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Association between parental socioeconomic status and offspring overweight/obesity from the China Family Panel Studies: a longitudinal survey

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ABSTRACT

Objective To examine the association between parental socioeconomic status (SES) and the risk of offspring overweight/obesity and the changes of the association that occur as children grow older.

Design We used data from the nationally representative longitudinal survey of the China Family Panel Studies of 2010 and its three follow-up waves in 2012, 2014 and 2016.

Participants A total of 6724 children aged 0–15 years old were included.

Primary and secondary outcome measures Average household income and paternal and maternal education levels were used as SES indicators. Logistic regression model for panel data was used to examine the associations between SES indicators and child overweight/obesity. A restricted cubic spline linear regression model was used to estimate body mass index (BMI) trajectories with child growth across parental SES levels.

Results Compared with the lowest education level (primary school or less), the ORs for fathers who had completed junior high school, senior high school and junior college or higher were 0.85 (95% CI 0.75 to 0.97), 0.77 (95% CI 0.64 to 0.92) and 0.72 (95% CI 0.55 to 0.93), respectively. The corresponding ORs for mothers were 0.76 (95% CI 0.67 to 0.86), 0.59 (95% CI 0.47 to 0.72) and 0.45 (95% CI 0.34 to 0.60), respectively. A negative association between parental education and offspring overweight/obesity was observed in the first 10 years but not in children 11–15 years old. BMI differences across parental education levels emerged from birth and widened before 6–7 years old, but decreased before adolescence. High average household income was related to a low risk of offspring overweight/obesity but not when parental education level was adjusted for.

Conclusion High parental education levels were associated with a low risk of offspring overweight/obesity, especially before adolescence. Effective approaches need to be adopted in early childhood to reduce socioeconomic differences in overweight/obesity.

Strengths and limitations of this study

► A nationally representative longitudinal dataset was used to estimate the association between parental socioeconomic status (SES) and offspring overweight/obesity and we also conducted subgroup analyses according to child's sex, residence, and baseline age groups.

► We used restricted cubic spline model to estimate body mass index trajectories with child growth across parental SES levels.

► Reported height and weight of children were used in this study.

► We did not adjust for dietary habits and physical activity factors among children who were under 10 years old.

INTRODUCTION

There has been a substantial increase in childhood overweight/obesity in the past few decades.[1 2] The global prevalence of obesity increased from 0.7% to 5.6% in girls and from 0.9% to 7.8% in boys between 1975 and 2016.[2] Numerous studies have reported that childhood overweight/obesity not only greatly increases risk of health problem in childhood,[3–5] but also children with overweight/obese are at high risk of being overweight/obese in adulthood, which may contribute to chronic diseases and even premature mortality.[6–9]

Previous studies have made headway in identifying the association between parental socioeconomic status (SES) and offspring overweight/obesity.[10–13] They have, however, arrived at different conclusions. For example, systematic reviews showed that in developed countries parents with higher SES were more likely to have a lower risk of offspring overweight/obesity[10]; conversely, in developing countries, higher parental SES was related to higher offspring overweight/obesity.[11] However, a multicentre study conducted in Europe, which employed a standardised study protocol, showed heterogeneous associations between parental SES and offspring overweight in different countries.[13] It seemed that the relationship varied depending on the

economic development status of participants' residing country.[10 11 13]

SES is often measured by indicators of income, education and occupation. Several studies have suggested that different indicators exert variable influences on childhood overweight/obesity through different pathways.[14] For instance, education improves one's knowledge, values and problem-solving ability, occupation influences one's lifestyle and shared peer values, and income relates to resource access.[14] Research has also shown that the association between parental SES and offspring overweight/obesity varied depending on the SES indicators that were used. A review analysed 158 studies in high-income countries and found that 65.8%, 41.7% and 37.5% of the studies showed an inverse relationship using parental education, parental occupation and household income, respectively.[10] It seemed that parental education was more consistently associated with offspring overweight/obesity than the other indicators.[14]

Although a large number of studies have recognised parental socioeconomic differences in childhood overweight/obesity, what remains unclear is when the differences emerge and how they change across the offspring's age. A study in Belarus among children 0–7 years of age suggested that socioeconomic differences in body mass index (BMI) were present at birth and increased after 3 years.[15] Howe *et al* found that socioeconomic differences in trajectories of obesity began at about 4 years in age and widened with the increasing age among children 2–10 years old in England.[16] Bann *et al*[17] reported that socioeconomic differences in BMI widened with age from 7 or 10 years to 15 years in the UK. These studies indicated a widening trend of socioeconomic differences in overweight/obesity as children grow older despite the different beginning ages. However, a systematic review found that negative relationships between parental SES and offspring obesity were less prevalent among children aged 12–18 years than those between 5 and 11 years.[14] It seemed that socioeconomic differences may decrease in adolescence.

In China, studies indicated that the rate of overweight and obesity was positively associated with provincial-level socioeconomic indicators.[18] The socioeconomic differences in children's overweight/obesity seemed to increase between 1991 and 2006.[19] Similar inconsistent results were found among studies that focused on families. A study among children aged 5–12 years in Guangzhou, China, suggested that both household per capita income and maternal education levels were positively associated with childhood overweight/obesity.[12] Conversely, another study among children aged 0–6 years old found that parents' lower education levels were associated with a higher risk of child obesity[20]; a study failed to identify a significant association between family SES and BMI in children aged 7–11 years old.[21] However, most of these research projects were cross-sectional studies in local cities. Therefore, this study with a longitudinal nationally representative dataset may provide important insights on the associations between parental SES and offspring overweight/obesity in China.

