily exercise and higher family income reduced the risk of mortality and prolonged the survival time, while smoking, drinking and education had no significant impact on the risk of mortality.

Table 2
The relationship between number of births and mortality risk

Variable	Model 1	Model 2	Model 3	Model 4
Control group: 1 and 2 children				
dummy_3child	0.004			
	(0.046)			
dummy_4child		0.060		
		(0.044)		
dummy_5child			0.072*	
			(0.044)	
dummy_6child				0.143***
				(0.039)
trueage	0.057***	0.059***	0.059***	0.057***
	(0.003)	(0.003)	(0.003)	(0.002)
sex	-0.378***	-0.357***	-0.332***	-0.376***
	(0.058)	(0.053)	(0.054)	(0.046)
marry	-0.466***	-0.329***	-0.319***	-0.229***
	(0.070)	(0.063)	(0.062)	(0.052)
residenc	0.135***	0.176***	0.130***	0.078*
	(0.051)	(0.047)	(0.048)	(0.040)
withchild	0.270***	0.238***	0.239***	0.171***
	(0.071)	(0.065)	(0.065)	(0.053)
selfhealth	-0.076***	-0.094***	-0.100***	-0.107***
	(0.025)	(0.024)	(0.024)	(0.020)
smoke	0.092	0.033	0.032	0.022
	(0.067)	(0.061)	(0.063)	(0.052)
drink	-0.062	-0.090	0.009	-0.069
	(0.068)	(0.060)	(0.061)	(0.050)
exercise	-0.171***	-0.206***	-0.216***	-0.191***
	(0.056)	(0.052)	(0.052)	(0.043)
disability	0.207***	0.191***	0.333***	0.315***
	(0.063)	(0.059)	(0.059)	(0.048)
edu	-0.070	-0.068	-0.034	-0.051

Variable	Model 1	Model 2	Model 3	Model 4
	(0.060)	(0.054)	(0.054)	(0.046)
lnincome	-0.047**	-0.041**	-0.041**	-0.023
	(0.020)	(0.019)	(0.019)	(0.015)
N	3215	3667	3535	4676

Due to the differences of gender preference and intergenerational support, we further explored the impact of the number of boys and girls on the risk of mortality in the elderly. As shown in Table 3, model 7 and model 10 gave us meaningful results. In model 7, when having three or more boys, the mortality risk of people over 65 increased significantly and survival time shortened significantly. In model 10, similarly, the mortality risk of people over 65 increased significantly when having three or more daughters. Their control group were all parents with one son or daughter. It should be noted that the risk of mortality for giving birth to girls was lower than that for boys among the elderly.

Table 3
The relationship between number of boys or girls and mortality risk

Variable	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
Control group:no boy						
dummy_1boy	0.066					
control group:0 and 1boy	(0.071)					
dummy_2boy		0.044				
		(0.034)				
dummy_3boy			0.147***			
control group:0 girl			(0.031)			
dummy_1girl				-0.043		
control group: 0and 1 girl				(0.045)		
dummy_2girl					0.033	
					(0.032)	
dummy_3girl						0.054*
						(0.029)
trueage	0.061***	0.061***	0.060***	0.057***	0.060***	0.059***
	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
sex	-0.402***	-0.372***	-0.403***	-0.329***	-0.374***	-0.368***
	(0.061)	(0.042)	(0.037)	(0.052)	(0.039)	(0.036)
marry	-0.293***	-0.306***	-0.251***	-0.386***	-0.310***	-0.288***
	(0.073)	(0.049)	(0.042)	(0.061)	(0.046)	(0.042)
residenc	0.111**	0.146***	0.108***	0.157***	0.189***	0.093***
	(0.055)	(0.037)	(0.033)	(0.046)	(0.035)	(0.032)
withchild	0.219***	0.200***	0.131***	0.185***	0.137***	0.160***
	(0.078)	(0.052)	(0.043)	(0.062)	(0.046)	(0.044)
selfhealth	-0.060**	-0.099***	-0.087***	-0.092***	-0.085***	-0.108***
	(0.027)	(0.019)	(0.016)	(0.023)	(0.018)	(0.016)
smoke	-0.015	0.096**	0.015	0.048	0.068	0.050
	(0.070)	(0.048)	(0.042)	(0.060)	(0.045)	(0.042)
drink	-0.052	-0.066	-0.041	-0.062	-0.056	-0.045
	(0.070)	(0.048)	(0.040)	(0.059)	(0.044)	(0.040)

