ECONOMICS & Sociology

Liu, H., Li, Y., Tisdell, C. A., & Wang, F. (2021). How does childcare by grandparents affect the health of children in China?. *Economics and Sociology*, *14*(4), 11-30. doi:10.14254/2071-789X.2021/14-4/1

HOW DOES CHILDCARE BY GRANDPARENTS AFFECT THE HEALTH OF CHILDREN IN CHINA?

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Received: May, 2021
1st Revision: September, 2021
Accepted: November, 2021

DOI: 10.14254/2071-789X.2021/14-4/1

JEL Classification: I1, I12, I14, I15, I18, Z1

ABSTRACT. Following China's economic reforms, working parents in China have become increasingly dependent on grandparents to help care for their children. This paper examines the effect of this care on the health of children. To do this, it relies on both objective and subjective indicators of the health of children. WHO criteria for the growth of children are used as markers of the objective health of children. Subjective valuations are based on the assessments of parents of children cared for by grandparents and on those of older children. The analyzed data are drawn from the China Family Panel Studies 2016 survey using OLS, 2SLS, GMM and Oprobit models. It is found that grandparent care of Chinese children has a positive effect on their physical health but parents of these children and older children given this care believe that it has a negative health effect. It is also found that boys are healthier than girls, the health of children rises with level of education attained by the mother, and improves with the level of income of their families. Policy measures are proposed to improve grandparent care of grandchildren and to reduce misperceptions about the value of this care for the health of children (under the age of 15).

Keywords: child health, China, gender and child health, grandparent care and child health, income and child health.

Introduction

The increased participation of grandparents in childcare has become a global phenomenon (Buchanan and Rotkirch, 2018). According to the Australian Bureau of Statistics Time Use Survey in 2006, about 60% of grandparents surveyed in Australia participated in taking care of their grandchildren (Craig and Jenkins, 2016). The 2017 report of the International Longevity Centre found that more than nine million grandparents in the UK were involved in caring for grandchildren (Holley-Moore, 2017). This trend is thought to be partly (but not entirely) related to the increasing proportion of single-parent families in western societies (Swartz, 2009).However, in China, where the female labor force participation rate is high and formal childcare services are scarce and relatively costly (Tisdell, 2019, Ch. 11),the caring of grandparents for their grandchildren is a frequent way for families to reduce work-family conflicts faced by women. With the transformation of China's economy and society, the collapse of the enterprise welfare system, the government and enterprises and institutions have greatly reduced their support for birth and family care. The supply of formal childcare resources is severely inadequate. At present, most kindergartens in China only accept children over 3 years old. Nearly 80% of children under the age of 3 in urban dual-income families are mainly cared for by grandparents, and 30% of children are even raised and cared for in grandparents' homes. After the age of 3, when most children go to kindergarten, the proportion of children directly raised by grandparents drops to about 40 percent. The proportion is higher in rural areas.[1] It can be seen that due to the reality of a serious shortage of formal childcare resources, intergenerational rearing has become the main mode of cross-regional and cross-class childcare in Chinese families (Zhengcheng, *et al.*, 2019).

According to the survey data of the China Ageing Center, in 2014, 60% to 70% of Chinese children aged 0-2 years old were mainly cared for by their grandparents, and 30% of them were completely cared for by their grandparents. Furthermore, about 40% of children who attended kindergarten were directly raised by their grandparents (National Health and Family Planning Commission of the People's Republic of China (NHFPC), 2015).Based on the 2008 data of China Health and Pension Tracking Survey (CHARLS), Ko and Hank (2014) found that 58% of the elderly in China had helped to take care of their grandchildren.

Moreover, the frequency with which grandparents are caring for their grandchildren in China is rising. Data from the 2018 National Urban and Rural Survey of China's Ageing Center showed that this proportion had already risen to 66.47 percent (Dang, 2018; National Health and Family Planning Commission of the People's Republic of China (NHFPC), 2017).

In order to cope with the rapid ageing of its population, China fully implemented its two-child policy in 2016, but the total fertility rate has not increased significantly(Liu, *et al.*, 2020). The high cost of childcare is one of the main reasons for the decline in family fertility. The caring of grandparents for their grandchildren is believed to be an important means of decreasing the cost of parenting, and thereby sustaining fertility rates (National Health and Family Planning Commission of the People's Republic of China (NHFPC), 2017; Zhong and Guo, 2017).

The way in which children are cared for and the quality of this care have a direct impact on children's well-being, such as their health. Children's health is consequential for their health in adulthood, their life expectancy, their educational attainment, and the future labor supply (Behrman, 1990; Hong and Liu, 2019; Palloni, *et al.*, 2009; Wisniewski, 2010).

[1] According to the survey on the Demand for Childcare Services for Urban Children under the age of 3, commissioned by the Family Department of the National Health and Family Planning Commission and carried out by the China Population and Development Research Center in 2016. http://www.cssn.cn/skjj/skjj_jjgl/skjj_xmcg/201805/t20180530_4312449.shtml,2021.10.24

According to a statement of the World Health Organization (World Health Organization, 1995) on children's health, the standard health level of children is influenced by the growth and development of their organs, tissues and the level of their mental health. Good mental health enables them to respond well to changing environments. The physical health of children has a major impact on the quality of their lives.

In China, grandparents are frequently the primary carers for their grandchildren (Wu and Wang, 2017).Therefore, the effect on children's health of their care by grandparents has become an important issue. But many studies ignore the subjective perceptions of parents and those of older grandchildren about the quality and health effects of their grandparents' care. If the objective influence on the health of children of grandparents as caregivers for children is inconsistent with the perceived valuations of this by their parents or the children involved, it is likely to cause disharmony in intergenerational family relations. This is not conducive to the healthy growth of children and can depreciate the value of the elderly in caring for children. Based on the objective and subjective dimensions, this article investigates the health effects of grandparents' care on children in China, and is divided into six parts. This section is followed by a relevant literature review, presentation of the theoretical framework and the research hypotheses. Next, the data used is described, the results of some comparative analysis are reported and the modelling to be applied is described. The results of this modelling follow and there is a subsequent discussion and conclusion.