In order to determine what socioeconomic determinants take the main responsibility for the differences in childhood overweight/obesity and find out the onset and development of the differences, we examined the associations between offspring overweight/obesity and parental SES, and the changes of BMI over children's ages across parental SES.

METHODS
Participants
The data used in this study were sourced from the China Family Panel Studies (CFPS),[22] which was carried out by the Institute of Social Science Survey of Peking University.[23 24] The CFPS was designed to be a nationally representative longitudinal survey and focused on factors such as subjects' economic situation, education level, health status and so on at the individual, family and community levels. The baseline was conducted in 2010 using a multistage probability sampling strategy. Twenty-five provinces were included, representing 94.5% of the total population of China. Since 2010, there have hitherto been four follow-up waves in the CFPS (2012, 2014, 2016 and 2018) and the databases from 2010 to 2016 are publicly available. New households and individuals were incorporated into each wave because of the change of family structure and formation of new families. Informed consent was obtained from all participants. Details have been described in previous work.[23 24] All members in selected households were interviewed. Those who were aged 0–15 years old, were interviewed at least twice (n=10 017), and had complete data for height and weight, household income, paternal and maternal education, child sex, child age, and residence were included in this study. As a result, a total of 6724 children were included for analysis.

Outcome measures
The height and weight of the children were reported by either their parents or guardians. Studies have examined the validity of self-reported height and weight in assessing the obesity status of children, which suggested an almost perfect agreement with the measured values.[25 26] An article published in *Lancet* reported that self-reported BMI was highly correlated with measured BMI (correlation coefficient 0.96) from the evidence of 538 country-years with both types of measurements available.[1] Therefore, self-reported height and weight can be used in large-scale epidemiological studies when the measurement is not practical. Participants' BMI is their weight in kilograms divided by the square of their height in metres. Since BMI cut-off points for overweight and obesity by the International Obesity Task Force do not apply to children under 2 years of age, we used age-specific and sex-specific WHO growth reference for children aged 0–5 years[27] and 5–19 years.[28] According to the BMI-for-age Z-score (BAZ) cut-off points by WHO, BAZ >+2 SD and BAZ >+3 SD indicate

overweight and obesity, respectively, for children under 5 years old, and BAZ >+2 SD indicates obesity for children aged 5–19 years old.[29] However, in this study children were tracked from under 5 years to over 5 years, and to avoid confusion by adopting two different cut-off points, we used +2 SD as the cut-off point to define overweight/obese (BAZ >+2 SD) and non-overweight/obese (BAZ ≤+2 SD).

Socioeconomic status

SES is often measured by indicators of income, education and occupation. Since occupation is an unordered categorical variable, some comprehensive indexes were constructed to rank occupations; however, some of them were derived from international average education and income,[30] which might not be suitable for the situation in China, and some of them were subjective indicators. Therefore, the average household income and paternal and maternal education levels were taken as the SES indicators in this study.

The CFPS conducted a very detailed survey of household income, including working wages, assets, monetary gifts, pensions and any other forms of subsidy. Average household income was calculated as the total household income divided by the number of family members. Considering the large economic disparities present in different regions in China, we converted the average household income into a relative variable using the reported average household income divided by provincial-level household per capita annual disposable income of urban and rural in each survey year,[31] which was further classified into the following five quintiles: poorest, lower 20%, medium 20%, higher 20% and richest. The paternal and maternal education levels were divided into four categories, namely primary school or less, junior high school, senior high school and junior college or higher.

Covariates

Covariates in this study included child's age, sex, birth weight, dietary habits and physical exercise, family residence (urban vs rural) and paternal/maternal obesity (BMI ≥28 kg/m²). The children's age at baseline was divided into three groups of 0–1, 2–10 and 11–15 years old when examining the association between parental SES and childhood overweight/obesity by different age groups. Birth weight of the child was recalled by parents or guardians and categorised as low (birth weight <2500 g), normal (2500 g ≤ birth weight <4000 g) or high (birth weight ≥4000 g). Dietary habits and physical exercise were self-reported by the children; however, only children over 10 years old were asked these questions. Dietary habits were estimated from three questions: 'Did you have meat last week?', 'Did you have fresh fruits and vegetables last week?', 'Did you have fried food last week'. Physical exercise was estimated by the question 'In the latest month which is not a vacation, how often did you participate in physical exercise' in 2010 and 2012, and the options include 'almost every day', '2–3 times a week',

'2–3 times a month', 'once a month' and 'never'. Another question, 'How many times did you participate in physical exercise last week', was used in 2014 and 2016. In order to be consistent, we classified children as participating in physical exercise 'more than 2–3 times a week' and 'less than twice a week'.

Statistical analysis

Stata V.13.0 was used to analyse the data. A descriptive exploratory analysis was carried out to identify the characteristics of participants. Logistic regression of random-effects model was performed for panel data to estimate the OR and 95% CI for the association between parental SES and offspring overweight/obesity. Demographic factors, including child sex, age and residence,[32 33] were adjusted for, while average household income and paternal/maternal education were further adjusted for. Subgroup analyses were also conducted by child's sex, residence and baseline age.

We estimated the BMI trajectories across different parental SES groups from 0 to 15 years old using a restricted cubic spline regression model to allow nonlinear patterns. Four knot points setting at 1, 6, 10 and 14 years for boys and 1, 6, 10 and 15 years for girls were identified by the spline models. The knot points were considered to be reasonable according to a previous study using similar models.[16] Linear spline regression of random-effects models for the panel data was used to examine whether BMI differences across different parental SES levels changed with child growth. Models of average household income, paternal education and maternal education were constructed separately. The new variables derived by spline models were included and were also used to assess the interaction with average household income or paternal/maternal education.[34] Given that the interaction terms in the average household income model were not statistically significant in either boys or girls, they were not included in the final model. The 95th percentile (P_{95}) of the predicted BMI by age is shown by line graphs.

