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One-child policy and childhood obesity

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ABSTRACT

This paper investigates the effect of only children on childhood obesity in China. We use implementation measures of family planning policies as instrumental variables in the estimations, and find that being raised in a one-child family significantly increases the weight, body mass index, and probability of being overweight or obese for children. By examining mothers' care-taking behaviors and their children's dietary habits and nutritional intake, we identify the following channels linking one-child families with childhood obesity. (a) In one-child families, parents prefer spending money to using their time to care for their children. (b) In one-child families, children eat more high-sugar, high-fat, and high-protein food. A time–money trade-off could be a plausible mechanism of the effects we document.

1. Introduction

Childhood overweight and obesity are becoming major public health concerns for China. With the rapid rise in living standards over the past three decades, the prevalence of childhood obesity has increased steadily. National surveys on the health of schoolchildren have shown that the obesity rate among children aged 7–18 years increased fourfold between 1985 and 2000 (China Daily, 2008). According to a 2015 report on nutrition and chronic diseases among Chinese children aged 6–17 years, the overweight rate was 9.6% and the obesity rate was 6.4%–5.1% and 4.3% higher, respectively, than in 2002. The situation is the most serious in larger cities. In 2000, the prevalence of obesity and overweight in boys aged 7–18 years was 11.3% and 6.5% in Beijing, 13.2% and 4.9% in Shanghai, and 9.9% and 4.5% in large coastal cities (Ji, 2006). According to a report from China's Working Group on Obesity in 2004, 21.7% of 2- to 18-year-olds was obese (Shan et al., 2010). Childhood overweight and obesity not only affect children's physical and mental development (Li et al., 2007), but also directly threaten their quality of life in adulthood (Webitsch, 2000). Of people who are overweight, 75.9% have at least one metabolic abnormality and 20.4% have metabolic syndrome (Li et al., 2010).

The literature suggests several possible causes of the rapid increase in childhood and adolescent obesity. Regarding health-related behaviors, Meng (2012) document an association between obesity and lack of sleep in urban children; Li et al. (2010) believe a 20-min-per-day vigorous physical activity could effectively prevent childhood obesity, and that insufficient physical activity could lead to childhood obesity; and Shang (2012) find a positive correlation between childhood obesity and sugar-sweetened beverage intake. Regarding social causes of childhood obesity, papers examine family income, parents' working status, environment, and other factors (e.g., Anderson & Butcher, 2006; Dehghan, Akhtar-Danesh, & Merchant, 2005; Ebbeling, Pawlak, & Ludwig, 2002; Papoutsi, Drichoutis, & Nayga, 2011). Most papers studying Western economies identify a positive correlation between childhood obesity and low socioeconomic status, which differs from the situation in China. Han and Wen (2014) document a positive correlation between family income and childhood obesity by using the data from Shanghai. Zhang et al. (2015) find corre-

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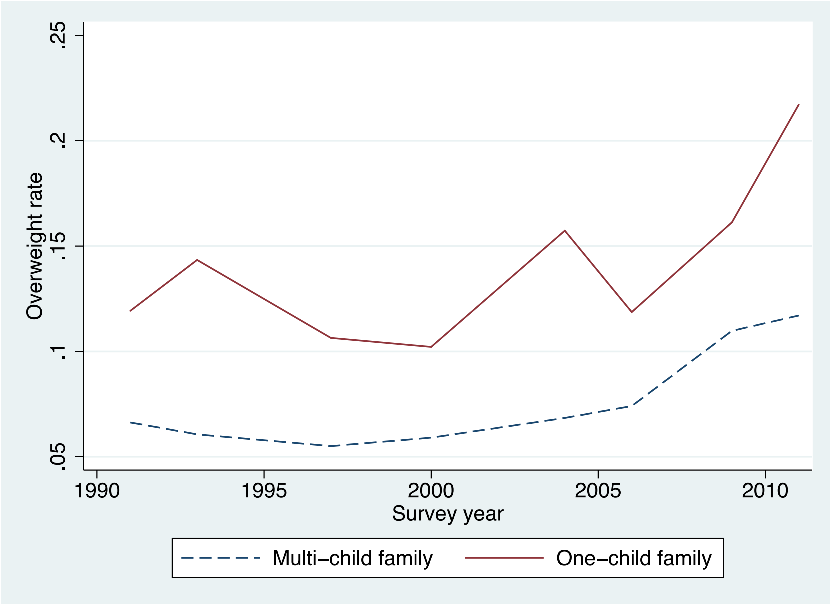

Fig. 1. Time trends between one-child family and multi-child family.

lation between northern dietary patterns and childhood overweight. As an emerging economy with deep-rooted Eastern traditions, China exists within its own unique context. In the late 1970s, the Chinese government introduced the controversial one-child policy (OCP), which dramatically reduced the birth rate and gradually changed the population structure. The only children resulting from the policy constitute a unique group in many aspects related to public health, among which this study focuses on body weight. Fig. 1 shows the overweight prevalence[1] for only children and children with siblings from 1991 to 2011.[2] Both groups exhibit upward trends, though the rate of the only children is always higher than that of the children from multi-child families. This difference motivates us to examine the OCP's effect and explore the policy-related channels behind the factors that might have caused childhood overweight in China.

The main theories on which our hypothesis stands are those exploring the mechanisms in the accumulation of children's human capital. One of the most widely known and intensively studied of these is the quantity–quality (Q–Q) trade-off theory. Briefly, the concept can be traced back to Malthus, who first theorized about economic constraints and population growth. After Becker and Lewis (1973) and Becker and Tomes (1976), studies on the trade-off between family size and quality of children began to grow into a large branch in modern labor economics. Various measures of quality are used to test the theory. These measures include education achievement, nutrition and health status, and cognitive abilities. Conclusions vary by region and time. Although earlier studies (e.g., Rosenzweig & Wolpin, 1980; Hanushek, 1992; Parish & Willis, 1993) tend to support the Q–Q theory, more recent studies are less conclusive. Conley and Glauber (2006) find that children with more siblings are less likely to attend private school. Li, Zhang, and Zhu (2008) and Rosenzweig and Zhang (2009) show that family size has a negative effect on children's education, particularly in areas with poor public education systems. Angrist, Lavy, and Schlosser (2010) do not find any negative consequences of having more siblings. Black, Devereux, and Salvanes (2005) report that family size has only a negligible effect on child quality after the birth order effect is controlled for. Qian (2009) argues that having a second child raises the school enrollment rate of the firstborn child in rural China. Liu (2013) finds a negative effect of family size on children's stature and health status in China.

Overweight and obesity are crucial factors affecting the health capital of children, so it is natural to consider taking them as measures of general quality[3] under the Q–Q framework. In this paper, we examine the relationship between family size and childhood obesity. For China, the OCP, which exogenously constrained family size, brought unique patterns to family size and composition across the country. According to a population survey, China had approximately 110–120 million only children aged 0–19 years in 2005, constituting approximately 20% of the child population (Wang, 2009).[4] Such a population structure may have profound influences on several generations' living quality and on the country's future development. Because of the uniqueness of this subpopulation, we focus on the differences in body weight between only children and those with at least one sibling. Thus, the results could also be considered an indicator of the policy effect of OCP from the perspective of public health. Taking

[1] Based on WHO standard, BMI-z-score larger than 85% quantile are defined as overweight.
[2] Calculated with our estimation sample from the CHNS.
[3] Unlike other general quality measures, body weight is not the higher the better. Moreover, we assume independence or little relevance between obesity and the general quality that parents care about. As you will see in following chapters, these differences are crucial in our explanation to the mechanisms behind the empirical findings.
[4] Data resource from http://www.stats.gov.cn/tjsj/ndsj/renkou/2005/renkou.htm.

advantage of the exogenous regional variations in the implementation of the policy, we document a causal relationship between being the only child and being overweight. We also explore possible channels for this causal relationship. Children from one-child families generally consume more high energy-dense food and receive less care-taking time from their parents, especially mothers. A time–money trade-off mechanism is proposed to link the two findings and explain the channel; specifically, because of the economies of scale in care-taking behaviors with respect to child number, mothers tend to spend less time caring for only children, and compensate for this by spending more money on high-energy food for them. To our knowledge, few research directly studies the consequence of OCP on childhood overweight: As a supplement result, Rosenzweig and Zhang (2009) find a negative correlation between body weight and being a twin. They do not control for the body height, and do not take the concept of overweight and obesity into consideration. We use BMI related variables, which are commonly taken as measurements for overweight and obesity. Yang (2007) finds no significant association between the OCP and childhood overweight in China during the 1990s. Her approach generally compares the child overweight probability with different community level policy intensity, and does not identify the causal effect of one child on overweight status. Our paper is the first that tries to identify the causal effect of being the only children to obesity/overweight status. We adopt the instrumental variable method to deal with the possible endogeneity, by utilizing the correlation of only children to both regional and time variations in the OCP. Besides identifying the causal relationship, we also explore the mechanisms behind.

