



# Grandparental care and childhood obesity in China

Yue Liu, Jianmei Zhao<sup>\*</sup>, Hai Zhong

China Academy of Public Finance and Public Policy, Central University of Finance and Economics, 39 South College Road, Beijing, 100081, China

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## ABSTRACT

Ongoing increases in childhood obesity have become a serious public health concern. Meanwhile, caregiving by grandparents becomes a worldwide social phenomenon. This study estimates the effect of grandparental care on childhood obesity and explores its pathways. Utilizing five waves of panel data from the China Family Panel Studies, we found that grandparental care significantly increases the probability of childhood obesity, adding 3.6 percentage points. The effect is heterogeneous between boys and girls and between grandparents with different education attainments. The channels through which grandparents contribute to childhood obesity include inappropriate dietary patterns and insufficient physical activities. Additionally, we found that grandparents' famine experience generates a long-term fear of hunger, which translates into overfeeding their grandchildren, thus aggravating childhood obesity in China.

## 1. Introduction

The World Health Organization (WHO) (WHO, 2016) has stated that childhood obesity is one of the most significant public health challenges of the 21st century, as childhood obesity is expected to increase the prevalence of numerous chronic conditions, including cardiovascular diseases, hypertension, diabetes, stroke, musculoskeletal disorders, and a range of mental health conditions (Gwozdz et al., 2013). Sustainable Development Goal 3 (SDG03) established by the United Nations aims to ensure healthy lives and promote well-being for all at all ages globally. However, the ongoing increases in childhood obesity and its potential diseases in adults obviously run counter to SDG03. According to the study of Global Burden of Disease (GBD), China had the largest number of obese children worldwide (GBD, 2015). Annual increasing rate of childhood obesity from 2010 to 2015 ranks first among countries of the United States, the United Kingdom, Germany, France, Thailand and Japan (WHO, 2006; WHO, 2016).

Over past 30 years, owing to the rapid transitions in dietary patterns and lifestyle, the childhood obesity in China has shown a growing trend. A national survey on the health of school children revealed that the obesity rate among children aged 7–18 years in 2014 was 55.8 times that in 1985 (Ministry of Education of China, 2014). In order to control the excessive growth of childhood obesity, Chinese government formulated “prevention and control of children obesity plan” in 2020, it is targeted that, from 2020 to 2030, the overweight rate and obesity rate of children and adolescents should decrease by 70% from the baseline that

calculated from the annual growth rate from 2002 to 2017.

There is considerable literature on the possible causes of the rapid increase in childhood obesity. Identified contributing factors include unhealthy health behaviors, such as insufficient physical activities (Li, 2010); excess intake of high-calorie food (Alviola et al., 2014; Schwartz et al., 2017); lack of sleep (Meng, 2012); and socio-economic factors, such as low family income, maternal employment, type of care provision, and the environment (Han & Wen, 2014; Chen et al., 2021). Among them, caregiving during childhood is a critical determinant. Previous research has primarily focused on the role of parents, currently there is a growing literature on the influence of grandparents on child health and development (Sadruddin et al., 2019).

As family size trends downward and maternal employment increases, caregiving provided by grandparents has become a global social phenomenon. Across seven European countries, about a quarter of households included at least one grandparent in 2010 (Masfety et al., 2019). In China, the rate of urban children (under 7) being taken care of by their grandparents increased from 40% in 1991 to 56% in 2011 and that of rural children aged 0–6 years increased from 28% in 1988 to 49% in 2011 (Zhao, 2017).

Does grandparental care influence childhood obesity? If so, how does it occur? This issue has not received sufficient attention in the literature, particularly in China, where grandparental care is prevalent and childhood obesity is increasing at an astonishing speed. This study formally investigates the effect of grandparental caregiving on childhood obesity and examines its channels. Utilizing five waves of panel data from the

<sup>\*</sup> Corresponding author.

E-mail addresses: [513760467@qq.com](mailto:513760467@qq.com) (Y. Liu), [jianmei@cufe.edu.cn](mailto:jianmei@cufe.edu.cn) (J. Zhao), [haizhong@cufe.edu.cn](mailto:haizhong@cufe.edu.cn) (H. Zhong).

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China Family Panel Studies (CFPS), we employed a difference-in-differences (DID) estimation and found that grandparental care increases the probability of childhood obesity by approximately 3.6 percentage points. Heterogeneous analysis revealed that grandparental care has a significant positive effect on the likelihood of obesity in boys; however, this effect is not significant in girls. Further, illiterate grandparents exhibit a larger probability of raising obese children compared to educated ones.

We investigated the channels through which grandparental care affects childhood obesity. Childhood obesity is obviously the result of imbalance between energy intake and energy expenditure, we first investigated the association between grandparental care and children's dietary patterns and found that grandparental care involves more home cooking and less outside dining. As eating at home is more economical than eating outside, home cooking may lead to a larger amount of food consumption, or a larger caloric intake, given equal amount of household food expenditures. Additionally, grandparental care is positively associated with children's high-energy food consumption. Further, we found that grandparental care has a positive effect on children's television-watching time and a negative one on physical exercise. Finally, because many grandparents overfeed their grandchildren while caregiving, we attribute such parenting practices to their personal famine experience. We argue that grandparents' famine experience generates their long-term fear of hunger, which translates into the parenting practice of overfeeding their grandchildren and contributing to their obesity.

This study makes two main contributions. First, we attempt to understand the causal and longitudinal nature of the association between grandparental childcare and childhood obesity. To date, most studies on grandparental care and childhood obesity derive their conclusions from cross-sectional analysis, there is limited information on the causal nature of this association. Utilizing data from five waves of CFPS, we can control children's unobservable features that determine their body weight. Coupled with multiple robustness checks, our estimation of the effects of grandparental care on childhood obesity is robust. The second contribution is that we particularly focus on the pathways through which grandparents influence children's obesity. Apart from the dietary patterns and children's physical activities discussed in the literature, we advance another new channel, which is unique to the Chinese context—that is, the intergenerational impact of famine experience. In other words, the experience of having starved during childhood influences parenting attitudes. In China, grandparents who experienced the Great Famine overfeed their grandchildren because of their misconception of nutrition. Notably, such a parenting practice aggravates childhood obesity in China.

## 2. Background

### 2.1. Why grandparental care is prevalent in China

Grandparental care is a common form of family intergenerational support and a crucial mode of childcare. Unlike many developed countries, where the grandparental care has increased over the past decade, there has been a long tradition for Chinese grandparents to live with and function as primary caregivers to their grandchildren. In China, more than half of grandparents used to provide care for their grandchildren (Ko and Hank, 2014).

Several factors contribute to the prevalence of grandparental care in China. First, a Chinese social norm leads to the co-residence of grandparents with their sons and the grandparents taking care of their grandchildren when they cease to work. In turn, their adult children take on the responsibility of their care until death. This living arrangement and reciprocal caregiving effectively strengthens the intergenerational solidarity of Chinese families and has done so for a thousand years of Chinese history.