We performed a sensitivity analysis by further adjusting for potential confounders that were associated with childhood overweight/obesity, including child's sex, age, residence, birth weight, average household income, paternal and maternal obesity, and child's dietary habits and physical exercise (online supplemental file 1).[33 35–37] A p value <0.05 with two sides was considered statistically significant.

Patient and public involvement

This research was done without patient and public involvement.

RESULTS

A total of 6724 children were followed up for 2–6 years, with a median follow-up duration of 4.0 (IQR: 2–6) years. The numbers of children who were interviewed two, three and four times were 3047, 2276 and 1401, respectively.

Table 1 Baseline characteristics of children and parents

Variable	Value (N=6724)
Child sex, n (%)	
Boys	3500 (52.1)
Girls	3224 (48.0)
Residence, n (%)	
Urban	2739 (40.8)
Rural	3985 (59.2)
Baseline age (years), mean (SD)	5.7 (4.0)
Paternal education level, n (%)	
Primary school or less	2272 (33.8)
Junior high school	2819 (41.9)
Senior high school	1000 (14.9)
Junior college or higher	633 (9.4)
Maternal education level, n (%)	
Primary school or less	2978 (44.3)
Junior high school	2440 (36.3)
Senior high school	764 (11.4)
Junior college or higher	542 (8.1)
Average household income (¥), median (IQR), mean	
2010	4662 (2583, 8433), 7280
2012	6667 (3075, 11 400), 8995
2014	7900 (3986, 13 333), 10 520
2016	8220 (3990, 14 690), 11 971
Birth weight (kg), mean (SD)	3.2 (0.54)

IQR, interquartile range.

The median number of surveys was 3 (IQR: 2–3). The sample size came to 4371 in 2010, 5049 in 2012, 4857 in 2014, and 4249 in 2016. The baseline characteristics of the children and parents are presented in table 1.

Children in families that are in the medium 20% quintile of average household income seemed less likely to be overweight/obese than those in the poorest families, with an OR of 0.85 (95% CI 0.74 to 0.99) (table 2). After adjusting for covariates, the medium 20% quintile, as well as those in the richest quintile, still had a negative association with overweight/obesity, independent of children's age, sex, residence and survey year; the ORs were 0.79 (95% CI 0.68 to 0.92) and 0.80 (95% CI 0.69 to 0.93). However, after further adjustment for paternal and maternal education levels, the associations among all the income groups were not significant.

Paternal and maternal education levels showed a consistent gradient of negative associations with their children's overweight/obesity (table 2). The effect estimates were even stronger after adjustment for covariates. This result indicates that higher parental education levels were associated with a lower risk of offspring overweight/obesity (all p_{trend} <0.001), independent of child's age, sex and residence. Compared with the lowest education level, after adjusting for all covariates, the ORs for fathers who had completed junior high school, senior high school and junior college or higher were 0.85 (95% CI 0.75 to 0.97), 0.77 (95% CI 0.64 to 0.92) and 0.72 (95% CI 0.55 to 0.93), respectively. The corresponding ORs for mothers were 0.76 (95% CI 0.67 to 0.86), 0.59 (95% CI 0.47 to 0.72) and 0.45 (95% CI 0.34 to 0.60), respectively. The results showed that paternal education was reversely associated with childhood overweight/obesity, largely independent of maternal education, average household income and other demographic factors of child, and the same results were found for maternal education. Compared with the same levels of education on the paternal side, improvements in maternal education levels seemed to have a stronger effect on offspring overweight/obesity.

We also examined the parental SES effect on offspring overweight/obesity in the subgroups. Figure 1 indicates that the association patterns between average household income and childhood overweight/obesity were different among the subgroups. After adjusting for the child's age, compared with those in the poorest families, urban boys in the medium 20% and higher 20% quintiles and urban girls in the higher 20% quintile were less likely to be obese, whereas no significant difference was found in rural boys and girls. Figure 2 shows a significant gradient of negative associations between paternal and maternal education levels and offspring overweight/obesity in urban girls and rural boys and girls after adjusting for age. The risk of overweight/obesity significantly decreased with higher parental education levels (p_{trend} <0.001). In urban boys, however, only parents who had completed junior college or a higher education level showed significance.

The associations between parental SES and offspring overweight/obesity by children's baseline age groups are shown in table 3. After adjusting for child sex, residence and survey year, inverse associations between average household income and childhood overweight/obesity were found in the medium 20% quintile in the 0–1 years group and in the richest quintile in the 2–10 years group. A significant gradient of negative associations was observed in different paternal and maternal education levels among the 0–1 years and 2–10 years groups (all p_{trend} <0.001) but not in the 11–15 years group.