1. Literature review

Researchers have divided grandparent caring for grandchildren into three categories: these are (1) where only grandparents live with their grandchildren;(2) grandparents live with their adult children and grandchildren, but take care of and help educate their grandchildren; and (3) grandparents live separately to their grandchildren but provide them with care (e.g. day care) when their parents are at work. Grandchildren often live only with their grandparents when their parents have chronic personal problems such as substance abuse or are mentally ill (Whitley, *et al.*, 2001)or parents have insufficient economic means to care for the next generation (Anltranan Bee, 2001). Grandparents often feel obliged to assist their offspring and vice versa (Dunifon, *et al.*, 2014). However, in this century, more and more grandparents are involved in the global convergence of childcare. This is closely related to demographic changes such as longer life expectancy, low fertility, drastic changes in family relations, and increased female employment rate (Buchanan and Rotkirch, 2018; Hamilton and Suthersan, 2020). Due to the differences in parenting systems and cultural traditions, intergenerational rearing has obvious differences between countries. Based on SHARE data, Igel and Szydlik (2011) found that, different from the common perception, grandparents in southern Europe had a lower participation rate in taking care of grandchildren, but a higher intensity. Northern European grandparents were more involved in grandchild-care, but less intense. In terms of parenting role differences, American grandparents tend to intervene in the crisis of the middle generation (such as neglect, abuse, etc.). However, Chinese grandparents' participation in childcare is to let children (including daughters) work at ease and improve the overall interests of the family (Baker and Silverstein, 2012; Guogui, *et al.*, 2021).

Traditionally, the family is a strong cooperative unit in Chinese society. Under the influence of traditional culture, grandparents regard taking care of grandchildren as their important contribution to the welfare of their family (Shen, 2001). However, Chinese society is in economic transition and social and economic competition has intensified. As a result, many parents devote most of their energy to the labor market and lack the time and energy to take care of their children.

Opinions differ about the effects of grandparent caring on children's health. Some Chinese studies have concluded that compared with paid care services, grandparent care is the best choice for children (Chen, *et al.*, 2011; Goh, 2009). Nevertheless, many studies have come to the conclusion that grandparent care has negative impacts on childrens' health. For example, Craig et al. (2015) argue that children's mental health and behavioral development resulting from grandparent caring is inferior to that of their parents. Pottinger (2005) concluded that grandparents tend to focus on the physical health of children, but neglect the development and cultivation of their psychology, personality and social behavior. This leads to psychological problems, character defects, social inadequacies and the poor adaptability of children raised by grandparents compared with those raised by parents (Crawford-Brown and Rattray, 2001).

Some scholars also believe that grandparents tend to provide children with an unhealthy diet. Grandparent care is thought to significantly increase the proportion of obese children as a result of the diet provided by grandparents and less strenuous daily activities undertaken by children (Dunifon, *et al.*, 2014).The negative effect of grandparents' taking care of children may be more frequent in rural areas. Due to the insufficient cognition of the nutritional requirements of children and food safety knowledge, grandparents in rural areas can establish unhealthy food consumption habits of children, and this significantly damages the physical health of children (Foley, *et al.*, 2014; Li, *et al.*, 2015; Liu, *et al.*, 2019).

Most studies by Chinese scholars of the influence of grandparent care on childrens' development focus on left-behind children and on migrant children. Chen (2009)compared the left-behind children and non-left-behind children in rural areas, and found that the care of children from grandparents had a comprehensive negative impact on the education, mental health and physical health of left-behind children (see also Liu, 2008). In a sample survey of preschool migrant children in Shenzhen, it was found that the incidence of obesity among children cared for by their grandparents and by their parents was respectively 6.24% and 4.95% (and that this was a statistically significant difference), mainly due to their differences in knowledge of the balanced diet required for children (Zhao, *et al.*, 2018).

A small number of studies suggest that grandparent caring has a positive effect on children's health. Grandparents have ample time and energy and can share their rich life experiences, with the children they care for and this is conducive to the children's health (Edwards and Mumford, 2005). Others claim that grandparents' intergenerational support helps mothers achieve a better work-family balance, allowing parents to go out to work (Dhanaraj and Mahambare, 2019), and obtain a higher family income which provides children with better access to nutrition, education and health services (Acosta, *et al.*, 2007; Arpino, *et al.*, 2014; Nobles, 2006). Chen et al. (2011) and Goh (2009) argue that in China, grandparent care of grandchildren is a superior choice compared to paid care for these children.

Existing studies mainly focus on the evaluation of children's mental health, cognitive ability and adaptability. Furthermore, studies of the physical health effects on children of caring by grandparents *rarely consider the subjective feedback of the dependent children and their parents about grandparent care*, and ignore the possible inconsistencies between them. This article addresses this gap in the literature. Secondly, previous studies have not been well controlled for varied family characteristics. This study takes account of such attributes, that is, the fact that health effects of grandparent care are likely to alter with a difference in family backgrounds. Many of the negative effects of grandparent care may be attributed to other family characteristics that use this parenting style (Fergusson, *et al.*, 2008).We use data from a nationally representative survey to control for confounding variables as much as possible. We also used Instrumental Variable methods and the Propensity Score Matching method to control for the influence of unobservable variables in order to obtain the real health effects of grandparent caring.