Second, the increased life expectancy and improved health of the

aging population encourage the involvement of grandparental care in China. For the past 30 years, life expectancy has steadily increased—from 66.9 years in 1990 to 74.52 years in 2017 for men and from 70.65 years to 79.92 years for women over the same period (Han et al., 2020; Gui & Chen, 2020). The national healthcare reform of 2010 ensures that more than 95% of the elderly in China are covered by health insurance. Various types of healthcare services are essential for maintaining health and preventing disease onset, thus ensuring healthy aging for elderly people in China (Hao et al., 2020; Hu et al., 2012).

Finally, the changes that have occurred in the childcare system following economic reforms have pushed young parents to resort to grandparents for childcare. After the launch of a program that radically restructured state-owned enterprises in 1997, publicly subsidized formal childcare programs such as nurseries and kindergartens have significantly decreased, while private care centers offering childcare services at higher prices have increased (Li, 2017). In China, public and private childcare programs are available only for children aged 3 years and above; the shortage of childcare institutions for children aged less than 2 years is serious (Carr, Duff, & Craddock, 2020). Urban families with children aged less than 3 years normally resort to grandparents for caregiving or privately hire nannies. Families with child aged above 3 years may also rely on grandparents because of the superior care they provide or to avoid the financial burden of hiring private services (Du & Dong, 2013; Li, 2017). In rural areas, the use of public childcare centers or private childcare services is rare. Because a majority of rural labors migrate out of rural areas for employment, rural children are left behind and taken care of by their grandparents (Mu and Brauw, 2015).

### 2.2. Why grandparental care causes childhood obesity

The common explanation why children cared for by their grandparents are more likely to be overweight or obese than those cared for by their parents is that intergenerational care generally provides greater love and patience from the caregiver (Farrow, 2014). Consequently, grandparents spoil their grandchildren by offering them their favorite food (which may be unhealthy) or allowing them to do what they like without restrictions. This contributes to the global childhood obesity problem (Sadruddin et al., 2019). Compared to other countries, the unique sociological characteristics of the Chinese society aggravate childhood obesity.

China's family planning policies over the past four decades has caused it to have the largest number of one-child families, worldwide (Min et al., 2017). The limited number of offspring leads grandparents in China to cherish or indulge their grandchildren to a greater degree compared to countries without population restrictions. Chinese grandparents endeavor to provide their grandchildren with the best nutrition; however, owing to a shortage of health knowledge, they tend to provide children with more food than they actually need. Further, high-calorie food or sugar-sweetened beverages are offered to children to stimulate their appetites (He et al., 2018). However, very few grandparents encourage their grandchildren to do physical exercise, as they are reluctant to see their grandchildren experience discomfort. Furthermore, some grandparents do not prevent their grandchildren from inappropriate behaviors, such as excessive television watching or videogame playing, even when they agree that such behaviors are detrimental to their grandchildren's health (Li et al., 2015).

Another factor that links childhood obesity to grandparental care originates in grandparents' famine experience. The Chinese Great Famine during 1959–1961 was attended by an unprecedented number of deaths due to malnutrition and social unrest. The effects of malnutrition were extremely acute for people in their early childhood during the famine (Meng et al., 2019). Because most people who are currently grandparents in China experienced the Great Famine, it likely shaped their values concerning food, which in turn possibly influenced their feeding practices (Zhang et al., 2015). Grandparents who experienced famine in their childhood tend to have various misapprehensions

regarding proper feeding. They tend to consider eating more to be a manifestation of successful feeding and worry that their grandchildren will suffer from starvation. Many grandparents provide their grandchildren with excessive food and pressurize them to eat, even in the absence of hunger (Jiang et al., 2007). Therefore, it is possible that the famine experience generates a long-term fear of hunger, which affects the parenting attitude of current grandparents (misconception of overweight) and translates into their parenting practice (e.g., overfeeding), thus aggravating childhood obesity in China.

### 3. Database, variables and analytical strategies

#### 3.1. Database

We use CFPS to conduct empirical analysis. CFPS is a biannual longitudinal survey of Chinese communities, households, and individuals. It covers 25 provinces in China and is nationally representative. The CFPS uses multistage probability proportional to size sampling with implicit stratification to represent Chinese society. All the subsamples are obtained through three stages: the primary sampling unit is either an administrative district (in urban areas) or a county (in rural areas), the second-stage sampling unit is either a neighborhood community (in urban areas) or an administrative village (in rural areas), and the third-stage (final) sampling unit is the household. Administrative units and measures of socioeconomic development are used as the main stratification variables. Within an administrative unit, local gross domestic product (GDP) per capita is used as the ordering index for socioeconomic development. If GDP per capita is not available, the proportion of nonagricultural population or population density is used (Xie and Hu, 2014). CFPS has been conducted in five waves (2010, 2012, 2014, 2016, and 2018), and our empirical analysis is based on the five waves of the CFPS panel data.

CFPS provides abundant information on economic and demographic characteristics, such as education, family dynamics, employment, health, and many other economic factors. Moreover, the survey provides ample important information on China at the household level, and its data have been used to study a broad range of issues. In this study, we focus on children aged 0–15. After matching household economic information and family demographic characteristics, we are left with data for 19,734 children from 5 different survey years.

#### 3.2. Variables

The dependent variable is childhood obesity. Although obesity is commonly defined as excess body fat, the quantity of body fat cannot be directly measured in a living subject. In line with most literature (Sweeting, 2007; Gwozdz et al., 2013; Zhang et al., 2020), we strictly follow the WHO's standard in which separately sets up the obesity standard for children aged 0–5 and children aged 5–15, according to children's growth characteristics in different periods<sup>1</sup> (WHO, 2006), and this childhood obesity measure is officially employed in WHO's recent research (WHO, 2016). Accordingly, we first calculate weight-for-length/height z-score (WHZ) for children aged 0–5 according to their gender and body mass index-for-age (BMIA) for children aged 5–15, following WHO's growth chart for Asian children. Then, we construct an obesity indicator as per the WHO standard, it equals 1 if the WHZ for children aged 0–5 is greater than the median plus three standard deviations of WHZ within their age group and 0 otherwise. Similarly, for children aged 5–15, obesity indicator equals 1 if the BMIA is greater than the median plus two standard deviations of the BMI within

<sup>1</sup> As our research is based on the survey data, we are not able to employ WHO Anthro software (WHO, 2011) to derive other obesity measures for children under-five, which requires the basic input variables, such as children's monthly age, oedema status (yes/no), and type of measurement (recumbent or standing).

their age group and 0 otherwise.

