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Dynamic Links between Socioeconomic Status and Obesity in China

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Dynamic Links between Socioeconomic Status and Obesity in China

Abstract

We examine how the association between socio-economic status (SES) and different weight indicators vary over time in the adult Chinese population. During the mid-1980s China experienced an increase in overweight and obesity rates as a consequence of the rapid economic and social changes that invested the country. Concomitant with the rapid economic growth there has been a relative reduction in food prices and an increase in the variety of available food. The literature on obesity and SES shows that higher income and education levels are protective factors against obesity in developed countries, while they are risk factors in developing societies. In this paper we document how the obesity-SES gradient is dynamic and changes over time. Using data from the China Health and Nutrition Survey (CHNS), we find that the effect of education on obesity and other weight indicators has shifted from positive to negative throughout the CHNS cohorts, suggesting that higher education is associated to lower levels of body mass index (BMI) in the younger population. We use the 1999 institutional reform on college expansion to control for unobserved heterogeneity. Although the prevalence of obesity is still concentrated in high-income segments of the population, our study detects an early shift in the education-obesity dynamic. We also provide empirical evidence on the mechanisms behind the shift and discuss what the main changes have been in preferences and attitudes towards diet-related behaviors. Among the younger segments of the Chinese population, higher educated individuals are more likely to value and pursue a healthier lifestyle. This evidence would also indicate that education attainment in China is linked to higher expectations towards the future.

JEL classification: I15 (*Health and Economic Development*), I14 (*Health and Inequalities*) I12 (*Health Production*)

Keywords: Obesity; China; SES; Education, BMI

1. Introduction

China began to experience a general increase in overweight and obesity rates as of the mid 1980s, as a consequence of the rapid economic development and the social changes that affected the country. During the same years, China entered the nutrition transition, a period where substantial changes in dietary and physical activity patterns occurred (Popkin, 2001; Du, 2002). Eating habits shifted from a traditional diet rich in fibers and vegetables and low in animal fat, to a diet rich in meat and edible oils. The causes of the shift in population BMI are related to changes in dietary patterns (increase in calorie intake) and to a reduction of the level of physical activity (decrease in calorie expenditure). According to the data from the China Health and Nutrition Survey (CHNS), we found that overweight rates in the adult population shifted from 15% in 1989 to almost 40% in 2009 and obesity rates increased from 1.3% to about 8%.

Figure 1 about here

Data elaboration from Xi et al. (2012) shows similar trends. In particular they found that between 1993 and 2009, overweight rates increased from 8% to 17.1% among men, and from 10.7% to 14.4% among women. In the same time period, obesity increased from 2.9% to 11.4% among men and from 5% to 10.1% among women, while abdominal obesity increased from 8.5% to 27.8% among men and from 27.8% to 45.9% among women. The World Health Organization's Global Database on Body Mass Index reported that, as of 2002, the prevalence of overweight and obesity in the Chinese adult population was respectively 18.9% and 2.9% (WHO, 1997).

The rapid increase in overweight and obesity rates requires particular attention because of the detrimental consequences on the health of the Chinese population. A study from Wang (2007) found that, together with the increase in overweight and obesity rates, China experienced an increase in the prevalence of cardiovascular diseases. Excess body fat is associated with many dietary-related non-communicable diseases (DR-NCDs), such as hypertension, diabetes and also some types of cancers. Mortality rates from cardiovascular diseases increased in China since the end of the 1980s, especially in urban areas (Du et al., 2004; Du, 2002). According to Wang and Zhai (2013), the increase of chronic and cardiovascular diseases is an important burden for the Chinese economy.

Previous studies have found that the prevalence of overweight and obesity in China is concentrated in the higher SES of the population, for both the adult and child population (for example Wang, 2001; Xu et al., 2005; He et al., 2014). However the distribution of prevalence of overweight and obesity is not homogeneous across the country, and varies according to gender, area of residence (urban or rural), region of residence, ethnicity and other socio-demographic factors. For example, overweight rates are growing among the Chinese rural population, though the absolute incidence remains higher in urban areas (Zhang et al., 2008; Wang et al., 2002). Among women, lifestyle and diet are the most important risk factors in explaining the differences between urban and rural residents, whereas socioeconomic status, lifestyle and diet are all important among men (Reynolds et al. 2007). The prevalence of obesity in China also varies across different ethnic groups and regions and other socio-demographic factors. Cai et al. (2013) found for instance that, in rural Yunnan, obesity and central obesity are higher for Han Chinese, for women, for lower education and higher income levels.