The remainder of this paper is organized as follows. Section 2 provides an introduction to the OCP and some of its consequences. Section 3 briefly presents the conceptual framework of the time–money trade-off. Section 4 introduces the data and variables. Section 5 describes our empirical strategy and discusses the endogeneity problem. Section 6 provides the main empirical results, evidence for possible channels, and robustness checks of the results. Section 7 concludes the paper.

2. Institutional background

In the 1970s, China's policy makers gradually enacted a series of measures to curb population growth. In 1972, the "later, longer, fewer" policy subsidized families that had relatively late births, fewer children, or 4 years between births. A mandatory 4-year birth gap was implemented in 1978 as a prelude to the OCP, which was officially announced in 1980 in an open letter to the public from the Communist Party of China's Central Committee. Economic rewards such as food stamps and money were given to one-child families, but were provided in amounts generally considered too small to make any tangible difference in parents' reproductive decisions (Liu, 2013; Short & Zhai, 1998). Severe economic and administrative punishments were imposed on those who did not abide by the restrictions. For public sector workers, having an unsanctioned child harms employment status, housing opportunities, and chances of promotion. In rural areas, besides fines, additional births often result in the confiscation of properties including livestock and houses. As a result of the strict enforcement of the policy amid a strong preference for sons, many families tend to keep only male babies. To address local needs and cope with rampant sex-selective abortions, the OCP was relaxed conditionally around 1984 (Short & Zhai, 1998) to allow a second child in certain regions if the first child was a girl or had a certain disease. In some areas, all couples became eligible to have two children, whereas in others, only couples with at least one member from an ethnic minority were allowed to have two children.

The OCP was advocated by the central government and implemented by local governments. Notably, despite the policy's rigid implementation around the country, it was worded as suggestions rather than commands.[5] Furthermore, the release of various provincial-level legal documents regarding the OCP covered an extensive time span, specifically 1984 to 1992. These features make it difficult for researchers to identify how the implementation status of the policy varied over time. However, the level of fines and conditions for additional children were made to suit the needs of local social development. As supplemental measures to the general principles of the OCP, local policies vary in intensity and other detail among administrative units as small as villages and communities. These regional differences in the implementation allow us to more accurately explore the influences of the OCP on child overweight and obesity.

3. Conceptual framework

We provide a simple model to illustrate the time–money trade-off under the exogenous child quantity constraint in mothers' behaviors as an explanation for correlations that we expect to find in our empirical investigation.

Consider a mother seeking to maximize her children's average quality Q.[6] The quality depends on her time spent in childcare C, the total money spent on her children M, and the number of children n. $M = M(W)$ is an increasing (linear or strictly concave) function of W, where W is her time spent working. This scenario can be expressed as follows:

$$\max_{n,w} Q(C, M, n)$$

[5] For example, the Population and Family Planning law of the People's Republic of China "encourages" later births and one child for one family. Most provincial level rules "advocates" the one child policy.

[6] As to what this quality refers to, previous research gives many alternatives (health and body development, academic achievements, etc.). Since the model describes a utility maximizing problem of parents, we believe what parents care for and their subjective evaluations to the children's wellbeing fit better to this quality. So when parents ignore the risk of overweight/obese in their children, the discrepancy between the quality and the overall health status occurs.

$$\text{s.t.} C + W = T, n \in N$$

$$M = M(W)$$

To simplify this, let $Q(C,M,n) = q(C,W,n)$ and rewrite the problem as

$$\max_{n,w} q(C, T - C, n).$$

Assume that q is well behaved; the first-order condition for maximization is

$$\frac{\partial q}{\partial C} = \frac{\partial q}{\partial W}$$

Take the total derivative and rearrange to yield

$$\frac{dW^*}{dn} = \frac{\frac{\partial^2 q}{\partial C \partial n} - \frac{\partial^2 q}{\partial W \partial n}}{\frac{\partial^2 q}{\partial W^2} - \frac{\partial^2 q}{\partial W \partial C}}$$

The key assumptions here are that $\frac{\partial^2 q}{\partial C \partial n} = \varepsilon \to 0$ and $\frac{\partial^2 q}{\partial W \partial n} < 0$, which means that care-taking behaviors have economies of scale with respect to child quantity, but that money (work) does not. This is supported by the fact that children can be taken care of together, but that money spent on each child seems have little synergy. With $\frac{\partial^2 q}{\partial W^2} \leq 0, \frac{\partial^2 q}{\partial W \partial C} \geq 0,$ we have $\frac{dW^*}{dn^*} < 0$, i.e., optimal working time increases as the number of children declines, and the time spent on child care falls consequently.

The child number n is exogenous in this model because we want to separate the time–money trade-off from the Q–Q trade-off. We believe that the decision process on child quantity is made by the whole family and is a relatively long-term event. Only when child quantity is determined, do mothers decide their time allocation to maximize their children's average quantity, which is more likely to be a daily event. Moreover, if we assume substitution between child quantity and quality, as is in the traditional Q–Q theory, mothers would be incentivized to invest more money and time on their only children, and their children do not face sibling competitions.

It is natural to assume an average n^* above 1. Thus, for mothers subject to the quantity constraint of the OCP, their working time increases and care-taking time declines.

China has never experienced a period in history when there was a public health problem of obesity. Just a few decades ago, its huge population was still struggling to be merely fed. Fatter children are traditionally believed by the Chinese to be more likely to survive the rigors of undernourishment. Some parents and most grandparents even consider "fat" as a plausible trait for children, especially for toddlers (Levine, 2008). We assume that on average, parents do not take the risk of obesity into their consideration for child quality. So the channels between maternal time allocation and childhood obesity may be modeled independent from the decision process for time and money allocation, i.e. obesity is a side effect of maximizing the child quality.

A number of papers find positive associations between maternal employment and child obesity (see the review in Anderson, 2011). In search of the mechanisms behind, Cawley and Liu (2012) study the time using data of mothers from the US, and find association between employment and less time in various child-care activities. Fertig, Glomm, and Tchernis (2009) investigate multiple channels and find small but significant effects from supervision and nutrition. Klesges, Stein, Eck, Isbell, and Klesges (1991) document significant impact of parents' food choice on childhood obesity. Based on these findings, we assume as an important channel that the less care-taking time results into unhealthy dietary patterns[7] through food selection.

We assume that children prefer high energy food. When parents spend less time looking after the children, the food choices are more likely to be determined by children themselves (e.g. through pocket money) or grandparents who usually have less knowledge on obesity and tend to spoil their grandchildren. Moreover, since high fat and high protein food such as meat and dairy products are traditionally considered "food for the rich" or "festival food", some parents may compensate for the time not spending with their children by providing more such food. As a result of the change in optimal time allocation corresponding to fewer children, food intake pattern may change, in both total calories intake and structure, and the risk of obesity increases.

[7] Energy expenditure is another important factor for obesity. Due to lack of data, we don't discuss it in this paper.

4. Data

4.1. The China health and nutrition survey

The main data that we use to test our hypothesis is from the China Health and Nutrition Survey (CHNS). The CHNS is a longitudinal survey providing rich data at the community, household, and individual levels collected from urban and rural China. It includes various information on the socioeconomic, demographic, health, and nutritional status of the Chinese population. The survey utilizes a multistage random cluster-sampling scheme and has collected nine waves of data (in 1989, 1991, 1993, 1997, 2000, 2004, 2006, 2009, and 2011). The sample is drawn from nine provinces (Liaoning, Heilongjiang, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi, and Guizhou) in coastal, central, northeastern, and western areas of China. In the first three waves (1989, 1991, and 1993), Heilongjiang Province was not included. In wave 1997, Liaoning Province was excluded. In each province, four counties and two cities are randomly selected, then 20 households are drawn from each of these communities. More than 190 households are included each year.