Grandparental care is active care by at least one grandparent; it equals 1 if the child is primarily taken care of by any grandparent and 0 otherwise. There is no requirement for cohabitation with the child or family composition; thus, the grandparents may or may not cohabit with the children. A household may have one parent, both parents, or no parents. The control variables include children's characteristics, such as gender, age, hukou, and health insurance status. Parental characteristics comprise education and BMI. At the household level, we control for family size, household income, and household food expenditure. Additionally, two indicators are introduced to reflect household sanitary water and hygienic fuel usage. Sanitary water equals 1 if the household uses purified water, otherwise it is coded as 0 for households that cannot use purified water in their daily lives. Similarly, hygienic fuel equals 1 if the cooking fuel of the household is gas or electricity, 0 otherwise (if the household primarily depends on grass or tree for their daily cooking). These dummy variables not only reflect living standard of the households, but also help to control the possible impact of water and fuel usage on the health outcome of children. Table 1 presents detailed variable definitions and summary statistics.

In our sample, approximately 20% of children are primarily cared by their grandparents. Approximately 16.6% of children are obese as per the WHO standard. Boys account for 52.7%, and 78% of children have rural hukou, suggesting that they are from rural areas.

#### 3.3. Analytical strategies

##### 3.3.1. DID estimation

To identify the causal impact of grandparents' care on childhood obesity, we apply a DID estimator, which compares the probability of obesity among children before and after grandparental care with that of children without grandparental care. We adopt the following model:

$$y_{ijt} = \alpha + \beta_1 GrandCare_{ijt} + X'_{ijt}\theta + Treat_{ijt} + Wave_t + Prov_j + u_{ijt} \quad (1)$$

where  $y_{ijt}$  denotes the probability of obesity of child  $i$  in province  $j$  at year  $t$ .  $Treat_{ijt}$  is a binary variable that equals 1 if the child is under the grandparental care and 0 otherwise.  $GrandCare_{ijt}$  is  $Wave_t * Treat_{ijt}$ , and it equals 1 if child  $i$  in province  $j$  is taken care of by grandparents in the period preceding survey wave  $t$  and 0 otherwise.  $X_{ijt}$  is the control variable.  $Wave_t$  is the survey wave indicators.  $Prov_j$  is the province fixed effect, capturing time-invariant geographic attributes that might influence the outcome of the interest.  $u_{ijt}$  is the error term.

##### 3.3.2. Heterogeneity analysis

The effect of grandparental care may be different among different families. We investigate the heterogeneous effects of grandparental care from two dimensions. One dimension is cross gender. It is well known that there is a widespread son preference in China. Many families allocate more resources to sons at the daughters' expense (Mu and Zhang, 2011). This gender bias may drive grandparents to provide their grandsons with the most nutritious food. Additionally, some grandparents have misconceptions of their grandchildren's weight, and boys' weight status is more frequently underestimated than girls (Li et al., 2014). The disparity in the underestimation of weight based on sex may contribute to the difference in the prevalence of obesity between boys and girls. Therefore, it is necessary to examine the heterogeneous impact of grandparental care on boys versus girls.

The second dimension of heterogeneity relates to grandparents' education. Most grandparents are not well educated and many lack health-related knowledge. Some believe that overweight babies are healthy and thin ones are malnourished. This misconception drives grandparents to overfeed their grandchildren (Li et al., 2015). To investigate the heterogeneous effects among grandparents, we grouped children according to the education of their grandparents (illiterate versus finished primary school and above) to see the different effect of grandparental care on

**Table 1**  
Descriptive statistics.

Variable	Description	N	Mean	Stdev
Obesity_WHO	1 if the child is obese based on the WHO standard, 0 otherwise	19,734	0.166	0.372
BMI	Logged body mass index	19,734	2.871	0.270
Obesity_IOTF	1 if the child is obese based on the IOTF standard, 0 otherwise	18,246	0.146	0.354
Grandparental care	The child is primarily cared by grandparents, 0 otherwise	19,734	0.199	0.399
<b>Child characteristics</b>				
Boys	1 if the child is a boy, 0 for a girl	19,734	0.527	0.499
Age: 0–2 years old	1 if the child aged 0–2, 0 otherwise	19,734	0.137	0.344
Age: kindergarten	1 if the child aged 3–5, 0 otherwise	19,734	0.198	0.399
Age: school age	1 if the child aged 6–15, 0 otherwise	19,734	0.665	0.472
Hukou (Rural = 1)	1 if the child reside in rural area, 0 otherwise	19,734	0.780	0.398
Insurance	1 if the child is covered by health insurance, 0 otherwise	19,734	0.554	0.497
Mother's education	Mother's years of education	19,734	7.729	4.433
Father's education	Father's years of education	19,734	8.704	3.950
Mother's BMI	Mother's body mass index	19,734	22.434	3.288
Father's BMI	Father's body mass index	19,734	23.453	3.329
<b>Household characteristics</b>				
Household size	The number of family members	19,734	5.229	1.891
Food expenditure	Logged (food expenditure per capita)	19,734	7.911	1.028
Household income	Logged (household income)	19,734	10.359	1.125
Sanitary water	1 if daily water use is purified water, 0 otherwise	19,734	0.652	0.476
Hygienic fuel	1 if the cooking fuel is gas or electricity, 0 otherwise	19,734	0.613	0.487
<b>Instrumental variables</b>				
Number of father's siblings	The number of siblings of parents	14,851	2.326	1.704
Grandmother's alive	1 if grandmother is alive, 0 otherwise	15,399	0.824	0.381
Grandfather's alive	1 if grandfather is alive, 0 otherwise	14,860	0.728	0.445
<b>Mechanism variables</b>				
Watching television or playing video games	Combined hours of watching television or playing video games per week	11,004	9.921	9.855
Physical exercises	Exercise frequency: 1 = never; 2 = once a month; 3 = two or three times a month; 4 = two or three times a week; 5 = almost everyday	6026	3.467	1.470
Cooking fuel	Logged (household fuel expenditure)	15,250	3.381	2.024
Dining out	Logged (dining out expenditure)	15,239	2.150	2.887
Famine experience	1 if the caregiving grandparents experienced the Great Famine	19,734	0.877	0.329
Grandparents' education	1 if grandparents' highest level of education is illiteracy, 2 = primary school, 3 = middle school and above	19,092	1.368	0.633
Mother care	1 if mother is the primary caregiver, 0 otherwise	19,734	0.472	0.499
Father care	1 if father is the primary caregiver, 0 otherwise	19,734	0.038	0.191
High-energy food	1 if the child eat meat, fish and fried food	4870	0.255	0.436

**Table 1 (continued)**

Variable	Description	N	Mean	Stdev
Vegetables	simultaneously within the past week, 0 otherwise 1 if the child eat vegetable and fruits regularly within the past week, 0 otherwise	4870	0.961	0.194

childhood obesity.

**3.3.3. Robustness check techniques**

We employ multiple techniques to conduct robustness checks, including (1) testing the parallel trend assumption underlying the DID estimation and conducting an additional DID matching estimation; (2) applying estimations of instrumental variables to address questions of potential reverse causality between grandparental care and childhood obesity; (3) running a placebo test to ensure that the study conclusions are not influenced by omitted variables; (4) confirming that grandparental care plays a central role in causing childhood obesity in three-generation families; and (5) employing alternative measures of childhood obesity.