Using pooled cross-sectional data from the China Health and Nutrition Survey (CHNS), this study shows empirical evidence on how the relationship between obesity indicators and educational attainment has changed over time. To control for unobserved heterogeneity (i.e. SES and health behavior are linked only because of SES proxies for omitted variables or there is reverse causality), we use the occurrence of college expansion in 1999 as an instrumental variable (IV). In this paper we also shed light on the mechanisms behind the change in the dynamic of the SES-BMI relationship, by discussing differences in diet-related behaviors in individuals with higher education levels. This is the first study that estimates the impact of education on obesity, with a focus on dynamic changes.

The paper is organized as follows. Section 2 presents the conceptual framework of the SES-BMI dynamic in developed and developing countries. Section 3 presents the data and the models employed in the analysis. Sections 4 and 5 present the results of the statistical analysis and discuss the main findings, and Section 6 concludes.

2. Conceptual Framework

From the perspective of development, the effects of increased income and education have generally been viewed as beneficial, since a higher socio-economic status is associated with better quality diets, improved health-care, increased child growth, and lower morbidity and mortality rates from infectious diseases. On the other hand, as income increases, dietary changes typically include higher energy and fat intake, and a greater consumption of animal and processed foods.

The association between the socio-economic status and obesity has been largely studied in the academic literature, in both developing and developed countries. Since the explosion of the obesity epidemic, a total of nine literature reviews on developing countries have been published; six of these are based on cross-sectional studies (Sobal and Stunkard, 1989; Monteiro et al., 2004-a; McLaren, 2007; Shrewsbury and Wardle, 2008; Jones-Smith et al., 2011-a; Dinsa et al., 2012) and three are based on longitudinal analyses (Parsons et al., 1999; Power and Parson, 2000; Ball and Crawford, 2005). One study (Jones-Smith et al., 2011-a) focuses on the SES-obesity dynamics in the female population only. In general, obesity and overweight rates in developed countries are concentrated in the lower SES of the population, while in developing economies the relationship is the opposite. In countries with a higher development status, people from higher SES tend to have a healthier diet (rich in fruits and vegetables and low in animal fat) because they can afford high-nutrient food options, which are usually more expensive. Higher SES individuals are also more likely to engage in leisure-time physical activity and, thus, reduce the risk of caloric imbalance. Among the lower SES groups of developed countries, the diet quality is instead poorer because the consumption of cheap and unhealthy food is higher. In developing countries, the higher SES segments of the population can afford enough – and often a surplus of – food and are thus the group with the highest overweight and obesity prevalence. On the other side, among the lowest socio-economic groups, the problem of food scarcity is the principal issue and many individuals are not able to get enough food (McLaren, 2011). Another important aspect is that in developing economies, social norms also play a role and being fat is considered desirable and a blessing.

However, the association between obesity and SES is likely to change over time within the same country. In developing countries, as income increases, the association can be subject to a reversal of the trend, while in developed societies the gap between the poorest and the richest may even increase. For example, in a US-based study examining the obesity-gradient by age and SES, Baum and Ruhm (2009) have shown that weight is negatively associated to SES in both childhood and adulthood, and the obesity gradient widens with age over time. Furthermore, evidence shows that, in developing societies, income and education can have an opposite effect on BMI within the country. Monteiro et al. (2001) reported that, in two Brazilian regions with a different level of development, income and education have differing effects on obesity. A higher income was found to be a risk factor for obesity in both regions, while higher education was discovered to be protective in the more highly developed region.