Variable	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
exercise	-0.155***	-0.164***	-0.188***	-0.169***	-0.183***	-0.173***
	(0.059)	(0.042)	(0.035)	(0.050)	(0.038)	(0.035)
disability	0.253***	0.271***	0.279***	0.169***	0.233***	0.264***
	(0.064)	(0.045)	(0.040)	(0.059)	(0.044)	(0.039)
edu	-0.082	-0.069	-0.092**	-0.100*	-0.099**	-0.073**
	(0.062)	(0.043)	(0.037)	(0.053)	(0.040)	(0.037)
lnincome	-0.062***	-0.037**	-0.021*	-0.024	-0.017	-0.027**
	(0.022)	(0.015)	(0.013)	(0.018)	(0.014)	(0.013)
N	2822	5919	7322	3859	6719	7559

4.3 Results of Robustness test

The test of Proportional Hazards

Cox PH model was based on the assumption of proportional risk, tits risk function needs to meet $\lambda(t; x) = \lambda_0(t)h(x) = \lambda_0(t)e^{x'\beta}$. Therefore, Schoenfeld residuals tests was carried out for each model and variable.

The results of Schoenfeld residuals tests were shown in Table 4 and Table 5. The significance level of having three children, having four children, and having five or more children cannot reject the assumption of proportion hazard (P > 0.1). The estimation of the number of children to the risk of death in the above model was reliable. Similarly, in model 15 ~ model 20, the P values of the main explanatory variables have 1, 2 or 3 or more boys and 1, 2 or 3 or more girls were greater than 0.10. The hypothesis cannot be rejected and the proportional hazard condition was met.

Table 4
The Schoenfeld residuals tests of number of children

variable	model(11)P-value	model(12)P-value	model(13)P-value	model(14)P-value
Dummy_3chid	0.997			
Dummy_4child		0.8438		
Dummy_5child			0.8075	
Dummy_6child				0.8758
Trueage	0.011	0.263	0.055	0.082
Sex	0.792	0.580	0.097	0.342
marry	0.932	0.760	0.385	0.991
residence	0.735	0.696	0.432	0.009
withchild	0.971	0.250	0.001	0.300
selfhealth	0.061	0.395	0.492	0.066
smoke	0.989	0.432	0.334	0.111
Drink	0.005	0.164	0.188	0.644
exercise	0.219	0.688	0.766	0.093
kazt	0.004	0.000	0.001	0.001
edu	0.029	0.002	0.778	0.546
lnincome	0.683	0.363	0.355	0.812

Table 5
The Schoenfeld residuals tests of number of boys or girls

Variable	model(15)Pvalue	model(16)P-value	model(17)P-value	model(18)P-value	model(19)P-value	model(20)P-value
Dummy_1boy	0.157					
Dummy_2boy		0.265				
Dummy_3boy			0.766			
Dummy_1girl				0.485		
Dummy_2girl					0.429	
Dummy_3girl						0.459
trueage	0.867	0.071	0.107	0.002	0.001	0.030
sex	0.953	0.852	0.946	0.371	0.931	0.694
marry	0.998	0.869	0.350	0.620	0.383	0.552
residence	0.447	0.555	0.215	0.661	0.673	0.209
withchild	0.705	0.873	0.011	0.085	0.030	0.101
selfhealth	0.164	0.106	0.452	0.290	0.353	0.183
smoke	0.523	0.225	0.263	0.356	0.225	0.039
drink	0.191	0.188	0.655	0.096	0.368	0.253
exercise	0.557	0.222	0.156	0.754	0.273	0.415
katz	0.000	0.000	0.000	0.000	0.000	0.000
Edu	0.486	0.431	0.125	0.039	0.022	0.284
lnincome	0.057	0.321	0.230	0.945	0.348	0.900