**3.3.3.1. Parallel trend test and a matching DID method.** The validity of the DID methods relies on the parallel trend assumption, implying that children under grandparental care would have followed the same pre-intervention trend as the ones who did not have grandparental caregiving. To examine the plausibility of the parallel trend, we follow [Yue et al. \(2020\)](#) and compare obesity trends between children with and without grandparental care in the periods before grandparental care took place. To do so, we added an indicator of grandparental care in the wave subsequent to actual grandparental caregiving:

$$y_{ijt} = \alpha + \beta_1 GrandCare_{ijt} + \beta_2 GrandCare_{ij(t+1)} + X'_{ijt}\theta + Treat_{ijt} + Wave_t + Prov_j + u_{ijt} \tag{2}$$

In Eq. (2),  $\beta_2$  tests for differences in trends subsequent to treatment.  $\beta_2$  simultaneously compares (a) wave 1 to wave 2 among children taken care of by their grandparents in wave 3 with those without grandparental care or those taken care of by their grandparents until wave 4 and after; (b) wave 2 to wave 3 trend among children taken care of by their grandparents in wave 4 with those without grandparental care or those taken care of by their grandparents until wave 5; (c) wave 3 to wave 4 trend among children taken care of by their grandparents in wave 5 with those consistently without grandparental care.

[Kahn-Lang and Lang \(2020\)](#) argue that apart from the trend, DID estimates will be more plausible if the treatment and control groups are at similar levels to begin with. [Ryan et al. \(2019\)](#) illustrate, via simulations, that matched DID deals well with non-parallel trends. To further confirm the reliability of the baseline results, we apply a combined propensity score matching (PSM) and a DID strategy wherein PSM is used to attenuate selection bias on observables (children with grandparental care may be different from those without), and DID estimation is used to eliminate the effects of unobserved characteristics.

Based on a set of observable covariates ( $X$ ), we match the children with grandparental care ( $P = 1$ ) with those without ( $P = 0$ ) and record their outcomes ( $Y^1$  and  $Y^0$ ), conditional on grandparent's care and non-grandparent's care. The practical treatment effect ( $\hat{\Delta ATT}$ ) is calculated using the mean of obesity probability changes between children with grandparental care ( $\Delta Y^1 = Y^1_{t+1} - Y^1_t$ ) and matched children without grandparental care ( $\Delta Y^0 = Y^0_{t+1} - Y^0_t$ ). The  $\hat{\Delta ATT}$  is calculated as follows:

$$\hat{\Delta ATT} = \frac{1}{N} \sum_i \left[ (\Delta Y^1_i | p = 1, X) - \sum_j \omega(i, j) (\Delta Y^0_j | p = 0, X) \right] \tag{3}$$



where  $N$  is the number of matches.  $\omega(i, j)$  represents the weight of matched children ( $j$ ) without grandparental care to that of children ( $i$ ) under grandparental care.

**3.3.3.2. Two instrumental variable estimations.** Another potential concern for correctly estimate the effect of grandparental care on childhood obesity is reverse causality. Children who receive grandparental care may have pre-existing obesity (before grandparental care). For example, it is possible that busy parents resort to grandparents for caregiving so that their children could eat regularly at home instead of consuming unhealthy food outside. To address this concern, we employ two instrumental variable (IV) estimations. The first is the traditional IV approach, wherein we consider the father's number of siblings and the grandparents' being alive as the IVs for grandparental care. Given the grandparents being alive, greater sibling numbers imply larger numbers of grandchildren and a lower chance that one specific grandchild is cared for by the grandparents. Nonetheless, father's number of siblings and whether the grandparents being alive are independent of children's obesity. We will run a two-stage least square (2SLS) estimation to obtain the estimates.

Nonetheless, classical IVs are usually challenged for their exogeneity assumption as they have received little empirical verification. To overcome the aforementioned difficulty, we employ an alternative identification strategy—that is, identification using heteroscedasticity (Lewbel, 2012). This identification method does not rely on standard exclusion restrictions but requires the uncorrelatedness of regressors with the heteroskedastic errors.<sup>2</sup> To provide an abridged general description, consider  $Y = R\beta + X\gamma + e$ , where  $Y$  is the dependent variable,  $R$  is endogenous explanatory variable, and  $X$  is the vector of exogenous variables. Initially, the set of exogenous variables  $Z$  ( $Z \in X$  or  $Z = X$ ) is identified. In the first stage, the endogenous variable  $R$  is regressed on the  $Z$  vector, followed by the retrieval of the first-stage residuals  $\hat{v}$ . Using these residuals,  $(Z_i - \bar{Z}_i)\hat{v}$  is constructed for  $Z_i$ , where  $\bar{Z}_i$  is the mean of  $Z_i$ .  $(Z_i - \bar{Z}_i)\hat{v}$  is used as the standard instrumental variable in the second stage, which can be estimated by 2SLS or GMM. Lewbel's method requires that the error terms in the first-stage equation are non-spherical; therefore, as long as there is some heteroskedasticity in the data, the identification can be achieved without the aid of external instruments. The Lewbel estimate is obtained in a similar way to the standard two-stage IV approach, except that the first-stage exclusion restriction is generated by the exogenous variables (Lewbel, 2012).

**3.3.3.3. The placebo test.** To determine the extent to which the results may be influenced by omitted variables, we follow La Ferrara et al. (2003) and Li et al. (2016) to conduct a placebo test by randomly assigning grandparental care to children. Using the pseudo-grandparental care variable and considering the random data generation, the randomly assigned grandparental care should produce no significant estimates with magnitudes close to zero. A significant positive or negative effect would indicate a misspecification of our DID estimation. To increase the identification power of this placebo test, we repeat the estimation 500 times and plot the distribution of the estimations from the 500 runs, if the mean estimate is not significant, it implies that it is the actual grandparental care generates a positive effect on childhood obesity, rather than other factors.

**3.3.3.4. Identify grandparents' central role in childhood obesity.** In multi-generational co-residing families, childcare is generally shared between the parents and grandparents. However, it may be that grandparents claiming to be primary caregivers share approximately equal responsibility with the children's parents, leading childhood obesity to be falsely attributed to grandparental care. To address this concern, we

restrict the sample to children that live in multi-generational co-residing families. We re-estimate the effect of grandparental care on children's obesity. Additionally, we estimate the effect of parental care on children's obesity if the claimed caregiver is the father or mother. If the positive effect of grandparental care on childhood obesity remains and the effect of parental care is not significantly positive within multi-generational co-residing families, our previous conclusion stands.

**3.3.3.5. Employing alternative measures of childhood obesity.** We also employ alternative measures to reflect childhood overweight or obesity. Instead of defining childhood obesity as a binary indicator, we directly calculate children's logged BMI (dividing measured weight in kilograms by squared height in meters), where higher BMI implies greater probability of obesity. Additionally, we calculate BMI z-scores based on the growth charts of the International Obesity Task Force (IOTF) (Cole et al., 2000),<sup>3</sup> calculated from six nationally representative data sets<sup>4</sup> of body mass indices during childhood. These growth charts are differentiated by age and sex, making the z-score reveal the corresponding percentile of the underlying growth chart. If grandparental care still imposes positive impact on childhood obesity with alternative measurements, it further confirm our conclusion.