Cross-country studies explore the presence of an inversion in the relationship between SES and obesity as per capita wealth indicators increase. Among these studies, some scholars have divided societies into low, middle and high-income economies, and have suggested the presence of a dynamic pattern. As a country moves from low to medium to high-income economy, the prevalence of obesity decreases in the higher SES of the population and increases in the lower SES. In a study on women from low and middle-income countries, Jones-Smith et al. (2011-b) observe that overweight rates are increasing at a faster rate in the lowest SES (measured by wealth and education) of the population. Monteiro et al. (2004-b) found that the crossover point of higher rates of obesity for women occurs when the per capita income is around US$ 2,500, while for men the association remained positive or non-significant. Dinsa et al. (2012) obtained a similar finding, but with an earlier turning point at US$ 1,000 in the female population, and no clear trend for men. According to the World Bank, China is at this time an upper middle-income economy, with an income per capita that increased from US$ 1,000 in 2001 to US$ 6,560 in 2013. The finding of an inversion of the trend between obesity and SES in China is thus consistent with cross-country studies discussed above.

Unveiling the mechanisms behind BMI-SES variations is very important to understand what segments of populations are at risk of obesity, and also to develop adequate prevention policies. The poorest segments of the population in low-income economies have to face the problem of food scarcity, and are also more likely to be employed in occupations that require high energy expenditure. The poorest segments of developing societies are thus the most protected against overweight and obesity, but are the most exposed to the health complications of undernutrition. As a country's income increases, food insecurity becomes less important, and other food-related constraints emerge. In high and middle-income economies, healthy foods (including fruits and vegetables) are expensive, while highly processed and high-energy food items are cheaper and largely available. In particular, during the nutrition transition, China experienced a relative reduction in food prices and an increase in the availability of Western food (Guo et al., 2000;

Popkin 2001; Du et al., 2004). Concerning variations in occupational physical activity, a country's technological development is associated to a shift in the labor structure, from a prevalence of active occupations to more sedentary ones. Following the rapid economic development, the employment rate in traditional Chinese occupations (such as farming, mining, and forestry) has decreased over time, against an increase of industrial and more sedentary activities. Other factors that have been associated to the increase in overweight and obesity rates in China are the rapid increase in the number of car and television owners, the level of health knowledge, the "single child" policy and the social norm that views body fatness as a wealth indicator (for example Bell et al., 2002; Popkin and Gordon-Larsen, 2004; Wu, 2006; Wu et al., 2009). Therefore, BMI and obesity dynamics are unlikely to be static but follow the pattern of a country's economic and societal development.

3. Methodology

Data description

To estimate the dynamic relationship between SES and BMI, this study employs data from the CHNS using all the available waves from 1989 to 2009. The CHNS is a large survey that targets the adult and child population of nine Provinces and collects an extensive number of information on socio-economic status, health, eating habits, dietary knowledge and preferences. After 2000, the number of Provinces included in the survey increased from eight to nine.

The waves of the CHNS contain a section with anthropometric data that were directly measured during a physical examination of the respondents. The use of direct measurement of weight and height helps to avoid the self-reported bias that might compromise the validity of the results. The BMI is calculated as a ratio of weight in kilograms and height in meters squared, and it is included in the analysis both as a continuous and a dummy categorical variable, indicating whether an individual is overweight or obese. For the Asian population, the World Health Organization recommends using the values ≥ 24 instead of ≥ 25 as the cut-off point for the overweight category, and ≥ 28 instead ≥ 30 for obesity (WHO, 2004). This is because the prevalence of obesity-related diseases begins to be higher at lower levels of BMI for the Asian population compared to non-Asian. We follow this approach and also identify outliers using the indications of Pan et al (2013), so that respondents with a BMI lower than 15 and higher than 35 were excluded from the analysis. We also excluded women that were pregnant at the time of the interview.

Another indicator that we use in the regression analysis is the waist circumference, measured in centimeters and reported in all waves except in 1989 and 1991. Waist circumference is a measure of abdominal obesity, which has been found to be highly correlated to the risk of cardiovascular diseases (for example Després, 2006). A large waist circumference is a good indicator of an excess of abdominal fat and increased risk of developing cardiovascular diseases, while a high value of the BMI does not always capture whether the individual has an excess of body fat. Furthermore, a study by Popkin (2013) found that waist circumferences are rising at all ages in China. The increases range on average from 2 cm for adolescents to 3-4 cm for adults across all ages groups. The research pointed out that, as for the BMI, this phenotype's change is a consequence of the reduction in physical activity, and of the increase of sugar intake. By integrating different BMI measures into the analysis, we can thus draw stronger conclusions on the effect that SES has on weight adjustments and, ultimately, on health status.