4.4 The results under Accelerate Failure Time Model

The commonly used survival analysis methods also included parameter estimation AFT (Accelerated Failure time) model. On the one hand, AFT model did not need to meet the premise of proportional risk assumption, on the other hand, it can effectively solve the problem of unobservable variables, and can carry out robustness analysis on the above conclusions. It was worth noting that AFT model mainly studied the influence of explanatory variables on average life time, that is, the time from the non-occurrence of concerned events to the occurrence of concerned events, which was different from Cox PH model.

The results in Table 6 showed that compared with the elderly who have given birth to 1 and 2 children, when giving birth to 6 or more children, the average survival time of the elderly would be significantly reduced and the death risk rate would increased. Specifically, when the number of children was 4, the average survival time of the elderly decreased, but the impact was small. When the number of children increased to 6 or more, the average survival time of the elderly decreased significantly, showing a trend of significant reduction in life expectancy. In Table 7, Model 27, compared with the elderly who had given birth to 0 and 1 boy, having given birth to 3 or more boys would

significantly reduce the average survival time of the elderly and increase the risk of death. The same effect also occurred in the case of giving birth to girls. In Model 30, having three or more girls would reduce the average survival time of the elderly and shorten life expectancy. On the whole, the results in Tables 6 and 7 were consistent with the results of Cox PH model, and the above conclusions were robust.

Table 6
The robustness test under AFT model

variable	model(21)	model(22)	model(23)	model(24)
control group:having 1 and 2 children				
dummy_3child	0.008			
	(0.038)			
dummy_4child		-0.051		
		(0.036)		
dummy_5child			-0.040	
			(0.036)	
dummy_6child				-0.110***
				(0.032)
Control variables	YES	YES	YES	YES
_cons	5.801***	5.773***	5.805***	5.710***
	(0.259)	(0.243)	(0.241)	(0.204)
lnsigma	-0.030*	-0.013	-0.029*	-0.056***
	(0.018)	(0.016)	(0.016)	(0.013)
N	3215	3667	3535	4676

Table 7
The robustness test under AFT model

variable	model(25)	model(26)	model(27)	model(28)	model(29)	model(30)
control group: no boys						
dummy_1boy	-0.013					
control group: 0 boy and 1 boy	(0.059)					
dummy_2boy		-0.029				
		(0.028)				
dummy_3boy			-0.123***			
control group: no girls			(0.025)			
dummy_1girl				0.031		
control group: 0 girl and 1 girl				(0.037)		
dummy_2girl					-0.013	
					(0.026)	
dummy_3girl						-0.038
						(0.024)
Control variables	YES	YES	YES	YES	YES	YES
_cons	5.984***	6.082***	6.000***	5.794***	6.060***	5.870***
	(0.285)	(0.190)	(0.167)	(0.233)	(0.174)	(0.164)
lnsigma	-0.018	-0.020	-0.038***	-0.025	-0.032***	-0.029***
	(0.018)	(0.013)	(0.011)	(0.016)	(0.012)	(0.011)
N	2822	5919	7322	3859	6719	7559

4.5 The results of Heterogeneity Analysis

Due to the existence of urban-rural dual system, there may be urban-rural differences in the impact of fertility trajectory on the life expectancy of the elderly. We further discussed the impact of the number of children born in urban and rural areas on the mortality risk of male and female elderly. As shown in Table 8 below, in the rural elderly group, having 6 or more children would significantly increase the death risk of male elderly people, but there was no significant impact on female elderly people. However, in the urban elderly group, whether male or female, having 6 or more children would significantly increase their death risk. It was worth noting that the death risk coefficient of male elderly was higher than that of female elderly.