2. More on grandparent care in China, and our hypotheses

2.1. More on grandparent care in China

In addition to bearing the task of childbirth and the role of a mother, modern Chinese women are increasingly employed outside their homes and make an important contribution to family income. According to data from China's Labor and Social Security Administration, the employment rate of women in 2019 was 49.08 percent, with 340 million women in the workforce, accounting for 43.5 percent of the total number of employed people. At the same time the proportion of children from 0 to 5 years old receiving formal care is lower in China than in many other nations, especially the degree of formal childcare of children under 3 years old (OECD, 2014). Chinese mothers who do not want to withdraw from the labor market do not have enough time and energy to take care of their children. As a result, Chinese families have a growing need for grandparent caring.

Grandparent care positively affects the health of children in the following ways. First, grandparent caring can increase the supply of women's paid labor which is conducive to raising family income and increasing family investment in children's health. For example, this increased income can add to purchases of children's nutritional health products and children's health insurance, or access to timely and effective treatment in the event of illness or unintentional injury, and reduce the impact of illness or injury on children's long-term health (Nobles, 2006). Second, the improvement of family living conditions is also beneficial to the growth of children. For example, the purchase of sanitary household products and the use of clean water can reduce the transmission of germs and reduce the risk of children contracting infectious diseases. In addition, most Chinese parents are unwilling to let their children go outdoors to play with other children unless they are accompanied by an adult. They usually choose to let the children play at home by themselves, which is not conducive to the healthy growth of children. However, grandparents usually have more time than parents to accompany children. Their caring can increase children's outdoor recreational time. In addition, the grandparents' whole-hearted care can avoid the accidental injuries that children may suffer in outdoor sports.

On the other hand, grandparent care may have a negative impact on children's health because of both their lack of knowledge about appropriate care and the absence of parental roles. There is a general lack of nutritional knowledge in China. According to China's Ministry of Health Report in 2012, the overall awareness rate of Chinese residents of the Dietary Guidelines for Chinese residents is only 26.13%. Some old people in rural areas sell home produced vegetables, eggs and fruit to buy snacks for their grandchildren. The old people in urban areas also often have the wrong concept of dietary nutrition, such as "big fish and big meat are nutritious food" and "expensive food is nutritious food". The indulgence of grandparents can be deleterious to the formation of good dietary habits by children, as well as to the physical health of children. Compared with parents, grandparents are often less aware of what are healthy habits for children, which also increases the risk of childhood diseases. In addition, the lack of parental roles may lead to psychological and behavioral problems in children, further increasing their risk of accidental injury and adversely affecting their health.

2.2. Our hypotheses

Hypothesis 1: The care of grandchildren by grandparents in China could have a positive effect on the health of children. Therefore, empirical evidence is used to test Hypothesis 1. This is done by determining the growth rates of Chinese children (0-15 years

old) cared for by grandparents using the WHO's measurements for the growth rate of children. These are objective measures.

Our second hypothesis (Hypothesis 2) is that the subjective evaluations of the parents (or guardians) of children cared for by grandparents and those evaluations by children (aged 10 and over) also cared for by grandparents display a negative association with grandparent care. These subjective evaluations have been extracted from China Family Panel Studies (CFPS) 16 as have been the objective growth data for children.

3. Materials and methods

3.1. Data source

CFPS is a national and comprehensive social survey program that aims to reflect the changes in China's society, economy, population, education and health based on data for individuals, families and communities. The baseline samples cover 25 provinces/municipalities/autonomous regions of China. The baseline survey in 2010 covered 14,960 households and 42,590 people. Three rounds of full sample follow-up surveys were conducted in 2012, 2014 and 2016. We use CFPS databases, for children and for adults to obtain their individual characteristics and we rely on CFPS databases for communities and families in order to access social and economic data. In addition, the relationship database of family members is used to match different databases. We chose the cross-sectional data of CFPS 2016 to obtain 8075 valid samples. CFPS has five types of community questionnaire, family member questionnaire, family questionnaire, adult questionnaire and children questionnaire.

In this paper, we use data of individual characteristics (height, weight, level of education, etc.) from children and adults database , access to social and economic data (household income, medical services, infrastructure, etc.), from community and family database, at last we using relational data to family members on different database for matching.

3.2. Selection of dependent variables

In order to determine the objective impact of grandparent care on children's physical health, measures of children's physical health suggested by the World Health Organization (1995) were selected as dependent variables in order to test hypothesis 1. The WHO height for age Z-score (HAZ score) and its weight-for-age Z score (WAZ) were used to indicate the physical health status of children aged 0-5 years. Its Bmit-for-age Z Score (BAZ) was used as the indicator of the healthiness of children aged 6-19 years. We use the WHO child growth standards of 2006 and 2007 in this article, the details of which are available at https://www.who.int/childgrowth/en.

The Z scores for these growth (physical development) indices of children can vary between −2 and +2. A score of zero indicates that a child's physical growth is equivalent to the WHO standards for children of the same age and sex. A negative Z score shows that a child's physical development is below the WHO standard and a positive score indicates that it exceeds this standard. On the whole, superior Z scores reflect a superior level of physical development. We use these scores as a proxy for the objective level of healthiness of children. It should, however, be noted that a high age body mass score (BAZ) can be associated with obesity. Details on the WHO formulae used to estimate the above-mentioned Z scores are

available at https://www.who.int/childgrowth/en. CFPS data were used to determine these Z scores for the Chinese national samples.

In order to test hypothesis 2, we used the subjective health orderings reported in CFPS 2016. There are two different disjoint sets of these orderings. One is by children 10 and over, the other set is that of parents or guardians of children under 10. Children 10 and overrated their health using the following ratings: (1) extremely poor; (2) very poor; (3) poor; (4) average; (5) good; (6) very good; and (7) extremely good. Parents or guardians were presented with the following five possibilities for ranking the health of their children: (1) poor; (2) average; (3) good; (4) very good; and (5) extremely good. We use the weights 1-7 to score the responses of children 10 and over – a higher weight corresponds to children saying they are healthier. In order to increase the comparability of the scale for the responses of parents or guardians about the health of their children, we used the following weights: 1 – poor; 3 – average; 4 – good; 5 – very good; and 7 – extremely good. This is because we want to make use of an index combining the two sets of responses.