The socio-economic status (SES) is measured by income and by education. The latter is measured by four dummy variables, asking if the respondent completed the primary, junior, senior or college level of study, and also by the continuous variable "schooling" indicating levels of years of completed education. Only respondents who provided information about schooling were retained in the analysis. The income level is per capita and indexed to the 2009 Consumer Price Index. The other covariates included in the analysis are gender, age, household size, employment status, marital status, and residence. The variable residence indicates whether the respondent lives in an urban area or not.

Our study is focused on the adult population aged between eighteen and sixty years old. We excluded individuals older than sixty years because after that age the rapid changes of skeletal muscle mass and other physiological parameters significantly affect an individual's body composition (Kyle et al., 2001).

The model

We follow a simplified version of the health production function of Grossman (1972) in order to identify the impact of the socioeconomic status on health, using individual weight-status indicators as outcomes (BMI, overweight and obese indicators, and waist circumference). Eq.1 presents our model.

$$W_i = \beta_0 + \beta_1 Edu_i + \beta_2 Inc_i + \beta_3 X_i + \varepsilon_i \quad (1)$$

W_i indicates the weight status of individual *i*, the socioeconomic level is represented by education (Edu_i) and income (Inc_i), and X_i is a vector of the other covariates included in the analysis. Coefficients are estimated using OLS regressions with Huber-White robust standard errors. We also include wave and provincial fixed effects.

There are at least two channels through which education can affect health behaviors. First, higher education is correlated with higher expected future wages. Therefore, a person with higher SES has a greater incentive to reduce unhealthy behaviors – such as unhealthy diet and sedentary lifestyles – that might limit his earnings capacity by making him ill in the future. In this sense, education would help to help encourage adoption of preventive behaviors because individuals have high expectations towards their future. Highly educated individuals also can be influenced to a greater extent by information on how to pursue a healthy lifestyle and are also more likely to act accordingly. Second, when SES is measured by education, a highly educated person is seen to be more efficient at health production, by engaging in healthier behaviors (for example, eating better and exercising more), and thus be in better overall health.

However, estimating the causal effect of education on health is problematic because of possible biases introduced by reverse causality and omitted variables. For example, it is possible that healthier individuals perform better in schools. Moreover, unobserved factors such as genetics and individual time preferences can simultaneously affect health status and education. To overcome the problem of endogeneity we use the reform of expansion of college enrollment of 1999 as an IV for education. In 1999, the reform encouraged the expansion of higher education enrollment, so that the number of students enrolled in college rose by 40% in only a year. This reform acted as an exogenous shock in the Chinese schooling system with a direct impact on educational attainment, but that is unlikely to have affected the overweight and obesity rates. Institutional reforms have already been used to deal with heterogeneity between SES and health in China. For example, Xie and Mo (2014) employed as instrumental variables two institutional reforms (respectively, the China's Compulsory Education Law of 1986 and the Provisions of Using Child Labor of 1991) as well as spouse's education.

The first stage regression is represented by Eq. 2 where the variable college is regressed using the institutional reform of 1999.

$$\widehat{Edu}_i = \beta_0 + \beta_1 CE_i + \beta_2 Inc_i + \beta_3 X_i + \varepsilon_i \quad (2)$$

The IV CE_i is equal to one if the individual was born after or in 1981, and zero otherwise. This is because the reform affected individuals that were eighteen at the time of college enrollment in 1999.