Spline models were used to estimate BMI trajectories across parental SES over child's age (figures 3 and 4 and online supplemental tables S1–S3). The P_{95} of predicted BMI of the richest and medium 20% quintiles was lower than the poorest quintile in boys (figure 3); however, there was no significant difference in girls. Figure 4 shows that the P_{95} of BMI disparities across paternal and maternal education levels varied from childhood to adolescence in both boys and girls. BMI disparities across parental education widened from birth until about 6–7 years in age and then narrowed until 11 years in boys and 12–13 years in girls. The disparities thereafter crossed and inversed in adolescence. Children whose parents with higher education levels had lower P_{95} of predicted BMIs from

Table 2 Association between parental SES and offspring overweight/obesity

	Unadjusted OR	Adjusted OR*	Adjusted OR†
Quintile of average household income			
Poorest	Ref	Ref	Ref
Lower 20%	0.88 (0.76–1.02)	0.86 (0.74–1.00)	0.89 (0.77–1.03)
Medium 20%	0.85 (0.74–0.99)	0.79 (0.68–0.92)	0.87 (0.75–1.02)
Higher 20%	1.04 (0.90–1.21)	0.89 (0.76–1.03)	1.02 (0.87–1.18)
Richest	1.01 (0.87–1.16)	0.80 (0.69–0.93)	0.95 (0.81–1.11)
P_{trend}	0.310	0.018	0.923
Paternal education level			
Primary school or less	Ref	Ref	Ref
Junior high school	0.93 (0.83–1.05)	0.77 (0.68–0.87)	0.85 (0.75–0.97)
Senior high school	0.74 (0.62–0.87)	0.61 (0.51–0.72)	0.77 (0.64–0.92)
Junior college or higher	0.58 (0.47–0.72)	0.46 (0.37–0.57)	0.72 (0.55–0.93)
P_{trend}	<0.001	<0.001	0.001
Maternal education level			
Primary school or less	Ref	Ref	Ref
Junior high school	0.95 (0.84–1.06)	0.71 (0.62–0.80)	0.76 (0.67–0.86)
Senior high school	0.68 (0.57–0.82)	0.51 (0.42–0.62)	0.59 (0.47–0.72)
Junior college or higher	0.55 (0.44–0.69)	0.37 (0.30–0.47)	0.45 (0.34–0.60)
P_{trend}	<0.001	<0.001	<0.001

P_{trend} value represents test of linear trends across five quintiles of average household income or parental education levels.
*Adjusted for child sex, age and residence. Survey year was also added for average household income.
†Adjusted for child sex, age, residence, survey year, average household income, paternal education level and maternal education level except itself.
Ref, reference; SES, socioeconomic status.

childhood to preadolescence; however, the results were then inverse in adolescence. Additionally, the disparities were greater among girls than among boys in preadolescence but were smaller in adolescence.

Findings of sensitivity analysis showed that the associations between paternal/maternal education level and offspring's overweight/obesity were similar after adjusting for child's sex, residence, age, birth weight, average household income, and paternal and maternal obesity (online supplemental tables S4 and S5).
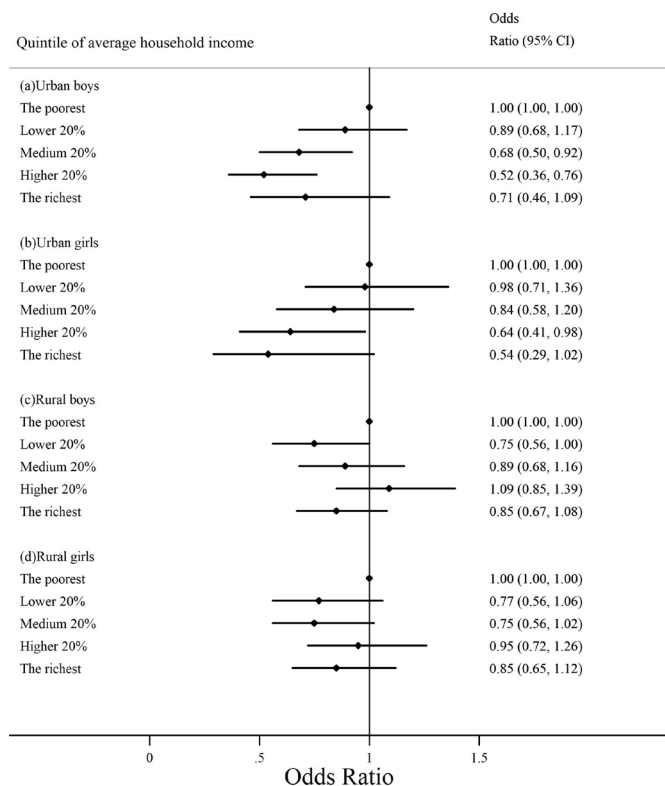
DISCUSSION

To our knowledge, the present study provides novel insight into the associations between parental SES and offspring overweight/obesity using nationally representative longitudinal data in China. These data confirmed that high levels of parental education are associated with a low risk of offspring overweight/obesity, especially before the children are 10 years of age. However, the association was not significant in children who are 11–15 years old. BMI differences in children across parental education levels emerged from birth and widened before they reached 6–7 years of age and then decreased before adolescence.

The gradient of negative association between parental education and offspring overweight/obesity before

adolescence has been well established in our study. The impact of parental education on offspring overweight/obesity was stronger in girls than in boys; this result was consistent with a previous study in Japan.[38] We also further substantiated that parental education has a much stronger effect on offspring overweight/obesity and is more representative as an SES indicator in its relationship with overweight/obesity than income is. The way in which parental education could exert an influence on offspring overweight/obesity is complex. First, education raises health literacy, which enables parents to access available information to make decisions and take actions that positively affect their children's health.[39] Second, studies have shown that high parental education levels are positively associated with their children's healthy lifestyles.[40 41] Third, education is strongly linked to employment opportunity, and therefore income, which may affect their ability to afford healthier food and other health-related resources.[42] Therefore, improving parental education levels is likely to reduce risk of childhood overweight/obesity. Additionally, parents with lower education levels should be given priority in public health measures implementation, such as health education.