## 4. Results and channels

In this section, we first illustrate the estimation results with robustness checks. Then we empirically explore major channels through which grandparental care affects childhood obesity.

### 4.1. Estimation results

#### 4.1.1. Baseline results

Table 2 presents the baseline results of DID estimation. All standard errors are clustered at the province level.

The DID estimate is significantly positive at the 5% level, implying that grandparental care has a positive effect on childhood obesity and that it increases the probability of obesity by approximately 3.6 percentage points. The coefficients for the control variables are reasonable. Boys are more likely to be overweight than girls. Children from high-income families are less likely to be overweight than those from low-income ones. Both father's and mother's BMI positively affect children's probability of obesity. In other words, children tend to be obese if their parents have large BMIs. Further, parents' education is negatively associated with children's obesity. Thus, it is more likely that better educated parents have greater health-related knowledge. Such parents may pay closer attention to their children's weight control than grandparents.

#### 4.1.2. Heterogeneous effect

The analysis of heterogeneous effect involves two dimensions: boys versus girls and illiterate grandparents versus grandparents that at least finished primary school. We present the heterogeneous effect in Table 3.

Columns 1 and 2 of Table 3 show the heterogeneous effect between boys and girls. Consistent with our expectations, grandparental care has a significant positive effect on boys' obesity; however, this effect is not significant for girls. Columns 3 and 4 in Table 3 indicate that the caregiving from illiterate grandparents generates a significant positive effect on children's obesity, whereas this effect disappears if the caregiving grandparents have at least finished primary school.

#### 4.1.3. Robustness checks

To reinforce the conclusion that grandparental care has a positive

<sup>3</sup> Ong et al. (2019) apply a similar BMI z-scores measure on children obesity.

<sup>4</sup> The six countries include Brazil, the Great Britain, Hong Kong, the Netherlands, Singapore, and the United States.

<sup>2</sup> For a more complete discussion, see Lewbel (2012).

**Table 2**  
DID estimation for the effect of grandparental care on childhood obesity.

Dependent variable: childhood obesity	(1)
Grandparental care	0.036** (0.016)
Age: [3–6]years old	−0.035*** (0.009)
Age:[6–15] years old	−0.129*** (0.008)
Boys	0.069*** (0.005)
Hukou (Rural = 1)	0.005 (0.008)
Insurance (Yes = 1)	−0.008 (0.006)
Sanitary water (Yes = 1)	−0.013** (0.006)
Hygienic fuel (Yes = 1)	−0.005 (0.006)
Mother's education	−0.004*** (0.001)
Father's education	−0.003*** (0.001)
Mother's BMI	0.004*** (0.001)
Father's BMI	0.006*** (0.001)
Household income	−0.009*** (0.003)
Family size	0.017*** (0.002)
Household food expenditure	−0.006** (0.003)
Province fixed effect	Yes
Waves	Yes
Observations	19,734

Note: \*, \*\*, and \*\*\* represent a 10%, 5%, and 1% significance level, respectively. Standard errors are clustered at the province level.

**Table 3**  
Heterogeneous effects of grandparents' care on children's obesity.

Variables	(1)		(2)		(3)		(4)	
	Gender of the children: boys vs girls		Grandparents' education: illiteracy vs primary school and above		Illiteracy		Primary school and above	
	Boys	Girls	Illiteracy	Primary school and above	Illiteracy	Primary school and above	Illiteracy	Primary school and above
Grandparental care	0.051** (0.024)	0.024 (0.021)	0.048** (0.020)	0.005 (0.027)				
Child controls	Yes	Yes	Yes	Yes				
Household controls	Yes	Yes	Yes	Yes				
Province fixed effect	Yes	Yes	Yes	Yes				
Waves	Yes	Yes	Yes	Yes				
Observations	10,397	9337	13,663	5429				

Note: \*, \*\*, and \*\*\* represent significance at the 10%, 5%, and 1% levels, respectively. DID estimation is applied. Standard errors are clustered at the province level.

impact on childhood obesity, we employ multiple techniques in the robustness check and presents results below.

**4.1.3.1. Parallel trend test and a matching DID result.** We first test parallel trend by comparing obesity trend between children with and without grandparental care in the periods before grandparental care took place. The results are presented in Table 4.

The coefficient of  $GrandCare_{ijt+1}$  is not significant, suggesting that pre-grandparental care trends of childhood obesity are similar for both types of children. Furthermore, the coefficient of  $GrandCare_{ijt}$  is similar to that in the baseline regression. The lack of differences in trends prior

**Table 4**  
Parallel trend test.

Dependent Variables:	(1)
GrandParentalCare $_{ijt+1}$	0.003 (0.010)
GrandParentalCare $_{ijt}$	0.040*** (0.009)
Child controls	Yes
Household controls	Yes
Province fixed effect	Yes
Waves	Yes
Observations	10,199

Note: \*, \*\*, and \*\*\* represent significance at the 10%, 5%, and 1% levels. DID estimation is applied. Standard errors are clustered at the province level.

to grandparental care increases our confidence that the parallel trend assumption is valid.

Next, we conduct a matching DID analysis to further confirm the existence of the parallel trend. The reliability of the PSM-DID estimate is based on the achievement of matching balance that illustrated in Fig. 1.

Panel A of Fig. 1 suggests that after matching, significant differences of covariates were removed between treated and controlled groups. Panel B indicates a similar distribution of propensity score between treated and controlled groups, indicating that a matching balance has been achieved. Using a matched sample of children, we re-estimate the DID model and present results in Table 5.

Table 5 shows that the estimates of PSM-DID are consistent with our baseline results, which supports our conclusion that grandparental care has a positive effect on childhood obesity.

**4.1.3.2. Instrumental variable estimation results.** We apply both classical IV estimation and Lewbel IV estimation to overcome the reverse causality problem between grandparental care and children obesity. The results are presented in Table 6.