As it transpires, the means of standard deviations and coefficients of variation of these two sets of responses are similar when the above-mentioned weightings are adopted. For children 10 and over, the mean healthiness weight (for 2,514 observations) is 5.72, its standard deviation is 1.117 and the coefficient of variation is 0.195. The corresponding statistics for the 5,564 responses by parents and guardians of children under 10 were mean: 5.86, standard deviation: 1.067 and coefficient of variation 0.182. In both cases, responses ranged between 1 and 7.

These statistics imply that the health of the relevant groups of children was rated as good to very good by both sets of respondents. This rating was slightly higher for parents and guardians than that by children 10 and over. The dispersion of responses was also slightly less in the former case than in the latter one.

Before describing the independent variables, let us consider some comparative observations based on the available raw data. Physical health indicators and subjective evaluations of the health of children cared for by grandparents and those not cared for by grandparents will be compared. In addition, indicators of the comparative healthiness of rural children compared with that of urban children will be reported.

3.3. The core independent (explanatory) variable

The core independent variable is the binary dummy variable: whether or not the child is primarily cared for by a grandparent. Respondents were asked in the CFPS 2016 questionnaire, "Who was the primary care giver of the child during the parents' most recent non-vacation month?" They were also asked "Who was the primary caregiver for the child on a recent non-holiday night?" We extract the core explanatory variable according to answers to the above questions. If it is responded that grandparents were the primary care givers, we classify it as grandparent care and assign it with 1, then otherwise the assignment is 0.

In addition, the health effects of grandparent care may be influenced by the intensity or amount of care provided by grandparents (Chen, *et al.*, 2011). More time spent by children with grandparents and more frequent care by grandparents is likely to have a greater impact on children's health. We use grandparents' answers to the following CFPS 2016 question to approximate the intensity of their childcare: "During the past six months, what was the frequency of doing chores or taking care of your grandchild for your adult children?" Possible answers and weights assigned by us are as follows: "(6 points) almost every day", "three to four days a week (5 points)", "1 to 2 days a week (4 points)", "2-3 days per month (3 points)", "1 day per month (2 points)", "a few months. 1 day (1 point)". These weights described as the "intensity of care variable", and the higher its value, the higher is the intensity of care.

3.4. Control (explanatory) variables

According to the relevant studies, the main factors affecting children's physical health can be roughly divided into four main influences: personal, genetic, family and community characteristics(Song, 2007). We chose the age of children and their gender as personal characteristic variables. The height, weight and other physical indicators of parents were used to control for genetic characteristics. The logarithm of family per capita income and parents' education level were selected to represent family characteristics. Whether or not a family has urban household registration and also has health insurance are two additional explanatory variables used in our modelling. Community attributes include whether the family's cooking water is tap water and whether their cooking fuel is coal. The definitions of all the variables to be used in our modelling and descriptive statistics are shown in *Table 1*.

Table 1. Variable definitions and descriptive statistics

Variable type	Variable name	Sign	Variable assignment	Sign sample mean	Sample variance
Dependent variable	HAZ score	HAZ	Z-score for age and height	0.001	0.994
	BAZ score	BAZ	Weight Z-score for age	1.179	3.728
	WAZ score	WAZ	Age specific Body mass index Z score	0.378	2.449
	Subjective health index	Subjective	Subjective health, with a score of 1-7 indicating very unhealthy to very healthy	5.815	1.087
Core independent variable	Grandparent care	Care	grandparent=1, others=0	0.278	0.448
	Care intensity	Intensity	1-6 represents increasing intensity	1.728	1.628
Control variable	Age	Age	Child's age (year)	7.117	4.337
	Gender	Gender	Child's sex, male = 1. Female = 0	0.534	0.499
	Hukou type	Urban	Whether it has urban household registration, Y = 1; N = 0	0.428	0.495
	Medical Insurance	Insurance	Having health insurance = 1; No = 0	0.850	0.357
	Annual per capita household income[1]	Income	Log of average household income over the past year.	8.960	1.069
	Father's education [2]	FEdu	Father's education	2.734	0.858
	Mother's education	MEdu	Mother's education	2.751	1.137
	Father's height	Fheight	cm	166.89	2.329
	Father's weight	Fweight	kg	61.933	3.979
	Mother's height	Mheight	cm	159.87	2.654
	Mother's weight	Mweight	kg	57.384	7.008
	Cooking Water	Water	Tap water =1, others =0	0.698	0 .458
	Cooking Fuel	Fuel	Natural gas/electricity =1, other =0	0.339	0 .473
Instrumental variable	The number of retired grandparents	Retire	Ranges from 0 to 4	0.925	0.893

Notes:

1. Source: *the Manual of China Family Tracking Survey. Family annual income consists of the sum of five parts of income, namely, wage income, operating income, property income, transfer income and other income. Annual per capita income is obtained by dividing annual household income by family size.*
2. *The educational level of the father and the education level of the mother are respectively established by selecting the item of "highest educational level" from the CFPS adult database. The criteria are "1 illiterate/semi-illiterate", "2 primary schools", "3 junior high school", "4 senior high school/technical school/vocational high school", "5 junior college", "6 university undergraduate", "7 master and above".*

3.5. Type of modelling used

Multiple regression analysis was used as the baseline regression to explore the effect of grandparent care on HAZ, WAZ and BAZ. These are objective indicators of the health of children.

$$health_i = \alpha + \beta support_i + \gamma X_i + \varepsilon_i,$$

where $health_i$represents the health status of the *i*-th child, $support_i$ represents whether the childcare is by a grandparent, $\beta$is the parameter to be estimated, $X_i$is a set of control variables,ε_i is a random disturbance error.