4.2. One-child and multi-child families

Unlike previous studies, our key explanatory variable examined here is the dummy variable for only children, instead of child number. Only children are a group with distinctive features in China, and we want to determine the effect of the OCP on family fertility decision and its unexpected consequence in childhood obesity.

The data for our empirical analysis comprises eight waves: 1991, 1993, 1997, 2000, 2004, 2006, 2009, and 2011. We focus on a sample of children aged from 5 to 18 years. Children younger than 5 years were excluded because they have not yet reached school age, have less independence, and receive full-time care from parents or grandparents (Peisner Feinberg et al., 2001). After deleting observations with missing values in the control variables, our sample comprises 9157 children, 2299 of whom are from one-child families. We construct the dummy variable "one-child family" by asking whether the number of children is 1 (families with no children are excluded). Because the information of birth history is incomplete for a relatively large part of the sample, we cannot know the exact number of children for these households. Instead of using birth history, we identify one-child families according to the number of children currently living in the family, which we believe does not meaningfully affect the estimation. Children old enough to work and leave the family are not our major concern, and they are not likely to distort the allocation of family resources by competing with younger siblings who still live with their parents.

4.3. Measures of children's obesity status

Obesity is commonly defined as excess body fat, but body fat itself cannot be directly measured in a living subject. Following the literature on childhood obesity in developed and developing countries (e.g. Sweeting, 2007; Gwozdz, Sousa-Poza, Reisch, et al., 2013; Herbst & Tekin, 2011), we adopt anthropometric measures. Using the World Health Organization (WHO) growth chart for Asian children (WHO, 2006), we construct the overweight dummy variable, body mass index (BMI) -for-age z-scores (5–18 years old) and weight-for-age z-scores (5–12 years old) as our measures of obesity.[8]

The CHNS provides accurate information on height and weight for each child presently living in the household. The BMI is a commonly used index for classifying overweight and obesity, and is calculated as shown in Eq. (1). The WHO growth standards list values of +1 standard deviations for each age and sex, which are taken as the overweight cut-off in our study, and the overweight dummy variables are constructed accordingly. For example, a 5-year-old boy is defined as overweight if his BMI value is larger than 16.9.

$$\mathrm{BMI}_{ij} = \frac{w_{ij}}{h_{ij}^2} \tag{1}$$

Using these BMI values, we calculate the BMI-for-age z-scores (BMIAZ) for each age and sex by using the LMS method (Cole, Bellizzi, Flegal, & Dietz, 2000). LMS method summarizes data in terms of three smooth age-specific curves: L, M, and S. The L curve allows for the substantial age-dependent skewness in the distribution of BMI whereas the M and S curves correspond to the median and coefficient of variation of BMI at each age by sex. The values for L, M, and S can be tabulated for a series of ages. The WHO growth chart gives detailed values for L, M, and S at each age for both sexes (WHO, 2006), and the BMI values can be converted to exact z scores from L, M, and S values by using the following formula (Cole et al., 2000):

$$\mathrm{BMIAZ}_i = \frac{\left(\mathrm{BMI}_{ij}/\mathrm{M}_j\right)^{\mathrm{L}} - 1}{\mathrm{L}_{ij}\mathrm{S}_{ij}} \tag{2}$$

[8] The weight standards are only available from 0 to 12 years in WHO reference 2007, because the indicator does not distinguish between height and body mass in an age period where many children are experiencing the pubertal growth spurt and may appear as having excess weight when in fact they are just tall.

The weight-for-age z-scores (WAZ) is defined as the number of standard deviations that a person's weight is away from the median of healthy children of the same age and sex. Median and standard deviation values of the reference weight distribution are extracted from the WHO growth chart.

$$\mathrm{WAZ_i} = \frac{w_{ij} - w_j}{\sigma_j} \tag{3}$$

where w_{ij} is the observed weight of child i in group j and h_{ij} is the observed height of child i in group j, where group is defined according to sex and birth month. Furthermore, w_j and σ_j are the median and standard deviation, respectively, of the weight in group j.

5. Empirical model

5.1. Basic models

Our basic ordinary least squares (OLS) regression is

$$y_i = \beta \mathrm{onechild}_i + X_i \gamma + \varepsilon_i$$

where dependent variable y_i could be the overweight dummy, BMIAZ, WAZ, or other variables we are interesting in examining. The parameter of interest here is β, which represents the effect of being an only child on y.

The control variables X are categorized into five groups: individual, family and mother, community variables, province dummy and trend control. Individual variables include age, sex, and birth order. Five variables make up the controls for family and mother: father's schooling years, mother's schooling years, household annual per capita income adjusted to the value of the yuan in 1989, and mother's age at the child's birth. To control for the effect of genetic endowment on childhood obesity, we include both mother and father overweight dummies. We define overweight for adults as having a BMI larger than 24 (WHO, 2006). Education level is measure by years of formal schooling.

The community-level variables include three aspects: local economic development level, fast food restaurants & recreation facilities and community food prices. Children living in richer communities may enjoy superior health and nutrition status to those living in poorer communities. In addition, community development level may be correlated to local family planning policy enforcement. Because some communities generally prefer fewer children or treat boys and girls more equally, the OCP may face less resistance, and the local government might be less likely to relax the policies and impose a higher fine rate. Electricity supply and bus stop information are used as proxy variables for a community's development level; more developed communities tend to have a more stable electricity supply and convenient transportation. The variables are derived from two survey questions: (1) On average, how many days a week is the electricity cut off? and (2) Does your community have a bus stop? If the electricity was cut off at least once a week, the variable “no stable electricity supply” equals 1; otherwise, it equals 0. If a respondent answered “yes” to the bus stop question, the variable “bus stop” equals 1; otherwise, it equals 0. To control for community environments for eating and exercising patterns, we add two variables: 1) Any fast food restaurants nearby? and 2) How far is the closest park or entertainment center? If the community has fast food restaurants, children are likely to consume more high-energy food; in communities with park or entertainment center, children are likely to do more physical activities. Both of them affect the obesity status of children. We also control community food prices for rice, flour and pork. Food prices as a measure of relative costs of taking carbohydrate versus fat and protein partly decide the dietary structure, which is assumed to affect the dependent variables. The community-level data were collected only until 2006 in the CHNS survey, thus, we use the 2006 data for the 2009 and 2011 waves.

To test the potential channels that link family size and child overweight, we also examine the effect of family size on maternal employment status, maternal care taking behaviors, child dietary habits, and average daily energy intake. We use the following three variables as dependent variables in the estimations: (1) a dummy for whether the mother is currently employed, (2) whether the mother cared for children aged 6 years or younger, or had cooked food for the household within the past 4 weeks, and (3) how long mothers spent caring for children or cooking food.

The CHNS data record variables for children's eating habits, including the frequency of eating at home, frequency of eating snacks in the past 3 days, frequency of eating fast food in the past 3 months, whether they have eaten breakfast at home in the past 3 days, and whether parents or children buy food/soft drinks often. Each of these variables is taken as a dependent variable to investigate the difference of eating habits.

Moreover, dietary intake data are collected at the individual level with un-weighted diets covering two weekdays and one weekend day, and form four indices in each wave of the CHNS: caloric intake (in kilocalories), carbohydrate intake (in grams), fat intake (in grams), and protein intake (in grams). To make proper comparisons within age and sex groups, the four energy intake measures are also standardized using adjusted sample mean and sample deviation within groups. Based on the existing literature (e.g. Johnson et al., 2008; Pérez-Escamilla et al., 2012; Gina, 2014), dietary energy density, percentage of energy intake from carbohydrate, fat and protein were selected as intermediate response variables. Dietary energy density was calculated by dividing total food energy (in kcal) by total food weight (in g) (Johnson et al., 2008). Percentage of energy intake from fat was calculated by dividing kilocalorie from fat by total energy intake. In the same way, we calculate the percentage of energy intake from carbohydrate and protein.

5.2. Endogeneity and the instrument variables

Son preference and sex selection are prevalent in China, which could be consequences of deep-rooted ancestral worship. In Chinese tradition, it is believed that only boys can support their parents and carry on the legacy of their ancestors (Lee, 1999). Furthermore, a mother's bargaining power within the household would rise if the first-born child was a son (Li & Wu, 2011). The enforcement of the OCP in 1980 made the sex of children more important to prospective parents (Edlund et al. 2013; Qian, 2009). Son preference leads to a sex imbalance, particularly in higher birth order. Parents who have a strong son preference are more likely to choose the sex and quantity of their children through sex-selective abortion (Ebenstein & Sharygin, 2009; Ebenstein, 2010). These parents are also willing to invest more family resource (time and money) into boys, which in turn may affect their body weight. Thus, the major endogeneity problem for our estimation is son preference; this may not only affect family fertility decision but also directly affect child overweight probability. In addition, a sex-selective abortion reduces the mother's health, which probably affects the probability of child obesity. In our paper, we adjust for these considerations by controlling for the mother's age when the child was born. Furthermore, we use the first-born children as our key sample, which is discussed subsequently.