Table 9 showed that whether in urban or rural areas, having three or more boys or three or more girls significantly increased the risk of death of the elderly. There was no difference between urban and rural areas. It can be seen that the gender of children would not affect the death risk of the elderly due to the difference between urban and rural

areas. The total number of children born was the key to affecting the death risk, when considering the difference between urban and rural areas.

Table 8
The relationship between number of children and mortality risk in subsample

Variable	Female		Male	
	model(31)rural	model(32)urban	model(33)rural	model(34)urban
Control Group:1and 2 children				
dummy_6child	0.010	0.176**	0.158**	0.268***
	(0.065)	(0.086)	(0.078)	(0.101)
Control variables	YES	YES	YES	YES
N	1722	958	1234	762
Note: the author also analyzed the situation of having 3, 4 and 5 children, but it was not shown in the table because of the limited space and the non-statistically significant impact of the results.				

Table 9
The relationship between number of boys or daughters and mortality risk in subsample

Variable	Female		Male	
	model(35)rural	model(36)urban	model(37)rural	model(38)urban
control group:0 and 1 boy				
dummy_3boy	0.118**		0.151***	
	(0.051)		(0.058)	
control group:0 and 1 girl				
dummy_3girl		0.115*		0.193**
		(0.066)		(0.075)
Control variables	YES	YES	YES	YES
N	2612	1524	2026	1261
Note: the author also analyzed the situation of having one or two boys and having one or two girls, but it was not shown in the table because of the limited space and the non-statistically significant impact of the results.				

5 Discussion

5.1 The high parity was associated with high mortality

A possible explanation was that, on the one hand, according to the disposable body theory, if the resources available to support physiological maintenance and physical activity were limited, then having children or having more children increased the additional cost of survival. Among other things, the costs for women came from fetal growth, milk

synthesis and breastfeeding, etc. Resources allocated to childbearing could only come at the expense of other functions, and increased the allocation of resources to current fertility led to a reduction in resources allocated to other bodily functions, such as reducing physiological health and a shorter future longevity. As a result, some physiological and metabolic functions may be negatively affected by fertility and ultimately led to reduce longevity in old age. On the other hand, life course theory suggested that major events experienced by individuals over the life course may have a cumulative impact on health in old age, and that in addition to the direct costs of pregnancy and breastfeeding, had more children brings with it increased childcare, work intensity and working hours to obtain the resources needed to support the family (Sujatha et al., 2000), thus crowded out parents' leisure time and affected parents' healthy production. At the same time, according to the Grossman model extended by Jacobson (2000), under the budget constraint mechanism, had more children led to a tightening of the family budget constraint, which reduced the resources available for the maintenance of parents' own health and thus had a negative impact on parental health. In China in particular, due to sociocultural influences, parents tended to pay more for their children's growth and development in terms of energy and health, and such sacrifices were irreversible and had lasting effects.

Having sons was associated with higher mortality than having daughters

Having sons was associated with higher mortality. This was because, physiologically, having sons was more costly than having daughters, for example, male fetuses grew faster intrauterine and were heavier on average at birth relative to female fetuses (Marsal et al., 1996. Loos et al., 2001), which could have more negative effects on the mother's health status and in terms of competition for family resources, in adulthood and in terms of competition for family resources, in adulthood and old age, family resources and an individual's position in the family could affect survival chances (Tsuya, 2001). In the “economic approach” to household food distribution, children represented the potential human capital of the household, and where resources were scarce, household food distribution depended on their expected benefits to the household (Kumar, 1983), men could use their role in manual labor to secure household status, and the number of sons was likely to influenced parental status more than that of daughters. daughters affect parents' share of household resources more than daughters (Van De Putte et al., 2003), an increase in the number of sons may have a negative impact on parental longevity by crowding out more household resources.