BMI disparities across parental education levels widened from birth until about 6–7 years in age, which is in
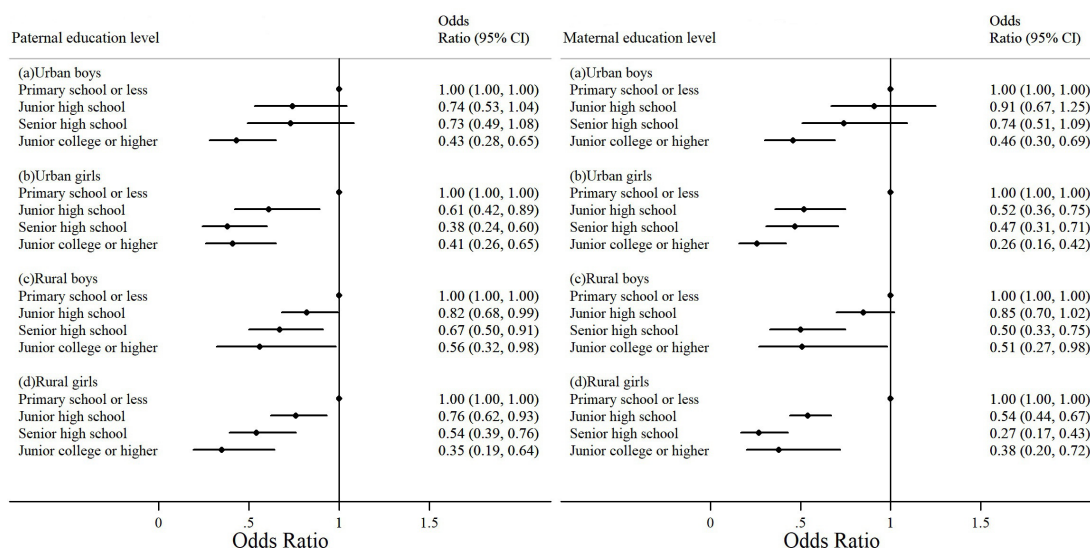
Figure 1 Association between average household income and offspring overweight/obesity by subgroups, with the poorest as reference, adjusted for child age and survey year.

differentials might be another possible explanation. A study suggested that the relationship between parental education and BMI was weaker in East Asia than in North American and Australia.[43]

Significant negative associations were observed in different parental education levels in children younger than 10 years, but no association was found in those aged 11–15 years. This result appears to support the narrowing trend of BMI differences. A systematic review also reported that fewer negative relationships between parental SES and offspring overweight/obesity were found among children aged 12–18 years than those aged 5–11 years.[14] Fu and George,[44] using longitudinal data from the China Health and Nutrition Survey (CHNS), found that parental education had little or marginal effect on the age trajectories of overweight in children who are 6–18 years old. Various parenting practices may lead to overweight/obesity disparities in early childhood; however, as children grow, adolescents are more likely to spend more time with their peers and be influenced by their peers in terms of dietary habits and physical activities.[45] Findings of this study highlight the importance of public health initiatives in early childhood to reduce socioeconomic differences in childhood overweight/obesity.

The association between family income and offspring overweight/obesity was not consistent. In urban areas, children in medium-income families seemed less likely to be overweight/obese and those in the richest families had the same risk as those in the poorest families, while the associations were not significant in rural children. High family income does not necessarily mean the family members have more health knowledge or lead a healthier lifestyle. A systematic review showed no association between income and children's healthy or unhealthy dietary patterns in medium-income countries.[46] China has been undergoing rapid socioeconomic changes, and the economic prosperity, urbanisation and supermarket

agreement with previous studies among children younger than 10 years.[15 16] However, the disparities narrowed once children grew to be older than 10 years. This was inconsistent with other studies which showed the continuous widening trend of socioeconomic differences in BMI.[17] A possible explanation for this might be due to differences in the statistical approach used, as the interaction terms we added in the models allowed for different interaction shapes in their respective age periods. Additionally, ethnic

Figure 2 Association between parental education level and offspring overweight/obesity by subgroups, with primary school or less education level as reference, adjusted for child age.

Table 3 Association between parental SES and offspring overweight/obesity by child baseline age groups