To avoid the sex-selection problem, we use the first-born child sample (Li & Wu, 2011). Despite the abnormal sex ratio of the overall population in China, the sex ratio of the first-born is largely normal. According to the Chinese 1990 and 2002 censuses, the sex ratio is 106.2% among firstborn children aged between 0 and 10, which is comparable with the international average. This also suggests that, for the first-born, sex-selective abortion does not distort the sex ratio and thus is unlikely to cause endogeneity problems through this channel (Yang, 2006; Ebenstein & Sharygin, 2009; Ebenstein, 2010; Chen, Li & Meng, 2013).

Finding an exogenous determinant of family fertility decision would be one means of solving the endogeneity associated with son preference. A valid instrumental variable (IV) for family fertility decision should not only reflect family size but also be exogenous to children's body weight. Previous studies of family size and child quality estimate IV models in which family size is instrumented by considering eligibility for having two children and the value of fines (Liu, 2013; Qian, 2009). Liu (2013) argues with evidence also from the CHNS that the relaxations of the OCP and the amount of fines on unsanctioned births are not correlated with parental preference for children, and do not affect family fertility decisions through sex-selective abortions. In this study, we use similar IVs, namely the fine-to-income ratio at both the provincial (Ebenstein, 2010) and community levels.

The province-level fine ratio varies by time and catches provincial policy changes. We use the fine-to-income ratio data set by province from 1979 to 2000 (Ebenstein, 2010). Ebenstein (2010) calculates the average fine ratio for having a third birth among residents of each prefecture by using demographic information and the policy rules in the province (Scharping, 2003). The province-level fine ratio does not change in some provinces. For example, the provincial fine-income ratio in Shandong is always 1 from 1979 to 2000, but in Henan it varies from 1.23 in 1979 to 1.98 in 1990 and later years. It does not convey more accurate regional variations, either. So we add community-level fine ratio as a complement. The community level fine-to-income ratio is constructed as follows. First, we calculate the annual average real household income[9] per capita by using all household samples in the community from the 1989, 1991, and 1993 waves; second, we calculate the fine-to-income ratio of each year for each of the 3 years by using the fine and annual average real household income in the exact community; finally, we calculate the annual average fine-to-income ratio. According to the relaxed policies, some families do not face unsanctioned birth fines. These include families whose oldest child was born before 1976 (4 years prior to the implementation of the OCP) and couples in communities where a second child is allowed unconditionally (Qian, 2009). We set the fine for these families to 0, because their decision of having a second child was not affected by the OCP. We further exclude families with multiple births and minority families (at least one parent is from a minority group), for children of multiple births are not comparable with others because of their endowment deficit (Rosenzweig & Zhang, 2009), and most minority families are not directly affected by the policy (Ebenstein & Sharygin, 2009).

6. Empirical results

6.1. Summary statistics

Table 1 summarizes the key dependent and independent variables in the study. The average BMI z-scores of one-child families is 0.162 standard deviations lower than the median, whereas the average BMI z-scores of multi-child families is 0.494 standard deviations lower. The average weight z-scores of one-child families are also higher than those of multi-child families. To illustrate the difference of childhood obesity between one-child and multi-child families, Fig. 2 plots the kernel density estimates of the BMI z-scores distribution. A clear pattern appears: the BMI z-scores distribution of the one-child families has a greater density at higher BMI z-scores.

6.2. First-stage estimation and the effect of instrument variables on family fertility decisions

Table 2 presents the results of first-stage regression in our two-stage least-squares (2SLS) estimations. We first include the IVs separately and then jointly in the regressions. The first three columns are coefficients estimated with only the firstborn. The

[9] The household level incomes in CHNS are constructed variables, which aggregate income derives from business, farming, fishing, gardening, retirement and non-retirement wages, subsidies and other income. A part of the missing values are replaced by values imputed from previous and subsequent waves, the mean of households in the community, or the mean in the city/county. The details of construction of household income could be find here: http://www.cpc.unc.edu/projects/china/data/datasets/Household%20Income%20Variable%20Construction.pdf

Table 1
Statistics summary.

Variables	(1) N	(2) Mean	(3) N	(4) Mean
	One-child family		Multi-child family	
Obesity measures				
Whether overweight	2299	0.181	6858	0.085
BMI-for-wage z-scores	2299	−0.162	6858	−0.494
Weight-for-wage z-scores	788	−0.066	2134	−0.668
Individual and family characteristics				
Female	2299	0.4	6858	0.49
Family annual income per capita (Yuan)	2299	7784	6858	3880
Birth order	2299	1	6858	1.642
Mother's age when child was born	2299	24.752	6858	26.5
Mother's schooling years	2299	9.074	6858	5.552
Father's schooling years	2299	10.139	6858	7.563
Mother's overweight status (BMI ≥ 25)	2299	0.347	6858	0.307
Father's overweight status (BMI ≤ 25)	2299	0.438	6858	0.337
Community characteristics				
Unstable electricity	2299	0.984	6858	0.985
Bus stop	2299	0.668	6858	0.587
Whether have fast-food shops?	2299	0.268	6858	0.09
Whether have recreation facilities?	2299	0.752	6858	0.637
Average rice price (yuan)	2299	1.416	6858	1.183
Average flour price (yuan)	2299	1.905	6858	1.17
Average pork price (yuan)	2299	5.651	6858	5.23
Instrumental variables				
Fine ratio (community level)	2299	3.9	6858	2.473
Fine ratio (province level)	2299	1.169	6858	0.626
Other dependent variables				
Whether mother works	1487	0.8	2103	0.732
Whether mother cooks	2276	0.923	6776	0.932
Cooking time (hours/day)	1728	2.276	5505	3.227
Whether mother takes care children	1075	1.46	2570	0.45
Take-care time (hours/day)	108	4.528	868	5.757
Times of eating breakfast at home in the past three days	2165	2.476	6397	2.634
Times of eating snack in the past three days	487	1.671	928	1.013
Times of eating at home in the past three days	2152	7.748	6354	8.285
Times of eating fast-food in the past three months	629	0.436	929	0.191
Times of parents buying you soft-drink and food from TV commercial	495	0.283	784	0.191
Times of buying yourself soft-drink and food from TV commercial	501	0.269	788	0.193
Dietary energy density (kcal/g)	2242	4.856	6633	4.619
Percentage of energy intake from Carbohydrate	2242	0.563	6633	0.647
Percentage of energy intake from fat	2242	0.308	6633	0.233
Percentage of energy intake from protein	2242	0.128	6633	0.12

results reported in columns 1 and 2 show that both provincial level and community level fine-to-income ratio have a strong and positive effect on the number of one-child families. On average an increase of one unit in the provincial level fine-to-income ratio raises the probability of having only one child by 18 percentage points; an increase of one unit in the community level fine-to-income ratio raises the probability of having only one child by 2.3 percentage points. The results in column 3 shows that the coefficients on the fine-to-income ratio are significant when they are included simultaneously in the regressions. Full sample results also present similar significance. Significant coefficients and the F-values suggest that the IVs are not likely to be weak.

6.3. Main results

Our main results are presented in Table 3.[10] Children from one-child families have a higher probability of being overweight than children from multi-child families. For the sample of first born children, the estimated coefficients are 0.056 by OLS and 0.078 by 2SLS (p-value 0.102). For the entire sample, the estimated coefficients of the one-child family dummy are also positive and significant. In Table 4, the results on BMI-for-age z-scores are reported. Again both OLS and 2SLS results suggest that being raised as an only child increases first-born children's BMI-for-age z-scores. The F-statistics on the IVs are much larger than the rule-of-thumb threshold of 10 suggested by Bound, Jaeger, and Baker (1995). These statistics indicate that our IVs have considerable explanatory power.

[10] The error terms for children in the same household are likely to be correlated, so the standard errors are clustered at the community level.