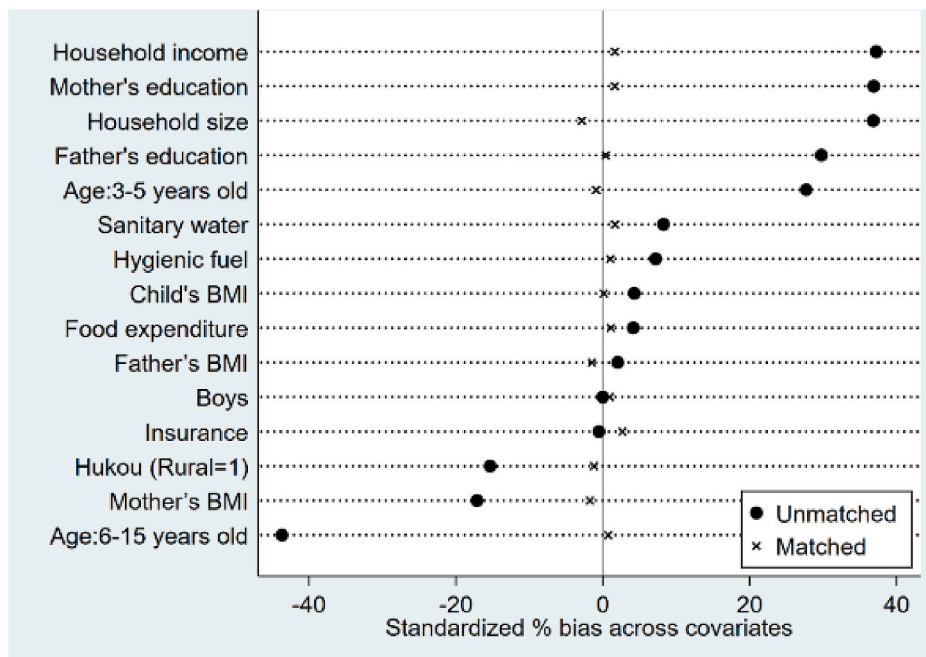
Column 1 and 2 of Table 6 shows the classical IV estimates. In column 1, the first-stage  $F$ -statistic is 113.49, which surpasses the conventional cutoff of 10, suggesting that the IV is a strong instrument. The  $p$ -value derived from the Anderson–Rubin weak identification test is nearly 0 and the Kleibergen–Paap Wald  $F$  statistic is 169.5, suggesting that the endogenous regressor is not under-identified and that the IVs are valid. The second-stage results in Column 2 indicate a positive impact for grandparents' caregiving on children's obesity.

Column 3 of Table 6 presents the Lewbel estimates. The Breusch–Pagan test of heteroscedasticity of the error term in the first-stage regression shows a  $p$ -value of nearly 0, meaning that the heteroscedasticity condition is satisfied. The effect of grandparental care on likelihood of childhood obesity is significant and positive, and it is quantitatively similar to the baseline results. Overall, both the traditional IV estimation and the heteroscedasticity-based IV estimation support our view that grandparental care increases the probability of childhood obesity.

**4.1.3.3. Placebo test results.** The placebo test involves the random generation of pseudo-grandparental care variable. Based on the pseudo-grandparental care variable, we run the placebo DID estimation with 500 times. We plot the distribution of the estimations from the 500 runs, as shown in Fig. 2.

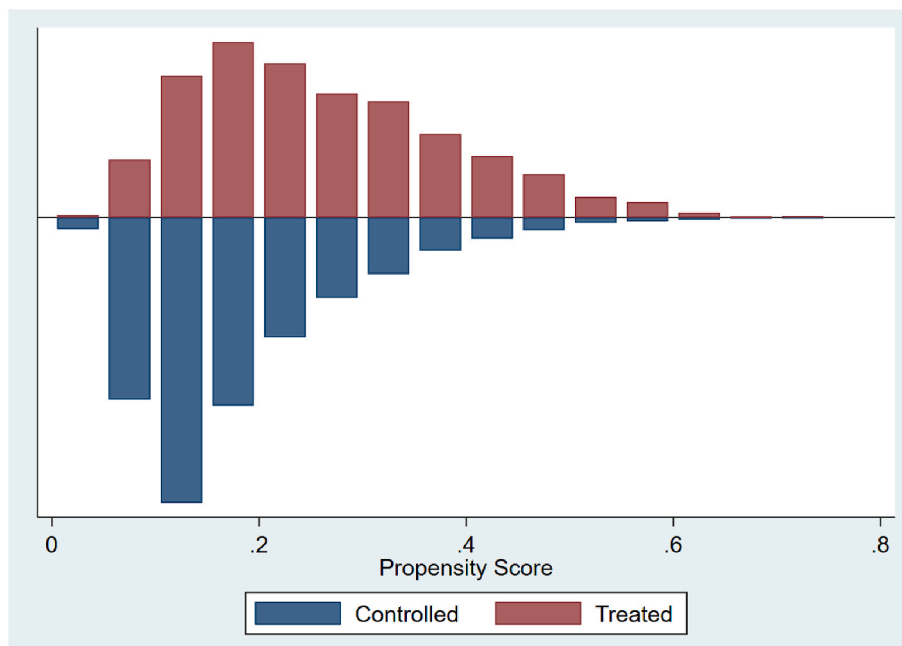
The distribution of the estimates from 500 runs of random assignments is clearly centered around zero, suggesting that there is no effect of the randomly constructed grandparental care (Fig. 2). Therefore, we conclude that the positive and significant effect of grandparental care on childhood obesity is not driven by unobserved factors.

**4.1.3.4. Grandparents' central role in children's obesity.** To identify that it is the grandparental care, rather than the parental care, generates a



A. Covariates before and after matching

Fig. 1A. Covariates before and after matching.



B. The distribution of propensity score of treated and comparison observations

Fig. 1B. The distribution of propensity score of treated and comparison observations.

positive effect on childhood obesity, we restrict our sample to co-residing families and separately estimate the effect of claimed grandparental care versus claimed parental care on children obesity. Table 7 illustrates the results.

Column 1 of Table 7 shows that claimed grandparental care still has a positive effect on children obesity. Column 2 indicates that when either the mother or father claims to be the primary caregiver, the positive effect disappears. These results confirm the central role of grandparents

on childhood obesity.

4.1.3.5. *Estimates from alternative measures of childhood obesity.* Finally, we employ two alternative obesity measures, BMI and BMI z-scores based on the IOTF standard, to see whether the positive effect of grandparental care on childhood obesity still exist, the results are presented in Table 8.

Consistent with the baseline results, Column 1 of Table 8 shows that

**Table 5**  
The PSM-DID estimation of grandparental care on childhood obesity.

Dependent variable: Childhood obesity	(1)
Grandparental care	0.036** (0.016)
Child controls	Yes
Household controls	Yes
Province fixed effect	Yes
Waves	Yes
Observations	19,722

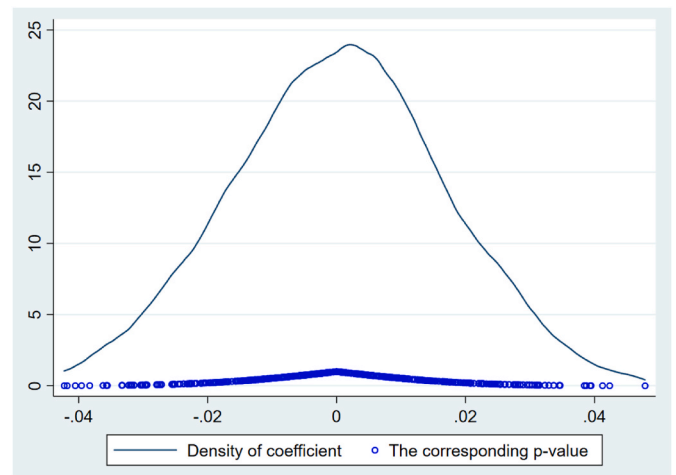
Note: \*, \*\*, and \*\*\* represent significance at the 10%, 5%, and 1% levels, respectively. Model 1 uses nearest neighbors matching (n = 4, caliper = 0.05).