	Unadjusted OR			Adjusted OR*		
	0–1	2–10	11–15	0–1	2–10	11–15
Quintile of average household income						
Poorest	Ref	Ref	Ref	Ref	Ref	Ref
Lower 20%	0.89 (0.68–1.16)	0.89 (0.75–1.06)	0.51 (0.18–1.45)	0.92 (0.70–1.19)	0.88 (0.74–1.06)	0.42 (0.13–1.39)
Medium 20%	0.72 (0.55–0.96)	0.91 (0.76–1.08)	0.77 (0.29–2.09)	0.72 (0.55–0.95)	0.85 (0.71–1.02)	0.55 (0.18–1.73)
Higher 20%	0.84 (0.64–1.09)	1.10 (0.93–1.31)	1.27 (0.48–3.35)	0.77 (0.59–1.01)	0.97 (0.81–1.17)	0.97 (0.33–2.90)
Richest	0.86 (0.66–1.13)	0.99 (0.83–1.18)	2.45 (0.91–6.58)	0.76 (0.58–1.01)	0.82 (0.68–0.99)	1.75 (0.60–5.15)
P_{trend}	0.246	0.386	0.026	0.024	0.147	0.134
Paternal education level						
Primary school or less	Ref	Ref	Ref	Ref	Ref	Ref
Junior high school	0.95 (0.76–1.19)	0.80 (0.70–0.93)	0.37 (0.15–0.93)	0.96 (0.77–1.21)	0.84 (0.72–0.96)	0.42 (0.18–1.00)
Senior high school	0.74 (0.56–0.98)	0.62 (0.51–0.76)	0.26 (0.06–1.04)	0.76 (0.57–1.01)	0.70 (0.57–0.87)	0.31 (0.08–1.24)
Junior college or higher	0.43 (0.31–0.60)	0.52 (0.40–0.68)	0.45 (0.08–2.49)	0.46 (0.33–0.65)	0.64 (0.48–0.84)	0.52 (0.10–2.82)
P_{trend}	<0.001	<0.001	0.042	<0.001	<0.001	0.076
Maternal education level						
Primary school or less	Ref	Ref	Ref	Ref	Ref	Ref
Junior high school	0.69 (0.56–0.86)	0.85(0.74–0.97)	0.37 (0.14–0.98)	0.70 (0.57–0.87)	0.89 (0.77–1.03)	0.52 (0.20–1.32)
Senior high school	0.51 (0.38–0.68)	0.57(0.45–0.72)	0.83 (0.23–3.02)	0.53 (0.39–0.71)	0.66 (0.51–0.84)	1.39 (0.37–5.19)
Junior college or higher	0.41 (0.30–0.57)	0.39(0.29–0.53)	1.23 (0.21–7.13)	0.43 (0.31–0.60)	0.46 (0.34–0.63)	2.67 (0.44–16.23)
P_{trend}	<0.001	<0.001	0.504	<0.001	<0.001	0.665

P_{trend} value represents test of linear trends across five quintiles of average household income or parental education levels.
*Adjusted for child sex and residence. Survey year was also added for average household income.
Ref, reference.

expansion lead to rapid shifts towards unhealthy dietary pattern (such as fat-rich diet, fast food, sugar-sweetened beverages) and reduced physical activity.[47 48] Income and food price are two main factors that influence the families' food choice. High income may increase access to supermarkets and allow for higher consumption of energy-dense foods.[46] Along with socioeconomic development, the unhealthy diet trends may shift towards the poor and rural people, and those who with low SES tend to adopt unhealthier diets and to be overweight/obese.[46 48]

The findings need to be interpreted in light of several limitations. First, parent-reported (or guardian-reported) height and weight of children were used in this study. In order to examine the validity of the reported data, we compared the data with the measured data from other nationally representative surveys. In this study, the prevalence of obesity among children aged 7–15 years
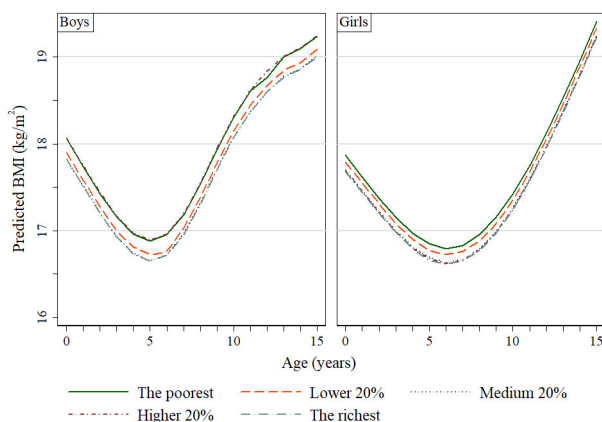
Figure 3 P_{95} of predicted BMI from 0 to 15 years by category of average household income. Adjusted for residence and survey year. BMI, body mass index; P_{95}, 95th percentile.
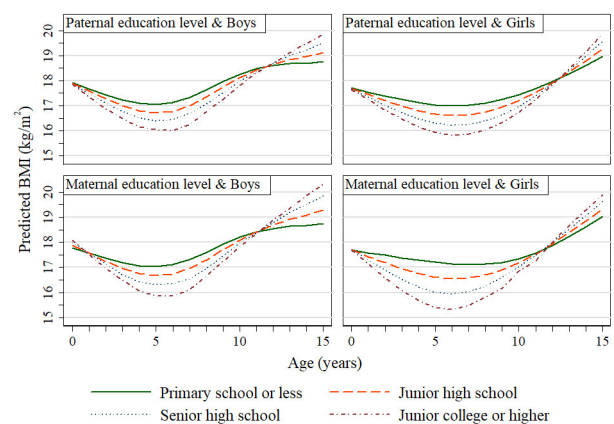
Figure 4 P_{95} of predicted BMI from 0 to 15 years by category of parental education level. Adjusted for residence and survey year. BMI, body mass index; P_{95}, 95th percentile.

was 10.9%. Data from the Chinese National Survey on Students' Constitution and Health showed the prevalence of obesity among children aged 7–15 years ranged from 1.2% to 10.5% across different age and sex groups in 2010.[32] The CHNS indicated that the prevalence of obesity among children aged 6–17 was 9.32% in 2011 and 10.75% in 2015.[49] The BMI trajectories of children aged 0–15 years old were almost the same as the measured results in Pan *et al*'s study.[50] It seems that the biases of the reported data were acceptable. Second, we did not adjust for the dietary habits and physical activity factors among children who were under 10 years old because the information was not collected in the survey. In addition, although we adjusted for several sociodemographic characteristics in the analysis, the possibility of residual confounding factors could not be fully eliminated. Despite these limitations, due to a large sample from a nationally representative longitudinal survey, a substantial association between parental SES and offspring overweight/obesity was identified.