Indicators for the mechanisms

To shed light on the mechanisms behind the dynamic link between obesity and education, we have built three indicators measuring food preferences, dietary knowledge and the daily total energy expenditure. Starting from 2004, the CHNS includes a series of questions querying respondents about their preferences for certain food items (including healthy and unhealthy options) and their level of agreements towards statements about healthy and unhealthy eating habits. Higher values of the first index (*preferences for a unhealthy diet*) indicate that individuals like more unhealthier foods, as for example salty snacks, rather than healthier options such as fruits and vegetables. Higher values of the second index (*knowledge of a healthy diet*) indicate instead that individuals have a higher degree of knowledge about healthy diet concepts. The third indicator is calculated on the basis of a joint report of the Food and Agricultural Organization (FAO), the World Health Organization (WHO) and the United Nations University (FAO/WHO/UNU, 2001). This report indicates the average daily calorie expenditure for several types of activities, including physical, occupational and leisure activities. The CHNS, as of 2004, collects detailed information on the weekly or daily time spent in doing several activities. By applying the factorial calculations following the methodology proposed in the report, we are able to calculate the Physical Activity Level Indicator (PAL). The Total Energy Expenditure is obtained by multiplying the PAL with the Basic Metabolic Rate (BMR) which is an age and sex specific measure of the calories consumed to maintain the vital functions working when the body is completely at rest. Finally, we also report the energy intake that was calculated on the basis of the nutrition survey that collects detailed information about food consumption at the household level.

4. Results

Table 1 reports descriptive statistics of the variables. Four measures were used for the weight status (BMI, overweight, obese and waist circumference). The average household income is 5,897 RMB with a standard deviation of 8,449. Overall, 21% of respondents completed primary education, 35% the junior education level, 20% the senior level, and 3% were college graduates. Those who completed the primary level are 21%. The average of the variable “schooling” is 7.4, which corresponds to the middle point between the variables “1 year lower middle school” and “2 years lower middle school.” These values refer to completed years of school. The average BMI is 22.5, and considering the pooled datasets, 28.7% of respondents are overweight and 5.4% are obese. A total of 52% are females, and the great majority of respondents are married (84%). The average household size is 4 members and 32% of respondents live in urban areas.

Table 1 about here

OLS regression analysis on weight status indicators

First we create two groups of pooled cross-sectional data of the adult surveys. The first group includes the waves before 2001 and the second group gives the waves after. We chose 2001 as the crossover year because in 2001 China became a member of the World Trade Organization, which represented an important turning point in the economic and social development of the country, characterized by several institutional reforms. Table 2 reports the results from the regression models obtained with random effects.

The first two columns report the effect on BMI for, respectively, waves until and after 2001. An inversion of the coefficients’ sign is always observed, though not always significant. In particular, completion of the primary, junior, and senior level is positively associated to BMI in the first wave group, while the relationship is negative after 2001 for those who completed senior level education ($p<0.01$ and $p<0.05$ respectively). The reference group includes illiterate individuals or primary-school drop-outs. For example, those who completed senior school level have a BMI that is 0.190 points higher with respect to the reference group in waves before 2001, while they have a BMI 0.191 points lower for waves collected after 2001. Columns three and four report estimates for the overweight indicator. There is a positive association between individuals who completed all the four levels of education and the overweight indicator before 2001, but no significant relation is found for later waves. For obese individuals (columns five and six) there is instead a negative relation for senior level of education in waves after 2001 ($p<0.01$). The last two columns report results of regressions using waist circumference as the dependent variable. There is a statistically significant inversion of sign for senior level from one group of waves to the other, and also an inverse relation of primary level in data collected after 2001. The magnitude of the negative change in columns seven and eight is the strongest found across the regressions in Table 2. For instance, individuals who completed senior education have a waist circumference that is 0.881 cm larger with respect to the reference group before 2001 and became 0.675 cm smaller in later waves. Income is always positively associated to a higher weight status, either when it is measured by the continuous variables (BMI or waist circumference) or by discrete indicators (overweight and obesity). However, the absolute values of the coefficients decrease from one group of years to the other, suggesting that there is a diminishing effect of income on BMI between the two time periods for all of the dependent variables (from a minimum decrease of 0.003 for obese to a maximum decrease of 0.164 for waist circumference).