5.2 The relationship was affected by difference from regions

Firstly, the difference in mortality risk between rural and urban the elderly women was mainly due to the fact that the survival of the older population in rural areas was more the result of natural selecting than in urban areas, with less intervention from external health services, especially as the "true health level" of rural older people aged 65 and above tended to be higher than in urban areas. This was why rural women tended to have a higher 'true level of health' than their urban counterparts, so that their own level of health moderates the impact of the number of births on their mortality risk, while urban women faced a higher mortality risk from having more children (six or more). Secondly, in terms of differences in mortality risk between male and the elderly women, on the one hand, foreign studies had shown that maternal longevity increased linearly with the number of children, with each additional child increasing life expectancy by 0.32 years, and this linear relationship was maintained up to 14 children (Mcardle et al., 2006). Similarly, contemporary Chinese women with a higher number of previous or current children also benefitted from a longer and healthier longevity in old age (Li and Zhang, 2017), and the available findings seemed to support women were better able to cope with the negative effects of childbearing. on the other hand, women were responsible for childbearing and nurturing, and women had a higher capacity for somatic cell maintenance and repair than men, so that in the face of the negative effects of childbearing, women may live longer than men when faced with the negative effects of childbearing, but if they chose to have more children, this may lead to a deterioration in female health and a reduction in longevity.

6 Conclusion

Based on data from the 2008–2018 CLHLS, this paper examined the impact of total number of births, number of sons and daughters on the longevity of older people in China using a Cox proportional hazard model and accelerated failure time model. The heterogeneity of the relationship was further examined with urban-rural and gender differences. The main findings of the study were as follows:

The trade-off between childbearing and longevity among older Chinese people existed only when having more than five children. In particular, having five or more children significantly increased the risk of death and produced a negative impact on longevity among older people, but there was no such trade-off between longevity with less than five children. Having three or more sons or daughters also had a significant negative impact on longevity, and there was also no trade-off between childbearing and longevity when having less than three sons or daughters. It was important to keep fertility level within a reasonable range to avoid the damage on longevity. According to the fertility desire of Chinese parents and current policy advocacy, having more children would not damage on longevity, especially at present fertility pattern.

In terms of urban-rural differences, having five or more children significantly increased mortality risk for both men and women in urban older people, and having five or more children significantly increased mortality risk for the elderly men in rural older people. There was no significant urban-rural difference in the risk of death for male and female births. The higher mortality risk for men was due to the fact that women had a higher capacity for somatic cell maintenance and repaired than men and tended to have a better longevity in the face of the negative socio-economic and health consequences of having children. The urban-rural difference in mortality risk for women was mainly due to the fact that the survival of the elderly in rural areas was more the result of natural selection, and without medical intervention, their own high level of health made them more likely to live longer, tempering the negative effects of childbearing on longevity.

The above findings gave a reasonable level of fertility to avoid the trade-off and facilitated the understanding of the long-term effects between fertility history and health in later life. Therefore, firstly, from the perspective of longevity and families' low desire of fertility, the policies to encourage childbearing should be accompanied by a gradual increase in the number of children, promoting a gradual shift in fertility patterns to achieve a steady increase in fertility, while unreasonable fertility behavior was not encouraged. Secondly, considering the difference in mortality risk between men and women, it was also important to focus on public services for men in childbirth and supporting health in later life, such as extending paternity leave for men and providing care services in later life. Finally, it was also important to promote reasonable childbearing behavior because of appropriate childbearing choices being particularly important for women's health in later life. Early motherhood and too late motherhood behavior were not advocated.

Abbreviations

CLHLS: Chinese Longitudinal Healthy Longevity Survey

AFT: Accelerated Failure Time model

DST: Disposable Soma Theory

Cox PH: Cox Proportional Hazards Model

Declarations

Ethics approval and consent to participate

This study was approved by the Institution of Peking University Open Research Data because of using public open data.

Consent for publication

Not applicable.

Availability of data and materials

The data and materials are availability from Corresponding author via E-mail.

Competing interests

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Authors' contributions

WYY has made a substantial contribution to the concept and design of the article in the writing and empirical analysis. YHL and PJH collected data, analyzed data and drafted the article. ZS and ZSQ collected relevant literature and data, adjusted article format and carefully revised and polished the language of article.

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