CONCLUSION

Associations are identified between parental SES and offspring overweight/obesity from the CFPS. The findings indicate the importance of parental education on offspring overweight/obesity, especially in children aged 0–10 years. This study may help identify the families with high risk of offspring overweight/obesity, and effective approaches need to be adopted in early childhood to reduce overweight/obesity for those families. From a long-term point of view, promoting universal education level in the society to improve parents' health literacy, parenting skills and healthy lifestyle may play important role in addressing childhood overweight/obesity.

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Association between parental socioeconomic status and offspring overweight/obesity from The China Family Panel Studies:

a longitudinal survey

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Table S1 P_{95} of Predicted BMI from 0-15 years by category of average household income (Kg/m^2)

Age (years)	Boys					Girls				
	The poorest	Lower 20%	Medium 20%	Higher 20%	The richest	The poorest	Lower 20%	Medium 20%	Higher 20%	The richest
0	18.06	17.90	17.83	18.07	17.83	17.87	17.79	17.70	17.69	17.68
1	17.74	17.58	17.52	17.75	17.51	17.62	17.55	17.46	17.45	17.44
2	17.43	17.28	17.21	17.44	17.20	17.37	17.31	17.22	17.21	17.20
3	17.16	17.00	16.93	17.17	16.93	17.15	17.08	17.00	16.99	16.98
4	16.96	16.81	16.74	16.97	16.73	16.97	16.90	16.81	16.80	16.79
5	16.88	16.72	16.65	16.89	16.65	16.85	16.77	16.69	16.68	16.66
6	16.95	16.76	16.72	16.96	16.72	16.79	16.72	16.63	16.62	16.61
7	17.18	17.03	16.96	17.19	16.95	16.83	16.76	16.67	16.66	16.65
8	17.54	17.38	17.31	17.55	17.30	16.95	16.88	16.79	16.78	16.77
9	17.94	17.78	17.71	17.95	17.70	17.15	17.08	16.99	16.98	16.97
10	18.31	18.15	18.08	18.32	18.08	17.42	17.35	17.26	17.25	17.24
11	18.61	18.45	18.37	18.62	18.37	17.75	17.68	17.59	17.58	17.57
12	18.77	18.67	18.60	18.84	18.60	18.13	18.05	17.97	17.96	17.95
13	19.00	18.85	18.78	19.01	18.77	18.54	18.46	18.38	18.37	18.36
14	19.10	18.94	18.87	19.11	18.86	18.96	18.89	18.80	18.79	18.78
15	19.24	19.09	19.02	19.25	19.01	19.41	19.33	19.25	19.24	19.23

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Table S2 P_{95} of Predicted BMI from 0-15 years by category of paternal education level (Kg/m^2)

Age (years)	Boys					Girls				
	Primary school or less	Junior high school	Senior high school	Junior college or higher	Difference	Primary school or less	Junior high school	Senior high school	Junior college or higher	Difference
0	17.91	17.89	17.88	17.86	0.05	17.71	17.69	17.67	17.64	0.07
1	17.67	17.58	17.49	17.35	0.32	17.55	17.45	17.34	17.24	0.31
2	17.44	17.28	17.11	16.87	0.57	17.39	17.21	17.02	16.84	0.55
3	17.24	17.01	16.77	16.49	0.75	17.25	16.99	16.73	16.47	0.78
4	17.10	16.81	16.52	16.16	0.94	17.12	16.80	16.48	16.16	0.96
5	17.05	16.72	16.40	16.05	1	17.04	16.67	16.30	15.94	1.1
6	17.12	16.78	16.44	16.01	1.11	17.01	16.61	16.22	15.83	1.18
7	17.34	17.01	16.69	16.25	1.09	17.03	16.64	16.25	15.87	1.16
8	17.64	17.35	17.07	16.77	0.87	17.11	16.75	16.40	16.04	1.07
9	17.97	17.75	17.53	17.26	0.71	17.25	16.95	16.64	16.33	0.92
10	18.26	18.12	17.98	17.80	0.46	17.44	17.21	16.97	16.74	0.7
11	18.49	18.42	18.35	18.32	0.17	17.69	17.54	17.39	17.25	0.44
12	18.60	18.65	18.70	18.70	-0.1	17.97	17.92	17.88	17.83	0.14
13	18.69	18.84	19.00	19.13	-0.44	18.28	18.35	18.41	18.48	-0.2
14	18.70	18.96	19.23	19.49	-0.79	18.62	18.80	18.98	19.16	-0.54
15	18.76	19.13	19.50	19.87	-1.11	18.96	19.26	19.57	19.87	-0.91

Difference indicates the P_{95} BMI difference between the lowest education level and highest education level.

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Table S3 P_{95} of Predicted BMI from 0-15 years by category of maternal education level (Kg/m^2)

Age (years)	Boys					Girls				
	Primary school or less	Junior high school	Senior high school	Junior college or higher	Difference	Primary school or less	Junior high school	Senior high school	Junior college or higher	Difference
0	17.77	17.88	17.99	18.09	-0.32	17.69	17.70	17.70	17.69	0
1	17.56	17.56	17.55	17.50	0.06	17.58	17.43	17.29	17.14	0.44
2	17.36	17.24	17.13	16.96	0.4	17.49	17.19	16.89	16.58	0.91
3	17.19	16.97	16.70	16.48	0.71	17.38	16.95	16.52	16.08	1.3
4	17.07	16.76	16.42	16.06	1.01	17.29	16.75	16.21	15.67	1.62
5	17.04	16.67	16.31	15.86	1.18	17.21	16.61	16.00	15.40	1.81
6	17.11	16.73	16.35	15.85	1.26	17.15	16.54	15.94	15.31	1.84
7	17.32	16.96	16.54	16.11	1.21	17.12	16.58	16.03	15.49	1.63
8	17.61	17.30	16.95	16.66	0.95	17.13	16.70	16.25	15.81	1.32
9	17.92	17.70	17.44	17.24	0.68	17.20	16.90	16.61	16.17	1.03
10	18.20	18.09	17.98	17.83	0.37	17.34	17.19	17.03	16.85	0.49
11	18.41	18.42	18.37	18.35	0.06	17.57	17.53	17.48	17.26	0.31
12	18.55	18.69	18.79	18.90	-0.35	17.88	17.94	18.00	18.01	-0.13
13	18.65	18.92	19.20	19.36	-0.71	18.23	18.38	18.52	18.67	-0.44
14	18.68	19.09	19.51	19.87	-1.19	18.63	18.85	19.07	19.28	-0.65
15	18.75	19.30	19.85	20.32	-1.57	19.04	19.33	19.62	19.90	-0.86