Because the factors affecting children's health may influence decision-making about grandparent caring, and since the assignment for child-caring responsibilities of grandparent caring are not based on the particular characteristics of grandparents, the above model has endogeneity problems. If the model is directly estimated, there will be some bias in the coefficient estimates. We selected the number of retired grandparents (retire)of children as the instrumental variable to perform a two stages least estimation squares (2SLS). The variable 'retire' can meet the requirements of the instrumental variable, and as well, it can represent the number of grandparents able to provide childcare. The higher the number of retired grandparents, the lower the barriers for families to choose a grandparent care strategy. On the other hand, the number of retired grandparents does not directly affect a child's health. The instrumental variable also passes the correlation test of weak validity (as shown by the F statistics in *Table 2* and *Table 3*).

To test hypothesis 2, we selected subjective health to represent the subjective evaluation by older children receiving grandparent care or by the parents of younger children. This is a discrete variable. Therefore, Ordered Probit model (Oprobit) was selected for regression to obtain the estimator of maximum likelihood estimation (MLE). In the Oprobit model, discrete variables are regarded as ranking variables and the estimators of maximum likelihood estimation are derived by using latent variables. The specific model is as follows:

$$subjective\ health_i^* = F(\alpha + \beta support_i + \gamma X_i + \varepsilon_i),$$

where $subjective\ health_i^*$represents the latent variable of the subjective health index for the *i*-th child. It is the unobtainable continuous variable behind *subjective health. F(.)*represents a nonlinear function. When $subjective\ health_i^*$ is below the threshold r_1, the child is rated as "very unhealthy." When $subjective\ health_i^*$ is greater than $r_1$and less thanr_2, it indicates that the child's rated health condition is "unhealthy", and so on. The details are as follows:

$$subjective\ health_i = \begin{cases} 1, & subjective\ health^* \le r_1 \\ 2, & r_1 \le subjective\ health^* \le r_2 \\ 3, & r_2 \le subjective\ health^* \le r_3 \\ 4, & r_3 \le subjective\ health^* \le r_4 \\ 5, & r_4 \le subjective\ health^* \le r_5 \\ 6, & r_5 \le subjective\ health^* \le r_6 \\ 7, & r_6 \le subjective\ health^* \le r_7 \end{cases}$$

The points, $r_1 < r_2 < r_3 < r_4 < r_5 < r_6 < r_7$ are parameters to be estimated.

Assuming that ε_i follows $N(0,1)$distribution, x represents an explanatory variable, and $\varphi(.)$represents cumulative distribution function, then

$$\begin{gathered} P(subjective\ health_i = 1|x) \quad = \\ = P(subjective\ health_i{}^* \le r_i|x) = \\ = P(x'\beta + \varepsilon \le r_i|x) = P(\varepsilon \le r_1 - x'\beta|x) = \varphi(r_1 - x'\beta); \end{gathered}$$

$$\begin{gathered} P(subjective\ health_i = 2|x) \quad = \varphi(r_2 - x'\beta) - \varphi(r_1 - x'\beta); \\ \ldots\ldots\ldots\ldots \\ P(subjective\ health_i = 7|x) \quad = 1 - \varphi(r_6 - x'\beta). \end{gathered}$$

Therefore, the sample likelihood function can be correspondingly written to obtain the MLE estimator.

We can now report the results of our modelling. This will be done first for the objective health effects of grandparent care of children aged 0-5 years and then for children older than 5 years. Modelling of the subjective evaluations of the health of children cared for by grandparents as reported by their parents or guardians (for children under 10) and of children (10 and older) follows. Our results will enable us to tell whether our initial hypotheses stated in section 3.2 are supported. As well, it will enable the identification of significant factors which influence the objective health of children cared for by grandparents and subjective evaluations of their healthiness.

4. Empirical results from our modelling

4.1. Regression results of objective health effects of grandparent care

As shown in *Table 2*, after controlling for other variables, there were significant positive effects of grandparent care on the objective health indicators of HAZ and WAZ for children aged 0-5 years. Because there may be a negative causal relationship between children's physical health and grandparent care, the result of model (1) multiple baseline regression results could have some bias. Therefore, we tested the inter-generational variable 'Care' for possible endogeneity. The Hausman test and DWH test results reject the null hypothesis at the significance level of 5%, indicating that the model has some endogeneity. Therefore, we selected the number of retired children's grandparents as an instrumental variable for 2SLS regression (model 2), and at the same time, considering the disturbance term characteristics, we further adopted the LIML (model 3) and Generalized Method of Moments(GMM, model 4) regression with finite information maximum likelihood to solve the endogeneity problem.

In model (2), the regression coefficients of the two health score indicators (HAZ and WAZ) are 0.305 and 0.306 respectively, and they are statistically significant at the 1% level. This suggests that the instrumental variable "Retire" is significantly correlated with the

independent variable care. However, the values of F statistics are respectively 103.77 and 103.7.

Table 2. Effects of grandparent care on the objective health of children aged 0-5 years