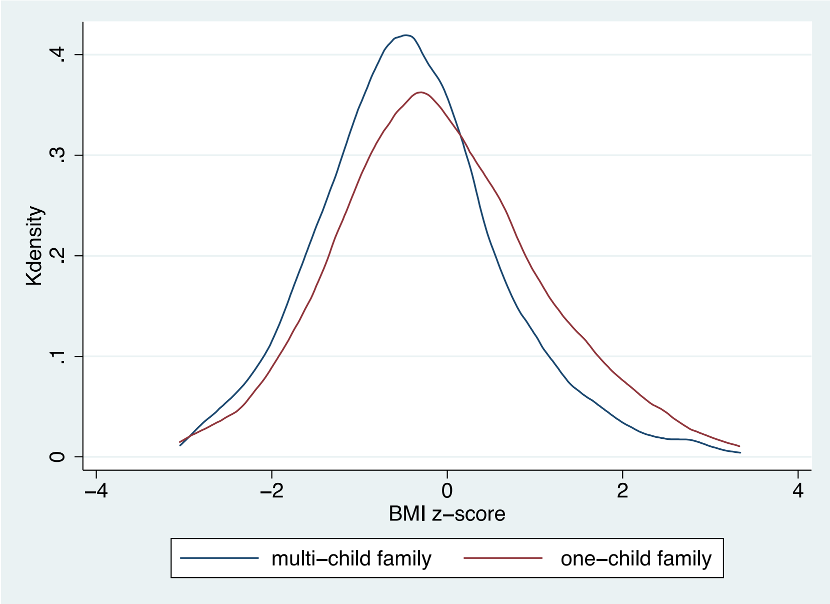

Fig. 2. The kernel density function of BMI z-scores.

Table 2
The first stage regressions.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	OLS	OLS	OLS	OLS
	The first born children sample			All sample		
	(Birth order = 1)					
Fine ratio-province	0.180***		0.176***	0.140***		0.135***
	(0.019)		(0.019)	(0.018)		(0.018)
Fine ratio-community		0.023***	0.022***		0.019***	0.018***
		(0.004)	(0.004)		(0.003)	(0.003)
Female	0.017	0.020	0.015	0.001	0.000	−0.001
	(0.016)	(0.016)	(0.016)	(0.010)	(0.011)	(0.010)
Birth order				−0.243***	−0.230***	−0.233***
				(0.020)	(0.020)	(0.020)
Log family income per capita	0.059***	0.066***	0.061***	0.043***	0.048***	0.046***
	(0.009)	(0.010)	(0.009)	(0.007)	(0.007)	(0.007)
Father's schooling years	0.011***	0.011***	0.011***	0.011***	0.011***	0.011***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Mother's schooling years	0.016***	0.019***	0.016***	0.011***	0.013***	0.011***
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)
Mother's overweight status	0.017	0.013	0.014	0.011	0.006	0.008
	(0.015)	(0.016)	(0.016)	(0.013)	(0.013)	(0.013)
Father's overweight status	0.030**	0.025*	0.027*	0.020*	0.015	0.017
	(0.015)	(0.015)	(0.014)	(0.011)	(0.012)	(0.011)
Mother's age when child was born	−0.028***	−0.034***	−0.027***	−0.018***	−0.022***	−0.017***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)
Community characteristics	Y	Y	Y	Y	Y	Y
Province dummies	N	N	N	N	N	N
Age dummies	Y	Y	Y	Y	Y	Y
Wave dummies	Y	Y	Y	Y	Y	Y
Constant	−0.067	0.247*	−0.213	0.419***	0.414***	0.314***
	(0.152)	(0.134)	(0.146)	(0.115)	(0.116)	(0.112)
F-statistic for fine ratio	43.22	45.55	47.73	19.45	19.36	21.96
Observations	5643	5643	5643	9157	9157	9157

Robust standard errors (clustered at community level) in parentheses.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Table 3
The impact of one-child family on children being overweight.

Variables	(1)	(2)	(3)	(4)
	OLS	IV	OLS	IV
	The first born children sample		All sample	
	Whether overweight (5 < = age < = 18)			
One-child family	0.056***	0.077	0.062***	0.090*
	(0.013)	(0.052)	(0.013)	(0.053)
Female	−0.043***	−0.044***	−0.037***	−0.037***
	(0.010)	(0.011)	(0.008)	(0.008)
Birth order			−0.001	0.006
			(0.006)	(0.013)
Log family income per capita	0.007	0.006	0.006	0.005
	(0.006)	(0.007)	(0.005)	(0.005)
Father's schooling years	0.005***	0.004**	0.003**	0.002
	(0.002)	(0.002)	(0.001)	(0.002)
Mother's schooling years	0.000	−0.000	0.001	0.000
	(0.002)	(0.002)	(0.001)	(0.001)
Mother's overweight status	0.081***	0.081***	0.067***	0.067***
	(0.012)	(0.012)	(0.009)	(0.009)
Father's overweight status	0.060***	0.060***	0.054***	0.054***
	(0.012)	(0.012)	(0.008)	(0.008)
Mother's age when child was born	0.001	0.002	0.001	0.002
	(0.001)	(0.002)	(0.001)	(0.002)
Community characteristics	Y	Y	Y	Y
Province dummies	N	N	N	N
Age dummies	Y	Y	Y	Y
Wave dummies	Y	Y	Y	Y
Constant	−0.192**	−0.201**	0.035	−0.112
	(0.084)	(0.087)	(0.068)	(0.073)
Wald F-statistic		249.138		286.975
Observations	5643	5643	9157	9157

Robust standard errors (clustered at community level) in parentheses.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

As a robustness check for the main results, Table A1 shows the estimations of the effect of being raised in a one-child family on weight-for-age z-scores for 5–12-year-olds. The findings are consistent with the BMI-for-age z-scores. Children from one-child families have higher probability to gain body weight.

Furthermore, to examine whether being raised in a one-child family has varying effects across the conditional individual BMI distribution, we use quantile regressions estimated at the 25th, 50th, and 75th percentiles under the same specifications as those in the OLS models. The results are presented in Table A2. For both BMI and weight-for-age z-scores, we observe significant positive coefficients for being raised in a one-child family at the upper end of the distribution (greater than 75%), which are larger in magnitude than those at the lower end. These results are similar to those of previous studies (Herbst & Tekin, 2010), suggesting that children at the upper end of the distribution have larger gains from being the only children in BMI and weight than do those at the lower end.

6.4. Time–money trade-off

In the following two subsections, we test the hypothesis that family size reduces the probability of childhood obesity through two channels: (1) in one-child families, parents tend to spend less time on child care; and (2) in one-child families, parents provide more high energy-dense food for their children.

We further examine the role of mother's employment and working status on child health outcomes, emphasizing the crucial role of mother's influence on the bodyweight or obesity of children and adolescent. Mother's employment status and work hours are found to be positively correlated to childhood obesity (Cawley & Liu, 2012; Ruhm, 2008; Gwozdz et al., 2013). To identify the potential channel of this relationship, we examine the effect of family size on maternal employment status and care taking behaviors. We directly estimate the OLS coefficients of family size on the dependent dummy variables presented in Table 1, which include whether the mother is employed, whether the mother cared for children aged 6 or younger, had cooked food for the household within the past 4 weeks, and total time spent performing care-taking behaviors. The regression results are presented in columns 1–5 of Table 5.[11] Column 1 suggests that the probability that mothers choose to work is 4.8 percentage points higher

[11] For columns 1, 4, and 5, rural samples are deleted for these estimations because mothers' working status and care-taking questions mainly apply to urban residents.

Table 4
The impact of one-child family on BMI z-scores.