**Table 6**  
The instrumental variable estimations.

Dependent variable: Childhood obesity	(1)	(2)	(3)
	Classical IV	Lewbel IV	
	1st stage	2nd stage	
Grandparental care		0.217*** (0.053)	0.030*** (0.007)
Age: [3–6]years old	0.013 (0.013)	−0.049*** (0.013)	−0.036*** (0.010)
Age:[6–15] years old	−0.050*** (0.011)	−0.129*** (0.012)	−0.129*** (0.009)
Male	−0.000 (0.007)	0.071*** (0.007)	0.069*** (0.005)
Hukou	−0.019* (0.011)	0.018 (0.011)	0.005 (0.007)
Insurance	0.024*** (0.008)	−0.015* (0.008)	−0.008 (0.006)
Sanitary water	0.002 (0.008)	−0.010 (0.008)	−0.014** (0.006)
Hygienic fuel	−0.002 (0.009)	−0.009 (0.009)	−0.005 (0.007)
Mother’s education	0.006*** (0.001)	−0.005*** (0.001)	−0.004*** (0.001)
Father’s education	0.000 (0.001)	−0.005*** (0.001)	−0.003*** (0.001)
Mother’s BMI	−0.004*** (0.001)	0.004*** (0.001)	0.006*** (0.001)
Father’s BMI	−0.002* (0.001)	0.007*** (0.001)	0.003*** (0.001)
Household income	0.027*** (0.004)	−0.020*** (0.004)	−0.009*** (0.003)
Household size	0.018*** (0.002)	0.008*** (0.003)	0.017*** (0.002)
Food expenditure	−0.005 (0.004)	−0.003 (0.004)	−0.006* (0.003)
Province fixed effect	Yes	Yes	Yes
Waves	Yes	Yes	Yes
Treat	Yes	Yes	Yes
IV(Number of siblings of parents)	−0.028*** (0.003)		
IV(Grandmother alive)	0.086*** (0.010)		
IV(Grandfather alive)	0.042*** (0.009)		
1st stage F statistic	113.49		
Kleibergen-Paaprk Wald F statistic	169.50		
Anderson-Rubin Wald test	7.19 (P- value = 0.000)		
Breusch-Pagan test			1771.81 P- value = 0.000
Observations	11,268	11,268	19,734

Note: \*, \*\*, and \*\*\* represent significance at the 10%, 5%, and 1% levels. Standard errors are clustered at the province level.

grandparental care increases children’s BMI by approximately 3.5 percentage points, all else being equal. Column 2 shows that, all else equal, grandparental care increases obesity likelihood by approximately 4.6



**Fig. 2.** Distribution of estimated coefficients of falsification test  
Note: Fig. 2 displays the probability density of the coefficients estimated from 500 simulations (randomly generates grandparental care).

**Table 7**  
Grandparental care and parental care within multi-generational co-residence families.

Dependent variable: Childhood obesity	(1)	(2)
	Grandparental care	Parental care
Grandparents’ care	0.039* (0.021)	−0.022 (0.020)
Child controls	Yes	Yes
Household controls	Yes	Yes
Province fixed effect	Yes	Yes
Waves	Yes	Yes
Observations	10,498	10,498

Note: \*, \*\*, and \*\*\* represent significance at the 10%, 5%, and 1% levels. Standard errors are clustered at the province level.

**Table 8**  
Alternative measures of children obesity.

Variables	(1)	(2)
	BMI	Obesity IOTF
Grandparents’ care	0.035*** (0.012)	0.046*** (0.015)
Child controls	Yes	Yes
Household controls	Yes	Yes
Province fixed effect	Yes	Yes
Waves	Yes	Yes
Observations	19,734	18,246

Note: \*, \*\*, and \*\*\* represent significance at the 10%, 5%, and 1% levels. Standard errors are clustered at the province level.

percentage points. Therefore, the positive effect of grandparental care on children’s obesity is robust to different measures of obesity.

#### 4.2. Channels

We elucidate three possible channels underlying the positive link between grandparental care and childhood obesity. First, we examine the correlation between grandparental care and children’s dietary patterns. Then, we compare physical activity between the children with grandparents’ care and those without. Finally, we emphasize that the famine experience of grandparents generates a particular parenting attitude that leads them to overfeed their children, thus causing childhood obesity.



#### 4.2.1. Grandparental care and children's dietary patterns

In multi-generational families, grandparents play an important role in planning and cooking family meals, which shapes the nutritional environment and dietary patterns of their grandchildren. As most grandparents prefer home-cooked food because—given the same nutrition levels—cooking at home is more economical than dining outside, we first examine the effect of grandparental care on children's dietary patterns; Table 9 illustrates the results.

Columns 1 and 2 of Table 9 show the effects of grandparental care on household expenses on cooking fuel and dining out. Considering fixed food expenditures, eating at home enables the household to consume larger amounts of food compared with dining outside. In practice, we observe a significant positive effect of grandparental care on household cooking expenses and a negative effect on dining out, all else being equal. This evidence suggests that families with grandparental care eat more food and have larger caloric intake than those without grandparental care.

Besides the amount of food, we further examine the effects of grandparental care on children's dietary intake. In particular, high-energy food consumption (defined as eating meat, fish, and fried food simultaneously in the past week) and vegetables. Columns 3 and 4 of Table 9 list the results. Children being cared for by their grandparents eat more high-energy food than those being cared for by their parents, and the differences in consumption of vegetables between the two groups are negligible. Taken together, children under grandparental care eat more food, particularly high-energy food, compared to those without grandparental care.

#### 4.2.2. Grandparental care and children's activities

Further, we examine the association between grandparental care and children's activities, since certain activities, such as television viewing, which may significantly contribute to becoming overweight by replacing physical activity and increasing high-energy foods consumption, the lack of physical activity may also encourage children to accumulate body fat. We investigate the effect of grandparental care on children's television hours and physical activities; Table 10 shows the results.

As expected, Column 1 of Table 10 shows that children under grandparental care watch more television and movies compared to those without. Consistent with this, Column 2 indicates a significant negative impact of grandparental care on children's physical exercise. The combined effects of unhealthy diet and lack of physical activities in children under grandparental care may contribute to childhood obesity.