	Model(1) OLS		Model(2) 2SLS		Model(3) LIML		Model(4) GMM	
	HAZ	WAZ	HAZ	WAZ	HAZ	WAZ	HAZ	WAZ
Care	0.427**	0.335**	0.707**	0.572**	0.707**	0.572**	0.707**	0.572**
	(2.29)	(2.39)	(2.08)	(2.21)	(2.08)	(2.21)	(2.08)	(2.21)
Age	0.244***	0.149***	0.239***	0.145***	0.239***	0.145***	0.239***	0.145***
	(4.20)	(3.10)	(4.13)	(3.02)	(4.13)	(3.02)	(4.13)	(3.02)
Gender	0.144	0.399**	0.143	0.398**	0.143	0.398**	0.143	0.398**
	(0.81)	(2.89)	(0.80)	(2.89)	(0.80)	(2.89)	(0.80)	(2.89)
Insurance	0.646**	0.437**	0.628**	0.422**	0.628**	0.422**	0.628**	0.422**
	(2.62)	(2.24)	(2.56)	(2.15)	(2.56)	(2.15)	(2.56)	(2.15)
Income	0.601***	0.157**	0.596***	0.152**	0.596***	0.152**	0.596***	0.152**
	(5.90)	(2.06)	(5.85)	(2.00)	(5.85)	(2.00)	(5.85)	(2.00)
FEdu	0.361*	0.033	0.355*	0.028	0.355*	0.028	0.355*	0.028
	(1.93)	(0.26)	(1.89)	(0.22)	(1.89)	(0.22)	(1.89)	(0.22)
MEdu	0.31***	0.028	0.30***	0.019	0.30***	0.019	0.30***	0.019
	(3.27)	(0.37)	(3.14)	(0.26)	(3.14)	(0.26)	(3.14)	(0.26)
Fheight	0.033	0.114**	0.038	0.119**	0.038	0.119**	0.038	0.119**
	(0.45)	(2.36)	(0.52)	(2.45)	(0.52)	(2.45)	(0.52)	(2.45)
Fweight	0.028	-0.001	0.029	0.000	0.029	0.000	0.029	0.000
	(1.40)	(-0.05)	(1.44)	(-0.01)	(1.44)	(-0.01)	(1.44)	(-0.01)
Mheight	-0.012	0.002	-0.015	-0.001	-0.015	-0.001	-0.015	-0.001
	(-0.28)	(0.07)	(-0.35)	(-0.01)	(-0.35)	(-0.01)	(-0.35)	(-0.01)
Mweight	0.021**	0.022**	0.021**	0.022**	0.021**	0.022**	0.021**	0.022**
	(2.08)	(2.79)	(2.09)	(2.81)	(2.09)	(2.81)	(2.09)	(2.81)
Water	0.159	0.0879	0.174	0.101	0.174	0.101	0.174	0.101
	(0.75)	(0.56)	(0.82)	(0.65)	(0.82)	(0.65)	(0.82)	(0.65)
Fuel	0.677***	0.218	0.672***	0.213	0.672***	0.213	0.672***	0.213
	(3.11)	(1.38)	(3.09)	(1.36)	(3.09)	(1.36)	(3.09)	(1.36)
_cons	-16.85	-22.81**	-17.31	-23.20**	-17.31	-23.20**	-17.31	-23.20**
	(-1.22)	(-2.50)	(-1.25)	(-2.54)	(-1.25)	(-2.54)	(-1.25)	(-2.54)
N	3398	3398	3398	3398	3398	3398	3398	3398
R^2	0.079	0.029	0.078	0.027				
Hausman test	P=0.0154	P=0.0004						
DWH test	P=0.0174	P=0.0004						
One stage regression			0.305***	0.306***				
			(34.49)	(34.49)				
F statistic			103.77	103.7				

Note: *the T-statistics are in brackets under the robust clustering standard error.* $^{*}p<0.1$, $^{**}p<0.05$, $^{***}p<0.01$

These values are far higher than the critical value 10, and so the null hypothesis of "existence of weak instrumental variables" can be rejected. Therefore, the instrumental variable we selected is valid. The two-stage regression results of model (2) also confirm our

hypothesis 1, because the positive effects of grandparent care on the objective health of children (0.572 and 0.707) are higher than the baseline regression results. The regression results of model (3) and model (4) also indicate the robustness of the results.

1. The following relationships can be observed from *Table 2*. Holding the other variables constant in each case:
2. The objective health scores of children increase with their age.
3. Boys have a significantly higher level of health than girls.
4. The health of children significantly rises with the level of education attained by their mother. This accords with a general finding of Le and Nguyen (2020) for developing countries.

The weight of the mothers of children is positively associated with the healthiness of their children. The healthiness of children improves with the level of income of their families. This result is consistent with the findings of other researchers (Case, *et al.*, 2002; Gu and Liu, 2012; Nobles, 2006).

The first result is consistent with the traditional family preference in China for boys rather than girls (Tisdell, 2019). It may be a consequence of boys being given greater access to medical care than girls and also to food, especially when it is in short supply.

The effect of grandparent care on the objective health of children over 5 years of age (shown in *Table 3*) is also positive, but less significant than that of grandparent care on the objective health of children aged 0-5. As shown in *Table 3*, OLS regression results are positive, but not significant. The regression results of the endogenetic-adjusted models (2) - (4) were statistically significant at 10% level, and the effect coefficient was also stable at 0.106. In general, there is a significant positive effect of grandparent care on children's physical health, especially for children aged 0-5 years old. Hypothesis 1 of the study is verified. We can also be confident in concluding that (on average) the health of children is not negatively affected as a result of them being cared for by their grandparents.

Table 3. Effects of grandparent care on the objective health of children over 5 years of age

BAZ	Model(1) OLS	Model (2) 2SLS	Model(3) LIML	Model(4) GMM
Care	0.125	0.106*	0.106*	0.106*
	(1.22)	(-1.70)	(-1.70)	(-1.70)
Age	-0.181***	-0.189***	-0.189***	-0.189***
	(-12.62)	(-12.69)	(-12.69)	(-12.69)
Gender	0.342***	0.337***	0.337***	0.337***
	(4.21)	(4.14)	(4.14)	(4.14)
Insurance	0.151	0.158	0.158	0.158
	(-1.29)	(-1.35)	(-1.35)	(-1.35)
Income	0.0990**	0.104**	0.104**	0.104**
	(-2.22)	(-2.33)	(-2.33)	(-2.33)
FEdu	-0.160	-0.159	-0.159	-0.159
	(-1.83)	(-1.83)	(-1.83)	(-1.83)
MEdu	0.120**	0.109**	0.109**	0.109**
	(-2.82)	(-2.57)	(-2.57)	(-2.57)
Fheight	-0.0246	-0.0206	-0.0206	-0.0206
	(-0.70)	(-0.57)	(-0.57)	(-0.57)
Fweight	0.0159	0.0156	0.0156	0.0156
	(1.51)	(1.47)	(1.47)	(1.47)
Mheight	0.0606	0.0608	0.0608	0.0608
	(1.64)	(1.63)	(1.63)	(1.63)
Mweight	0.0414***	0.0417***	0.0417***	0.0417***
	(8.43)	(8.52)	(8.52)	(8.52)