Variables	(1)	(2)	(3)	(4)
	OLS	IV	OLS	IV
	The first born children sample		All sample	
	BMI-for-age z-scores (5 ≤ age ≤ 18)			
One-child family	0.172***	0.335**	0.217***	0.483***
	(0.047)	(0.162)	(0.046)	(0.175)
Female	−0.072**	−0.076**	−0.054*	−0.055*
	(0.035)	(0.036)	(0.029)	(0.029)
Birth order			−0.034	0.029
			(0.025)	(0.045)
Log family income per capita	0.017	0.006	0.014	0.002
	(0.020)	(0.021)	(0.017)	(0.019)
Father's schooling years	0.009	0.007	0.002	−0.000
	(0.006)	(0.007)	(0.006)	(0.006)
Mother's schooling years	0.003	0.000	−0.001	−0.004
	(0.006)	(0.006)	(0.005)	(0.006)
Mother's overweight status	0.351***	0.349***	0.335***	0.332***
	(0.036)	(0.036)	(0.031)	(0.031)
Father's overweight status	0.305***	0.300***	0.282***	0.277***
	(0.036)	(0.037)	(0.028)	(0.029)
Mother's age when child was born	0.003	0.009	0.003	0.009*
	(0.005)	(0.007)	(0.004)	(0.005)
Community characteristics	Y	Y	Y	Y
Province dummies	N	N	N	N
Age dummies	Y	Y	Y	Y
Wave dummies	Y	Y	Y	Y
Constant	−1.467***	−1.540***	−0.359	−1.101***
	(0.328)	(0.335)	(0.279)	(0.288)
Observations	5643	5644	9157	9157

Robust standard errors (clustered at community level) in parentheses.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

in one-child families. By contrast, columns 2–5 show that mothers spend less time cooking and caring for their children in one-child families. These results reveal that mothers from one-child families tend to go out and work, and thus spend less time on children.

Table 6[12] shows the differences in eating habit between children from one-child and multi-child families. We find that children in one-child families are less likely to eat at home, particularly for breakfast, and they tend to eat more snacks and fast food. In addition, parents directly buy their children high-energy food and soft drinks or give them pocket money more frequently. These results meet with our expectation that only children tend to receive more money or material from their parents and have higher odds in exposure to high energy food.

6.5. Nutrition intake and obesity

The nutritional transition from traditional vegetable-fiber based diet to a more westernized diet intensive in meat and dairy products accompanies the rapid income growth in China (Tian & Yu, 2013; Yu & Abler, 2014). For Chinese children, Cui and Dibley (2012) find that daily carbohydrate and protein intakes steadily declined, whereas daily fat intake steadily increased. The rapid nutritional transition to a high-fat diet could be a physiological explanation for the rapid increase in childhood obesity. A number of papers try to identify the factors behind such dietary transitions, mostly focus on food price and income. To further set up link between our present findings and childhood obesity, and explore potential policy or institutional factors behind the nutritional transition for Chinese children, we examine the effect of being the only child on dietary patterns. Carbohydrate, fat, protein, fiber and some microelements are important components of diet. Children consume different amounts of them, which supply different quantity of calories, and form dietary patterns.

The CHNS only provides total energy intake and three nutrition ingredients data. Hence, we examine four dependent variables: Dietary energy density, percentage of energy intake from carbohydrate, fat and protein (Johnson et al., 2008; Pérez-Escamilla et al., 2012; Gina, 2014). Yang et al. (2008) shows that while prevalence of overweight has increased by 39% from 1992 to 2002 in China, the average daily calorie intake has changed little over the years. Instead of overall calorie intakes, we focus on the dietary energy density. Dietary energy density represents the amount of energy gaining from food per gram, which is a

[12] From Table 5 to Table 7, many IV results are not statistically significant at conventional level. However, the signs of IV results are the same as OLS. Therefore we only present OLS results.

Table 5
The impact of one-child family on mother's time allocations.

Variable	(1)	(2)	(3)	(4)	(5)
	OLS	OLS	OLS	OLS	OLS
	Whether mother works	Whether mother cooks	Cook time (hours/days)	Whether mother takes care children	Take-care time (hours/days)
One-child family	0.048*	−0.028***	−0.224*	−0.087***	−1.414**
	(0.026)	(0.010)	(0.121)	(0.017)	(0.586)
Female	−0.009	−0.006	0.069	0.006	0.067
	(0.016)	(0.005)	(0.078)	(0.011)	(0.295)
Birth order	0.013	−0.000	0.088	0.155***	0.582**
	(0.020)	(0.006)	(0.091)	(0.019)	(0.265)
Log family income per capita	0.035**	0.006	−0.092	0.020***	0.487**
	(0.015)	(0.005)	(0.069)	(0.007)	(0.221)
Father's schooling years	0.008***	0.000	−0.016	−0.008***	0.007
	(0.003)	(0.001)	(0.020)	(0.002)	(0.058)
Mother's schooling years	0.005	−0.003*	−0.024	0.002	−0.064
	(0.003)	(0.001)	(0.021)	(0.002)	(0.075)
Mother's overweight status	−0.012	−0.023***	0.140	0.014	0.210
	(0.017)	(0.009)	(0.124)	(0.015)	(0.412)
Father's overweight status	0.002	0.006	0.000	−0.014	0.242
	(0.020)	(0.007)	(0.122)	(0.015)	(0.427)
Mother's age when child was born	−0.007**	−0.002**	−0.011	−0.004*	−0.083**
	(0.003)	(0.001)	(0.012)	(0.002)	(0.041)
Community dummies	Y	Y	Y	Y	Y
Province dummies	Y	Y	Y	Y	Y
Age dummies	Y	Y	Y	Y	Y
Wave dummies	Y	Y	Y	Y	Y
Constant	0.296	0.962***	18.359***	−0.163*	7.512**
	(0.185)	(0.055)	(1.759)	(0.090)	(3.320)
Observations	3590	9052	7233	3645	976

Robust standard errors (clustered at community level) in parentheses.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

relatively new concept that has been identified as an important factor in body weight control in children and adolescents (Johnson et al., 2008). In order to investigate detailed dietary components, we further decompose overall energy into energy intake percentage from different nutrition factors. The regression results are in Table 7. Column (1) shows that only children have higher dietary energy density. Columns (2)–(4) show that fat and protein take larger proportion in only children's energy intake, while carbohydrate takes less. In conclusion, children in one-child family are prone to dietary pattern that are high energy-dense and high-fat. The World Health Organization (WHO and FAO, 2003) has identified the consumption of energy dense food as one of the major dietary causes of the obesity. It is a potential explanation to our findings that children from one-child families have higher probability of being obese.

6.6. Obesity and cardiometabolic risk factors

Obese children are more likely to develop a variety of health problems. Using the biomarker of 2009 wave CHNS data, Wang, Piernas, Du, and Popkin (2015) investigate the prevalence of cardiometabolic risk factor and their association with specific dietary factors. They find that dietary patterns with higher total sugar consumption are significantly correlated to cardiometabolic risk. Following the measures used in Wang et al. (2015), we further evaluate: 1) whether obesity echoes high glucose and hemoglobin, and 2) the effects of obesity on cardiometabolic risk factors.

We use six indicators to measure cardiometabolic risk factors, which includes fasting glucose, HbA1c, total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, and triglycerides. Higher glucose and HbA1c are associated with a greater risk of pre-hypertension. The cutoff points for pre-hypertension are from American Heart Association and Centers for Disease Control and Prevention (Pearson et al., 2003). Our results are presented in Tables 8 and 9. We could see that, obesity status of children have significantly positive correlations with cardiometabolic risk factors. We believe that the economic consequence of the OCP on the energy intake of children, especially for the only children, is a major cause of obesity and related health problems.

6.7. Heterogeneous effects

Table A3 presents the results of estimations examining heterogeneous effects for different subpopulations.

Table 6
The impact of one-child family on diet habits.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	OLS	OLS	OLS	OLS	OLS
	Times of eating at home in the past three day	Times of eating breakfast at home in the past three day	Times of eating snack in the past three day	Times of eating fast-food in the past three months	Times of parents buy you soft-drink and food from TV ads	Times of buy yourself soft-drink and food from TV ads
One-child family	−0.303***	−0.156***	0.067	0.086**	0.029	0.039
	(0.080)	(0.048)	(0.091)	(0.035)	(0.036)	(0.034)
Female	−0.047	−0.023	0.058	0.080***	0.035	0.039
	(0.039)	(0.021)	(0.055)	(0.021)	(0.024)	(0.025)
Birth order	0.070	0.075***	0.029	−0.018	0.003	−0.018
	(0.046)	(0.024)	(0.048)	(0.020)	(0.024)	(0.025)
Log family income per capita	−0.116***	−0.042**	0.077**	0.020	0.037***	0.031***
	(0.027)	(0.016)	(0.037)	(0.013)	(0.011)	(0.011)
Father's schooling years	−0.020**	−0.007	0.010	0.009**	−0.000	−0.004
	(0.009)	(0.005)	(0.012)	(0.004)	(0.004)	(0.004)
Mother's schooling years	−0.022**	−0.010*	0.024**	0.024***	0.005	0.004
	(0.009)	(0.005)	(0.010)	(0.004)	(0.004)	(0.005)
Mother's overweight status	−0.001	−0.032	0.005	0.045*	−0.003	−0.005
	(0.044)	(0.025)	(0.073)	(0.024)	(0.025)	(0.025)
Father's overweight status	−0.083*	−0.063**	0.055	0.036	0.026	0.004
	(0.047)	(0.027)	(0.074)	(0.027)	(0.027)	(0.028)
Mother's age when child was born	0.000	0.003	0.009	0.003	−0.006*	−0.005
	(0.007)	(0.005)	(0.008)	(0.003)	(0.003)	(0.003)
Community dummies	Y	Y	Y	Y	Y	Y
Province dummies	Y	Y	Y	Y	Y	Y
Age dummies	Y	Y	Y	Y	Y	Y
Wave dummies	Y	Y	Y	Y	Y	Y
Constant	9.132***	3.088***	0.513	−0.187	0.095	0.092
	(0.433)	(0.251)	(0.502)	(0.234)	(0.230)	(0.249)
Observations	8506	8562	1415	1558	1279	1289