#### 4.2.3. Grandparents' famine experience and their parenting attitudes

As noted in section 2, grandparents who experienced China's 1959–1961 Great Famine experienced starvation or inadequate

**Table 9**  
Grandparental care and children's dietary patterns.

Dependent Variables	(1)	(2)	(3)	(4)
	Cooking fuel expenses	Dining out expenses	High-energy food	Vegetables
Grandparental care	0.079** (0.038)	-0.108** (0.053)	0.082** (0.041)	0.020 (0.019)
Child controls	Yes	Yes	Yes	Yes
Household controls	Yes	Yes	Yes	Yes
Province fixed effect	Yes	Yes	Yes	Yes
Waves	Yes	Yes	Yes	Yes
Observations	15,250	15,239	4870	4870

Note: \*, \*\*, and \*\*\* represent significance at the 10%, 5%, and 1% levels. Standard errors are clustered at the province level. The questions pertaining to high-energy food is not surveyed in CFPS 2016, the effects of grandparental care on high-energy food diet is estimated from the data of CFPS 2014.

**Table 10**  
Grandparents' care and children's physical activities.

Dependent Variables:	(1)	(2)
	Watching television or playing video games	Physical exercises
Grandparents' care	2.099*** (0.227)	-0.290** (0.130)
Child controls	Yes	Yes
Household controls	Yes	Yes
Province fixed effect	Yes	Yes
Waves	Yes	Yes
Observations	11,004	6026

Note: \*, \*\*, and \*\*\* represent significance at the 10%, 5%, and 1% levels, respectively. Standard errors are clustered at the province level.

nutrition early in their lives. Such an experience can generate a long-term fear of hunger that would affect parenting attitudes and persist into feeding practices by leading to overfeeding. To verify this conjecture, we construct an indicator to represent famine experience that equals 1 if the caregiving grandparents were born before 1956, making them at least 5 years old during the Great Famine and able to form memories of poor nutrition or starvation that could affect their future parenting attitude. Thereafter, we introduce an interaction term between "famine experience" and "grandparental care" to identify an additional famine effect on children's obesity. Because the majority of grandparents who experienced the famine also did not complete primary school because of the poor economic conditions, it may be thought that grandparents' lack of knowledge affecting childhood obesity, rather than the famine experience itself. To resolve this concern, we control grandparents' education in the regression; Column 2 of Table 11 presents the results.

Column 1 of Table 11 indicates that the coefficient of the interaction term is significantly positive, suggesting that famine experience aggravates the effect of grandparental care on childhood obesity. Column 2 presents the results by additionally controlling grandparents' education. This effect remains significant and positive, and the magnitude of the coefficient is quantitatively similar, which further corroborates our conclusion.

## 5. Discussion and conclusions

Ongoing increases in childhood obesity have become a serious public health concern, which betrays the SDG03 established by the United Nations. Simultaneously, caregiving by grandparents is becoming an

**Table 11**  
Grandparents' famine experience and childhood obesity.

Dependent variable: childhood obesity	(1)	(2)
Grandparents' care	0.045*** (0.016)	0.041** (0.017)
Famine*Treat	0.046*** (0.018)	0.050*** (0.018)
Famine	-0.011 (0.010)	-0.016 (0.011)
Grandparents education		-0.003 (0.005)
Child controls	Yes	Yes
Household controls	Yes	Yes
Province fixed effect	Yes	Yes
Waves	Yes	Yes
Observations	19,734	19,092

Note: \*, \*\*, and \*\*\* represent significance at the 10%, 5%, and 1% levels, respectively. Standard errors are clustered at the province level. In Model 1, famine indicates that grandparents were born before 1956 and experienced the Great Famine during childhood. Model 2 adds the education level of the grandparents.

increasingly widespread social phenomenon worldwide. However, the influence of grandparents on the occurrence of childhood obesity has received little attention in the literature. The purpose of this study is to estimate the effect of grandparental care on childhood obesity and explore the major channels through which childhood obesity may occur. Utilizing five waves of surveyed panel data from CFPS, we apply a DID approach, couple with multiple robustness checks, we found that grandparental care significantly increases childhood obesity. Heterogeneity analysis revealed that grandparental care has a significant and positive effect on boys' obesity, whereas no significant effect occurs for girls. Additionally, we found that the caregiving by illiterate grandparents generates a significant positive effect on children's obesity, whereas this effect disappears if grandparents have at least a primary school education. The channels through which grandparental care leads to childhood obesity include inappropriate dietary patterns and insufficient physical activity. Beyond that, we advance a new channel that grandparents' famine experience generates a long-term fear of hunger, which translates into their parenting practices by overfeeding the children, thus aggravating childhood obesity problem in China.

The limitation of this paper lies in two aspects. One is that our research is based on observed survey data instead of experimental data. As children under grandparental care are not randomly assigned, there may exist systematic differences between children with grandparental care versus those without. Although the applied DID methodology could theoretically eliminate the potential systematic differences between the treatment and control groups, results from experimental data would be more convincing. In addition, due to the limited information of survey data, we are not able to apply WHO Anthro software (WHO, 2011) that directly derives multiple childhood obesity measures. The other limitation is the channel analysis. There are many potential channels through which grandparental care cause childhood obesity. However, due to the inability of variable measurement or data unavailability, we can only empirically test several major working channels. Therefore, policy suggestions originated from those channels may be incomplete for preventing and controlling childhood obesity.

Despite above shortages, our paper has established a robust causal relationship between grandparental care and childhood obesity. Based on a national representative panel data in China, we find that grandparental care increases the likelihood of childhood obesity by 3.6 percentage points. This means that, children under the grandparental care would have a larger probability of 3.6 percentage points to be obese than those without grandparental caregiving, given other things being equal. Additionally, beyond the channels of unhealthy dietary and insufficient physical activities discussed in the previous literature, we advance another new channel that effectively explains why grandparental care results in childhood obesity. In particular, this new channel is unique to the Chinese context. Namely, the famine experience of grandparents creates misconception of nutrition, which causes them to overfeed their grandchildren and, consequently aggravates childhood obesity in China. To the best of our knowledge, we are the first to empirically identify this channel of childhood obesity yet.

This paper fits into a growing literature on grandparental care on children's physical health. Our findings add support to the research by Jiang et al. (2007) and Li et al. (2015), who argue that grandparental care causes children overweight or obesity problems. Different from their interview or case study methods that based on very small sample, our research is based on the national representative data in China. We also conduct a solid econometric analysis by applying DID combined with multiple robustness checks. As a result, we are able to answer the question of how much exactly is the increased probability of childhood obesity caused by grandparental care. Our paper is also similar to He et al. (2018), who study the effect of grandparents' residence on childhood obesity. They apply an IV estimation on the survey data of China Health and Nutrition Survey. However they fail to take the advantages of panel data structure and the IV approach is commonly criticized by the hardly satisfaction of exclusion assumption. Further, relative to their

channel analysis, we advance a novel channel by emphasizing that caregivers' famine experience is another important channel through which childhood obesity occurs.

The implication of this paper suggests that, besides the regulation on children's dietary patterns and encouragement of their physical activities, Chinese policymakers should also focus on promoting better health knowledge and behaviors among grandparents who are involved in childcare. Furthermore, more studies should be conducted to identify other factors in grandparental childcare that may influence children's health.

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## Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

## Informed consent

Informed consent was obtained from all individual participants included in the study.

## Declaration of competing interest

The authors declare that they have no conflict of interest.

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