Water	0.200*	0.188*	0.188*	0.188*
	(2.11)	(1.98)	(1.98)	(1.98)
Fuel	-0.293**	-0.300**	-0.300**	-0.300**
	(-2.91)	(-2.99)	(-2.99)	(-2.99)
_cons	-5.239	-5.721	-5.721	-5.721
	(-0.63)	(-0.69)	(-0.69)	(-0.69)
N	4677	4677	4677	4677
R^2	0.084	0.082	0.082	0.082
Hausman test	P=0.0154	P=0.0004		
DWH test	P=0.0174	P=0.0004		
One stage regression		0.305***		
		(34.49)		
F statistic		103.77		

Note: *the T-statistics are in brackets under the robust clustering standard error.* $^{*}p<0.1$, $^{**}p<0.05$, $^{***}p<0.01$

As is evident from *Table 3*, the five relationships listed above also apply in the case of children aged 10 and over, namely older children are healthier on average; boys are healthier than girls; the health of children rises with the level of education of their mothers (and also her weight); and the healthiness of children increases with the level of income of their families. Note that the level of education of the fathers of children does not appear to be a very important influence on the health of children.

4.2. Regression results for the subjective health evaluations of grandparent care

A subjective health indicator was used to determine the subjective perception of the health effect on children of grandparent care. These evaluations were made by children receiving this care aged 10 years and older and by the parents or guardians of children 6-9 years old being cared for by grandparents. As shown in *Table 4*, the results of the model (1), multiple regression, and the model (2), ordered Probit model, show that when other variables remain unchanged, grandparent care has a significant negative effect on the subjective health index for children. Because these two models do not take account of the bidirectional causality and endogeneity problems associated with missing variables, we introduced instrumental variables (IV) and adopted the Conditional Mixed Process (CMP) (Roodman, 2011) and Heckman method for estimating two-stage regression. In model (3), the endogeneity test variable atanhrho_12 was 0.095, is statistically significant at the significance level of 5%. This indicates that the estimate of CMP are more reliable than those for model (2). Furthermore, using the Heckman two-stage method, Model (4) shows that the influence of grandparent care on children's subjective health index was significantly negative. This indicates that the subjective perception of the health effects of grandparents' intergenerational care by children 10 years or older being cared for or by the parents or guardians of children aged 6-9 years receiving grandparent's care is negative. Therefore, our hypothesis 2 is also verified.

The above empirical results demonstrate that subjective perceptions of the health effects of grandparent care by older children in care and the parents of younger children in care is negative. On the other hand, we found the objective effect of the grandparent caring on the children's health to be positive.

Table 4. Effects of grandparent care on subjective health ratings of children older than 5

Subjective	Model(1) OLS	Model(2) Oprobit	Model(3) CMP	Model(4) Heckman
Care	-0.185***	-0.309***	-0.151***	-0.185***
	(-5.91)	(-5.46)	(-3.32)	(-2.49)
Age	-0.0141***	-0.0227***	-0.0163***	-0.0205***
	(-4.17)	(-3.66)	(-5.38)	(-3.29)
Gender	-0.0110	-0.0218	-0.00233	0.0110
	(-0.39)	(-0.43)	(-0.10)	(0.26)
Insurance	0.0503	0.0625	0.0433	0.0356
	(1.21)	(0.81)	(1.27)	(0.59)
Income	0.163***	0.298***	0.148***	0.158***
	(10.76)	(10.73)	(11.54)	(6.80)
Edu	0.0381	0.0703	0.0555	-0.0000175
	(1.01)	(1.05)	(1.83)	(-0.00)
MEdu	0.117***	0.241***	0.154***	0.110***
	(8.00)	(8.66)	(11.62)	(4.39)
Fheight	-0.0120	-0.0160	0.00390	0.0293
	(-0.79)	(-0.63)	(0.33)	(1.16)
Fweight	-0.0000606	-0.00262	-0.00101	-0.00285
	(-0.02)	(-0.42)	(-0.32)	(-0.48)
Mheight	0.00135	0.00667	-0.000236	0.00273
	(0.17)	(0.43)	(-0.03)	(0.21)
Mweight	0.00334*	0.00659*	0.00418**	0.00604*
	(2.04)	(2.15)	(2.72)	(1.99)
Water	0.109***	0.215***	0.146***	0.176***
	(3.38)	(3.80)	(5.31)	(3.58)
Fuel	0.131***	0.225***	0.116***	0.185***
	(3.68)	(3.68)	(4.04)	(3.56)
_cons	-0.185***	-0.309***	-0.151***	
	(-0.63)	(-0.69)	(-0.69)	(-0.69)
N	4677	4677	4677	4677
R^2	0.084	0.082	0.082	0.082
Hausmantest	P=0.0104			
DWH test	P=0.0103			
/atanhrho_12			0.095**	
			(2.57)	
One stage regression			0.869***	1.088***
			(46.63)	(49.13)

Note: *The T-statistics are in brackets under the robust clustering standard error.* $^{*}p<0.1$, $^{**}p<0.05$, $^{***}p<0.01$

4.3. Robustness test

Given the nature of the available research data and considering that only one instrumental variable was allowed for, it could happen that missing regional characteristic variables could biasourparameter estimation. Therefore, the Propensity Score Matching (PSM) method is adopted to conduct a robustness test. For the whole sample, the nearest neighbor matching method, radius matching method (matching according to 0.01, 0.05 and 0.1 respectively) and nuclear matching method were used to estimate the average treatment effect (ATT). All the control variables were significantly different before the matching. The t − L values of the differences between the objective health score and subjective evaluations were mostly significant at 5% level. Hence, the propensity score matching method passes the balance test and basically achieves a similar status to a randomized trial. In general, the effect of grandparent care on children's objective health indicators HAZ, WAZ and BAZ scores

were significantly higher than zero, indicating that the objective effect of grandparent care on children's health was positive. The ATT of self-rated health index under the five matching methods is significantly lower than zero at the 1% level. Therefore, the results of the above analysis are very robust.