Robust standard errors (clustered at community level) in parentheses.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

First, on the sex dimension, we find that girls but not boys in one-child families have a significant positive relationship with BMI z-scores. Considering that son preference is a prevalent tradition in China, boys may be treated generally the same regardless of whether they are in a one-child or multi-child family. By contrast, girls with siblings may suffer competition in resource allocations.

Second, we divide the households into urban and rural by their locations. We find that children in one-child families in urban area have a significant coefficient. In contrast, there is no significant effect for the rural group. The possible reason is the one child sample in rural is too small, only 14.42% in our sample. The children's obesity in one child family is more affected by family factors, such as family and parents' characteristics.

Third, we divide the sample into poor and rich families, and find that for wealthy families (income above the 50th percentile), children in one-child families have much larger BMI z-scores; the effect is smaller and insignificant in poor families.

Fourth, we examine whether being raised in a one-child family has different effects according to children's age. We divide all children into two age groups: 5–10 and 11–18 years. We find that being raised in a one-child family has a larger and significant effect on younger children. One possible explanation for this finding is that some social body weight norms (e.g., peer effects) are stronger among adolescents (Nie, Sousa-Poza, & He, 2015), thus partially weakening family factors to some extent.

7. Discussion and conclusions

In this paper, we use the variations in the implementation of the OCP family planning policy to investigate the effect of one-child families on obesity in a sample of 5–18-year-old children and adolescents. We find that the probability of being overweight or obese is significantly higher for children in one-child families. By exploring the channels behind this relationship, we find

Table 7
The impact of one-child family on nutrition intake.

Variables	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	OLS
	Dietary energy density (kcal/g)	Percentage of energy intake from Carbohydrate	Percentage of energy intake from fat	Percentage of energy intake from protein
One-child family	0.081***	−0.027***	0.024***	0.002**
	(0.015)	(0.005)	(0.005)	(0.001)
Female	0.039***	−0.012***	0.013***	−0.000
	(0.007)	(0.002)	(0.002)	(0.000)
Birth order	−0.041***	0.014***	−0.014***	−0.001
	(0.008)	(0.003)	(0.003)	(0.001)
Log family income per capita	0.054***	−0.020***	0.017***	0.002***
	(0.006)	(0.002)	(0.002)	(0.000)
Father's schooling years	0.005***	−0.002***	0.002***	0.000***
	(0.002)	(0.001)	(0.001)	(0.000)
Mother's schooling years	0.012***	−0.004***	0.004***	0.000***
	(0.002)	(0.001)	(0.001)	(0.000)
Mother's overweight status	0.035***	−0.011***	0.011***	0.000
	(0.010)	(0.003)	(0.003)	(0.001)
Father's overweight status	0.023***	−0.007***	0.007**	0.001
	(0.009)	(0.003)	(0.003)	(0.001)
Mother's age when child was born	−0.001	0.001*	−0.000	−0.000
	(0.001)	(0.000)	(0.000)	(0.000)
Community dummies	Y	Y	Y	Y
Province dummies	Y	Y	Y	Y
Age dummies	Y	Y	Y	Y
Wave dummies	Y	Y	Y	Y
Constant	4.181***	0.802***	0.088***	0.108***
	(0.088)	(0.028)	(0.028)	(0.006)
Observations	8875	8875	8875	8875

Robust standard errors (clustered at community level) in parentheses.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Table 8
Effect of overweight/BMI z-score on blood sugar measures (hypertension).

Variables	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	OLS
	Glucose ≥ 100 mg/dl		HbA1c ≥ 5.7%	
Whether overweight	0.143**		0.108*	
	(0.058)		(0.059)	
BMI for-age z-score		0.032*		0.028
		(0.019)***		(0.019)
Female	−0.045	−0.044	0.033	0.041
	(0.042)	(0.045)	(0.043)	(0.044)
Birth order	0.003	−0.030	0.019	−0.001
	(0.042)	(0.044)	(0.042)	(0.043)
Log family income per capita	−0.012	−0.022	0.004	−0.006
	(0.021)	(0.022)	(0.021)	(0.022)
Father's schooling years	−0.002	−0.002	−0.009	−0.009
	(0.007)	(0.007)	(0.007)	(0.007)
Mother's schooling years	0.002	0.003	−0.004	−0.005
	(0.007)	(0.007)	(0.007)	(0.007)
Mother's overweight status	0.038	0.033	0.002	−0.007
	(0.045)	(0.047)	(0.046)	(0.047)
Father's overweight status	0.018	0.014	0.107**	0.104**
	(0.041)	(0.044)	(0.042)	(0.044)
Mother's age when child was born	0.008	0.013**	0.003	0.008
	(0.005)	(0.005)	(0.005)	(0.005)
Community characteristics	Y	Y	Y	Y
Age dummies	Y	Y	Y	Y
Constant	0.504*	0.060	0.477*	0.059
	(0.274)	(0.286)	(0.279)	(0.284)
Observations	489	489	489	489

Robust standard errors (clustered at community level) in parentheses.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Table 9
Effect of overweight/BMI z-score on Four Lipid measures (childhood cardiometabolic risk).

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	TC/HDL-c ≥ 4		LDL-c ≥ 3.4 mmol/l		HSCRP > 1 mg/l		TG ≥ 1.13 mmol/l	
Whether overweight	0.148**		0.121**		0.230***		0.201***	
	(0.057)		(0.055)		(0.062)		(0.062)	
BMI for-age z-score		0.043**		0.042**		0.067***		0.050**
		(0.018)		(0.017)		(0.019)		(0.019)
Female	−0.021	−0.024	0.018	0.016	−0.039	−0.043	−0.014	−0.019
	(0.042)	(0.042)	(0.040)	(0.040)	(0.045)	(0.045)	(0.045)	(0.045)
Birth order	0.009	0.010	0.000	0.002	−0.023	−0.022	0.019	0.019
	(0.041)	(0.041)	(0.039)	(0.039)	(0.044)	(0.045)	(0.044)	(0.044)
Log family income per capita	−0.011	−0.011	−0.006	−0.007	−0.002	−0.003	−0.038*	−0.038*
	(0.021)	(0.021)	(0.020)	(0.020)	(0.023)	(0.023)	(0.022)	(0.023)
Father's schooling years	−0.010	−0.009	−0.016**	−0.016**	−0.003	−0.002	−0.006	−0.005
	(0.007)	(0.007)	(0.007)	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)
Mother's schooling years	0.009	0.008	0.012*	0.010	0.015**	0.013*	0.006	0.005
	(0.007)	(0.007)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)
Mother's overweight status	−0.010	−0.013	−0.011	−0.017	−0.010	−0.016	−0.024	−0.024
	(0.044)	(0.044)	(0.042)	(0.043)	(0.048)	(0.048)	(0.048)	(0.048)
Father's overweight status	0.045	0.041	0.037	0.030	−0.108**	−0.116***	0.039	0.038
	(0.041)	(0.041)	(0.039)	(0.039)	(0.044)	(0.045)	(0.044)	(0.045)
Mother's age when child was born	0.006	0.005	0.004	0.003	0.003	0.002	0.002	0.001
	(0.005)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)
Community characteristics	Y	Y	Y	Y	Y	Y	Y	Y
Age dummies	Y	Y	Y	Y	Y	Y	Y	Y
Constant	0.543**	0.603**	0.517**	0.579**	0.739**	0.834***	0.914***	0.981***
	(0.270)	(0.272)	(0.260)	(0.261)	(0.293)	(0.295)	(0.292)	(0.295)
Observations	489	489	489	489	489	489	489	489

Robust standard errors (clustered at community level) in parentheses.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

evidence linking different care-taking patterns and nutritional intake habits with different family sizes. We believe that our findings could be explained by the time–money trade-off: because the opportunity costs in caring for children in one-child families are higher, mothers in these families prefer working outside the home and spending more money on their children.