Difference indicates the P_{95} BMI difference between the lowest education level and highest education level.

Table S4   Association between paternal education level and offspring overweight/obesity (OR, 95%CI)

	Model 1 (N=4520, observation=10588)	Model 2 (N=1826, observation=2954)	Model 3 (N=2400, observation=4087)	Model 4 (N=1826, observation=2954)
Paternal education level				
Primary school or less	Ref	Ref	Ref	Ref
Junior high school	0.79(0.67-0.94)	1.09(0.55-2.16)	0.82(0.45-1.47)	1.14(0.56-2.29)
Senior high school	0.65(0.51-0.82)	1.43(0.57-3.62)	0.70(0.31-1.62)	1.52(0.59-3.93)
Junior college or higher	0.55(0.41-0.74)	1.75(0.54-5.66)	0.95(0.34-2.66)	1.97(0.59-6.58)
Residence	1.28(1.09-1.51)	1.19(0.61-2.34)	0.84(0.47-1.51)	1.18(0.59-2.35)
Sex	0.56(0.48-0.65)	0.08(0.03-0.19)	0.11(0.05-0.22)	0.07(0.03-0.18)
Child age	0.82(0.80-0.83)	0.56(0.46-0.69)	0.56(0.47-0.66)	0.57(0.46-0.70)
Average household income	0.97(0.92-1.02)	0.90(0.73-1.11)	0.97(0.81-1.16)	0.91(0.74-1.12)
Birth weight	1.27(1.06-1.53)	2.13(1.05-4.30)	2.01(1.08-3.74)	2.20(1.07-4.51)
Paternal obesity	1.66(1.34-2.06)	2.88(1.21-6.84)	3.06(1.49-6.31)	3.16(1.30-7.69)
Maternal obesity	1.63(1.23-2.16)	2.12(0.72-6.25)	1.73(0.73-4.10)	2.31(0.76-6.97)
Consumption of meat		0.97(0.41-2.27)		0.92(0.39-2.20)
Consumption of vegetable and		0.16(0.05-0.53)		0.19(0.06-0.63)
Consumption of fried food		0.59(0.35-1.00)		0.61(0.36-1.03)
Exercise			0.57(0.36-0.91)	0.46(0.25-0.82)
Constant	0.61(0.35-1.08)	135.67(4.97-3701.48)	39.41(3.27-474.43)	158.72(5.36-4699.56)

Table S5   Association between maternal education level and offspring overweight/obesity (OR, 95%CI)

	Model 1 (N=4520, observation=10588)	Model 2 （N=1826, observation=2954）	Model 3 (N=2400, observation=4087)	Model 4 （N=1826, observation=2954）
Maternal education level				
Primary school or less	Ref	Ref	Ref	Ref
Junior high school	0.74(0.63-0.87)	1.20(0.61-2.36)	1.09(0.61-1.92)	1.31(0.65-2.63)
Senior high school	0.55(0.42-0.71)	2.53(0.91-7.00)	0.97(0.39-2.39)	2.69(0.94-7.73)
Junior college or higher	0.42(0.31-0.58)	2.17(0.61-7.71)	0.90(0.30-2.73)	2.52(0.67-9.44)
Residence	1.17(0.99-1.39)	1.38(0.69-2.76)	0.88(0.49-1.59)	1.38(0.67-2.82)
Sex	0.56(0.49-0.65)	0.08(0.03-0.18)	0.11(0.05-0.22)	0.07(0.03-0.17)
Child age	0.81(0.80-0.83)	0.57(0.46-0.69)	0.56(0.48-0.66)	0.57(0.46-0.70)
Average household income	0.98(0.93-1.03)	0.89(0.72-1.09)	0.97(0.82-1.16)	0.90(0.72-1.11)
Birth weight	1.26(1.05-1.52)	2.17(1.08-4.38)	2.01(1.08-3.74)	2.27(1.10-4.71)
Paternal obesity	1.69(1.36-2.10)	2.74(1.16-6.48)	2.99(1.46-6.16)	2.99(1.22-7.29)
Maternal obesity	1.62(1.22-2.15)	2.11(0.72-6.20)	1.70(0.72-4.03)	2.32(0.76-7.05)
Consumption of meat		0.96(0.41-2.25)		0.91(0.38-2.19)
Consumption of vegetable and fruit		0.16(0.05-0.50)		0.18(0.05-0.60)
Consumption of fried food		0.57(0.34-0.96)		0.58(0.34-1.00)
Exercise			0.57(0.36-0.91)	0.45(0.25-0.81)
Constant	0.72(0.41-1.26)	110.16(4.23-2870.20)	30.27(2.62-350.12)	131.86(4.56-3811.72)