Table 2 about here

Similar regressions are performed using two age groups, individuals born before and after 1962. We use this year as a cut-off point because of the Great Famine of 1959-1961 which caused many premature deaths. The experience of famine dramatically changed eating habits and dietary intake of the Chinese population living in the affected areas. There is evidence that the anthropometrics of individuals born soon after the famine period or who were toddlers during that time were significantly affected. For example, a study by Wang et al. (2010) found that, even 50 years after the disaster, women in the Chongqing area were shorter and overweight. This is because the lack of adequate nutritional intake during childhood led to consequences that affected successive periods of life. Another reason we use the year 1962 as a cut-off point is that many educational, social and economic reforms were promoted between 1981 and 1985, affecting in particular individuals who enrolled in college in 1981 and were born in 1962. These reforms were thought to expand university education and, more generally, Chinese economic competitiveness.

OLS regression results are reported in Table 3. Coefficients indicate that the BMI is higher for more highly educated individuals born before 1962, while it is lower for respondents born after 1962. Interestingly, an inversion of the coefficient signs is always observed for the junior, senior and college levels of education from the younger to the older group, with a p-value lower than 0.01 in most of the cases. This would suggest that having a higher education represents a protective effect against the long-term health consequences of the Great Famine. With respect to previous research (Wang, 2010) we found that individuals born after 1962 who completed primary, senior and college levels had a lower BMI and waist circumference and were less likely to be overweight and obese. Furthermore, these individuals were also affected by the cycle of educational reforms (they were at least eighteen at the time of enrollment) and this may also have had an impact on their weight status. Coefficients have to be interpreted as indicated previously. As in Table 2, income is positively associated to the BMI and to the other obesity indicators, and there is a significant decreasing effect between the younger and older age groups when the BMI, the obese and the overweight indicators are used. This is consistent with the twin results in Table 2.

Table 3 about here

OLS regression with interaction terms

The choice of cutoff year in Tables 2 and 3 (2001, 1962, respectively) may be arbitrary. Therefore, in Tables 4 and 5, we relax the restriction and use interactions terms instead. Tables 4 and 5 thus report results of regressions with interaction terms. The variable schooling is used as a measure for education, and we examine the effect of schooling on obesity respectively by wave and birth year on both education and income. In Table 4 the variable *schooling*year* has been constructed by interacting schooling with the year of the wave, and the variable *income*year* by interacting the income with the year of the wave. Although schooling is always positively associated to weight status, indicating that higher education corresponds with higher weight, the coefficients of *schooling*year* show a a decreasing effect over time for all of the four indicators chosen as dependent variables ($p<0.01$ in all cases). The maximum decreasing effect is obtained in regression four, where waist circumference is the outcome. This coefficient indicates that the schooling effect, though positive, on average decreases progressively by 0.030 in each subsequent wave. The same is observed with the variable income which is always positively related to the weight indicators, but has a decreasing effect with each successive wave. Similar results are observed in Table 5 by interacting schooling and income with birth year (variable *schooling*birth-year* and *income*birth-year*). Again, results suggest that the BMI is higher when the number of years of schooling and the income increase, but the overall impact of schooling and education on BMI diminishes for younger individuals ($p<0.01$).

Tables 4 and 5 about here

IV estimates

Table 8 reports results from the second stage of the IV regression and a F-statistic of the first-stage of F 43.002. In the first stage we regress the variable *college* on the IV that corresponds to the 1999 college expansion. More precisely, the IV is a dummy variable that indicates whether an individual was born before (= 0) or after (=1) 1981, i.e., indicating whether an individual was affected by the educational reform by the age of eighteen. Four regressions are performed, each using as dependent variable one of the indicators of weight status. In all of them, the coefficients of the instrumented variable college are strongly negative with a significant p-value lower than 0.01 for the BMI and the overweight indicator. This result has to be interpreted as a Local Average Treatment Effect (LATE) because, among those who were affected by the reform, only a subset of them was actually influenced by the treatment. In fact, among those who enrolled in college in 1999, some would have done so with or without the reform.

Table 6 about here

This result suggests substantial evidence that a higher educational level is associated to a lower BMI, and that this protective effect is also robust when the overweight indicator is used ($p < 0.01$). Although not significant, the relationship is negative also when the obesity indicator and the waist circumference are used as dependent variables.