Some considerations could not be addressed in this study because of insufficient data. Many crucial aspects should be examined in future studies. First, in this study, the intensity of the OCP is measured using provincial- and community-level fine ratios. However, there are fundamental differences in the policy implementation between rural and urban areas. For example, if parents work in a state-owned enterprise, one of them may be laid off if they have an unsanctioned birth. These constraints are not reflected by fine ratios. We include community data in our regressions, but do not distinguish between rural and urban conditions. Second, mothers' actual working hours are the most accurate and relevant measure of maternal employment, but it is specific to the survey day and may be casual or temporary rather than steady employment. Third, parents' health knowledge or possibility of gaining such knowledge could be essential to the healthy living habits of their children. The CHNS data provide insufficient observations for exploring related patterns. Fourth, the channels we explore cover only energy intake. Limited data prevent us from examining energy expenditure, which is a critical factor in overweight and obesity.

The policy implications of our results are clear: in addition to curbing population growth, the OCP has had other unintended effects on the quality of the population. Our findings serve as evidence of the policy's unfavorable side effect on childhood and adolescent obesity. Our exploration of the channels through which the side effects occur may guide policy makers in fighting the rising trend of childhood overweight and obesity.

Appendix A

Table A1
The impact of one-child family on weight z-scores.

Variables	(1)	(2)	(3)	(4)
	OLS	IV	OLS	IV
	The first born children sample		All sample	
	Weight-for-age z-scores (5 ≤ age ≤ 12)			
One-child family	0.410***	0.625**	0.411***	0.711***
	(0.059)	(0.249)	(0.057)	(0.253)
Female	−0.122***	−0.136***	−0.092***	−0.104***
	(0.044)	(0.048)	(0.034)	(0.036)
Birth order			−0.033	0.049
			(0.034)	(0.076)
Log family income per capita	0.027	0.014	0.040**	0.026
	(0.023)	(0.026)	(0.019)	(0.021)
Father's schooling years	0.028***	0.025***	0.021***	0.017**
	(0.008)	(0.009)	(0.007)	(0.008)
Mother's schooling years	0.017**	0.013*	0.016**	0.013*
	(0.007)	(0.008)	(0.006)	(0.007)
Mother's overweight status	0.387***	0.382***	0.344***	0.335***
	(0.055)	(0.055)	(0.044)	(0.044)
Father's overweight status	0.211***	0.206***	0.204***	0.198***
	(0.052)	(0.052)	(0.041)	(0.041)
Mother's age child born	0.016**	0.026**	0.014**	0.024**
	(0.007)	(0.012)	(0.006)	(0.010)
Community dummies	Y	Y	Y	Y
Province dummies	N	N	N	N
Age dummies	Y	Y	Y	Y
Wave dummies	Y	Y	Y	Y
Constant	−1.477***	−1.651***	−1.462***	−1.596***
	(0.373)	(0.409)	(0.311)	(0.405)
Wald F-statistic		84.194		97.294
Observations	1997	1997	2922	2922

Robust standard errors (clustered at community level) in parentheses.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Table A2
Quantile regressions.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	QR	QR	QR	QR	QR	QR
	BMI z-scores			Weight z-scores		
	25%	50%	75%	25%	50%	75%
One-child family	0.036	0.099**	0.147***	0.111**	0.177***	0.263***
	(0.037)	(0.040)	(0.053)	(0.046)	(0.048)	(0.057)
Female	0.010	−0.055	−0.112**	0.006	−0.084	−0.118**
	(0.032)	(0.045)	(0.046)	(0.028)	(0.054)	(0.048)
Log family annual income	−0.012	0.010	0.039*	0.018	0.031	0.039
	(0.015)	(0.026)	(0.020)	(0.021)	(0.027)	(0.027)
Father's schooling years	−0.004	0.006	0.004	0.021***	0.016*	0.023**
	(0.006)	(0.005)	(0.006)	(0.006)	(0.008)	(0.010)
Mother's schooling years	0.009*	0.006	0.010*	0.024***	0.018***	0.019**
	(0.006)	(0.005)	(0.006)	(0.005)	(0.006)	(0.009)
Mother's overweight status	0.239***	0.281***	0.328***	0.190***	0.179***	0.298***
	(0.049)	(0.037)	(0.028)	(0.045)	(0.053)	(0.085)
Father's overweight status	0.252***	0.249***	0.281***	0.111**	0.144***	0.170***
	(0.039)	(0.032)	(0.051)	(0.045)	(0.050)	(0.057)
Mother's age when child was born	−0.001	0.000	0.005	0.007*	0.005	0.011**
	(0.003)	(0.003)	(0.004)	(0.004)	(0.005)	(0.006)
Community characteristics	Y	Y	Y	Y	Y	Y
Province dummies	Y	Y	Y	Y	Y	Y
Age dummies	Y	Y	Y	Y	Y	Y
Wave dummies	Y	Y	Y	Y	Y	Y
Constant	−1.850***	−1.158***	−0.516	−1.627***	−0.766*	−0.589
	(0.307)	(0.307)	(0.326)	(0.392)	(0.414)	(0.455)
Observations	5553	5553	5553	1964	1964	1964

Robust standard errors in parentheses.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Table A3
Heterogeneous effects.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	OLS	OLS	OLS	OLS	OLS	OLS
	Male	Female	Rural	Urban	Low-income	High-income	Age 5–10	Age11–18
One-child family	0.104	0.141**	0.016	0.140**	0.046	0.155***	0.151**	0.099*
	(0.054)	(0.060)	(0.066)	(0.062)	(0.062)	(0.056)	(0.063)	(0.051)
Log family annual income	0.034*	−0.014	−0.027	0.066***	−0.024	0.063*	0.015	0.005
	(0.020)	(0.019)	(0.018)	(0.022)	(0.025)	(0.035)	(0.027)	(0.016)
Father's schooling years	0.004	−0.007	−0.014**	0.005	−0.006	0.002	−0.002	−0.001
	(0.008)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)	(0.009)	(0.006)
Mother's schooling years	0.012*	0.002	0.001	0.014**	0.004	0.009	0.008	0.007
	(0.007)	(0.006)	(0.007)	(0.007)	(0.006)	(0.006)	(0.007)	(0.005)
Birth order	0.023	−0.041	−0.021	−0.003	−0.028	−0.004	0.005	−0.024
	(0.036)	(0.026)	(0.023)	(0.048)	(0.029)	(0.034)	(0.033)	(0.025)
Mother's overweight status	0.316***	0.257***	0.293***	0.296***	0.334***	0.262***	0.297***	0.283***
	(0.042)	(0.039)	(0.038)	(0.046)	(0.042)	(0.040)	(0.044)	(0.033)
Father's overweight status	0.285***	0.183***	0.191***	0.301***	0.130***	0.322***	0.181***	0.272***
	(0.038)	(0.037)	(0.037)	(0.041)	(0.037)	(0.036)	(0.046)	(0.034)
Mother's age when child was born	0.004	0.003	0.003	0.000	0.004	0.003	0.009	0.001
	(0.005)	(0.005)	(0.005)	(0.006)	(0.005)	(0.005)	(0.006)	(0.004)
Female			−0.033	−0.156***	−0.049	−0.097**	−0.189***	0.005
			(0.035)	(0.041)	(0.032)	(0.040)	(0.042)	(0.032)
Community characteristics	Y	Y	Y	Y	Y	Y	Y	Y
Province dummies	Y	Y	Y	Y	Y	Y	Y	Y
Age dummies	Y	Y	Y	Y	Y	Y	Y	Y
Wave dummies	Y	Y	Y	Y	Y	Y	Y	Y
Constant	−1.634***	−0.445	−0.417	−1.535***	−0.390	−1.695***	−1.099**	−0.774***
	(0.351)	(0.307)	(0.333)	(0.381)	(0.399)	(0.403)	(0.429)	(0.262)
Observations	4819	4212	5485	3546	4425	4606	3521	5510

Robust standard errors (clustered at community level) in parentheses.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

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