5. Discussion

5.1. Widespread and increased reliance in China on the care of grandchildren by grandparents

Our empirical results have relied on data reported in CFSP16 for 8075 children of which 3,458 (42.8%) were cared for by their grandparents to some extent. This compares to 4,620 children (57.2%) not receiving grandparent care. These figures reflect the high proportion of children in China who rely to some extent on their grandparents for their care.

This proportion has increased since China has initiated its economic reforms for the following reasons:

1. Prior to these reforms, state enterprises, collectives and workplaces generally provided free childcare to working mothers for their young children at these workplaces. After China's economic reforms, this socialist support ended and working mothers had to find alternative possibilities for the care of their younger children while working and for their children before and after school hours. They now have to pay for these services, which are often provided by private institutions such as private day care centers. The cost of sending children to these centers is fairly high for most working mothers with young children. Consequently, the proportion of young children enrolled in the childcare service system is relatively low. The percentage of children 3 years and under enrolled in this system is only 4.1% compared to an average of 32.3% for OECD countries (OECD, 2019). Hence, a greater number of working Chinese mothers now rely on their grandparents to help care for their children than in the past.
2. Following Chinese economic reforms (Tisdell, 2009a), there has been a tremendous increase in labor mobility in China (Chang, *et al.*, 2011). China's rapid rate of economic growth and the transformation of its industrial structure (Tisdell, 2009b) have provided many off-farm employment opportunities for its rural population (Meng, 2000) and the proportion of rural women participating in the off-farm labor force has risen markedly (Lohmar, *et al.*, 2001). Large scale off-farm migration has resulted in a major rise in the demand for childcare. In China now, there are nearly 18 million elderly migrants accounting for 7.2% of the country's floating population. According to the Health Commission of China, 43% of these elderly migrants migrate (almost 8 million) to help look after their grandchildren. However, many also stay behind in rural areas to look after grandchildren left behind.

5.2. Comments on our results and analysis

Our modelling supports the hypothesis that in China, grandparent care of grandchildren has a beneficial effect overall on the physical development of these children compared to the absence of this care. The effect is especially beneficial among the children of low-income groups. We have used the physical development of children as a proxy for their healthiness. We have not considered the psychological development of children. The WHO Z scores for the growth of children are not perfect indicators of the health of children but we believe that these indicators and the physical healthiness of children are highly correlated.

This article makes a significant contribution to this topic because there is widespread belief that when grandchildren are cared for by grandparents this has a negative effect on their physical development and health. We found also that parents and older children believe that when grandparents help take care of their grandchildren this has a negative effect on the health of these children.

1. Our modelling also revealed that the physical health of children tended to be better (1) the older they were; (2) better for boys than for girls; (3) increased with the level of income of the child's family(a result similar to that of Christiaensen and Alderman, 2004); and (4) was better the more educated was their mother(a compatible result to that of Chang, *et al.*, 2011). It was also found that the subjective health rating of grandparent care (1) tended to be **lower** the greater the age of the child; (2) increased with the income of the family and (3) with the level of the mothers' education. The disparity between the child's age and the indicators of its physical health compared to the subjective evaluation of this is interesting. It seems to reflect the fact that older children are more dissatisfied with grandparent care than younger ones. This requires more investigation.

It is also interesting that although the physical health of boys was on the whole better than that for girls (and mostly statistically significant), the subjective health evaluations for children older than 5 years indicates that this was not so. This may be because the ill health of boys is considered to be more serious than that of girls.

Conclusion

In the absence of affordable and easily available childcare for the children of working parents, a case exists in China (given our findings) to strengthen and extend the role of grandparents in helping care for their grandchildren. Policy possibilities include the following:

2. The provision of information by public bodies in order to improve the perception of parents and families about the value for the health of children of the role of grandparents in helping care for grandchildren.
3. Adopting measures that improve the quality of care provided to grandchildren by grandparents. This might be achieved for example, by providing selected senior citizens with education and training about desirable childcare practices and relying upon them to pass this knowledge onto peer groups, for example, nutritional knowledge (Hirvonen, *et al.*, 2017). This education should take account of the socioeconomic constraints faced by different groups of families.
4. Initiating policies that make it easier or more rewarding for grandparents to help take care of the children of working parents. For example, in China, grandparents could be allowed to have access to more social service benefits if they are helping to take care of the children of working parents, for example, they might be given access to free or subsidized medical care if they move to new locations to help take care of their grandchildren. Other possibilities include the provision of an income subsidy to grandparents who take care of the children of working parents or a housing subsidy to enable some grandparents to live with or nearby their grandchildren as is done in Singapore.

This is not to say that the value of other measures to improve the affordability and availability of care of the children of working parents should not be explored, such as the availability of before and after school care for children. However, institutional care of children is unlikely to be a perfect substitute for care by grandparents and is unlikely to meet

the needs of all parents and children. Therefore, the role of grandparents in helping to take care of their grandchildren in China is likely to remain important for the foreseeable future.

Acknowledgement

This research was funded by the project of "Digital Rural Construction under the Consciousness of Forging a Strong Chinese Nation Community (20211000304)" of Minzu University of China.The authors would like to thank the anonymous reviewer for their helpful and constructive feedback on this paper. Thanks also go to Evelyn Smart for processing the revision of the paper. The usual *caveat* applies.

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