Summing up, we find a switching point (from positive to negative) in the dynamic SES-BMI relationship from earlier to later waves and from older to younger individuals. Most of all, this finding is confirmed when an IV design is applied in order to identify a causal relationship between education and weight status.

Exploring the mechanisms

While we provide support for a causal interpretation, we move forward by exploring the mechanisms through which better education changes dietary choices and preferences. To explain the effect of the dynamic relation between BMI and education, we estimate linear probability models. These data were available only for the 2004, 2006, and 2009 waves and here, 2004 is treated as the reference group. Results are presented in Table 7.

Table 7 about here

The first two columns report the results obtained when the two indicators (*preferences for a unhealthy diet* and *knowledge about a healthy diet*) are used as outcomes. There is a strong negative association between higher education levels (primary, junior and senior) and preferences for an unhealthy diet, suggesting that, with respect to 2004, being more educated positively affects dietary choices. Similar results are observed in column 2, indicating that for all four education levels, there is a higher level of awareness towards healthy eating. Columns 3, 4 and 5 report actual measures of caloric intake, expenditure and energy balance. Except for the primary level, we observe a significant decrease in the amount of caloric intake and an increase in the caloric expenditure for the junior, senior and college variables. We also observed that these values change proportionally across the education level, suggesting that the higher the educational degree, the better the health outcome. For example, respondents with a junior degree eat 57 calories less than the reference group in 2004, those with a senior degree eat 114 less, and those with a college degree consume 178 less ($p < 0.01$). Similar patterns are observed for the amount of calories burned. By calculating the differences between energy intake and energy expenditure, we obtain the energy balance. Results suggest that for junior, senior and college levels the overall amount of calorie balance has decreased, as an effect of variation on both sides.

Younger generations seem to eat less (or better) and move more, and results indicate that these changes are happening quite rapidly.

Since we find that after the educational reforms introduced in China, higher education is associated with lower probability of obesity, this final analysis wanted to explain what mechanisms behind the association. Higher education is associated with low preference for unhealthy food, better knowledge about healthy diet, less energy intake, and more energy expenditure. This would thus suggest that the younger Chinese generation prefers healthy food options, aware of what constitutes a healthy diet, and exercise more. Furthermore, these changes become stronger as the level of education increases.

5. Discussion

This paper is the first that empirically tests the presence of an early inversion in the dynamics between obesity and education in China. The change has been tested on four different weight status indicators, and findings were always consistent. Our results are also consistent with previous studies on the association between obesity and education patterns in China. For example, Jones-Smith et al. (2012) shows how BMI and overweight prevalence in Chinese women have not grown proportionally across different educational levels in China, and specifically, between 1989 and 2006, the highest education segments presented the slowest growth rates, while the poorest educated showed the fastest growth rates. Our results are also in line with Popkin (2010) who documents that the BMI of Chinese children aged six is not different from the BMI of children in the USA of the same age at or above the 95th percentile of the distribution. This would be a sign that SES-obesity dynamics in China are catching up with those observed in the United States (no controls for SES were, however, included in the study).

Our paper adds further important empirical evidence, suggesting that the country is switching towards the pattern observed in many developed countries, where the higher socio-economic groups of the population present the lowest overweight and obesity prevalence. While no inversion of the trend is found in the dynamics between income and BMI, there is a diminishing effect over time and a significant negative correlation between BMI and educational attainment. Our results indicate how a change in the institutional framework can significantly affect the quality of life of individuals. The first wave of educational reform was introduced during the first half of the eighties and, although we were not able to control for causal relation, we observe that individuals born before 1962, and that were thus not influenced by the reform, were more likely to be overweight, have a higher BMI and a larger waist circumference with respect to those born afterwards. This evidence would also suggest that this educational reform has attenuated the effect of a higher BMI for those born after the Great Famine. By using an instrumental variable approach we were instead able to control for causality for the successive educational reform of 1999 that aimed at increasing the number of new freshmen enrolled in college. Our findings indicate that educational attainment does positively affect diet, and individuals with higher educational levels present lower levels of overweight and obesity. These findings require attention also because of the possible health consequences and the increase in obesity-related diseases.

We also explore the mechanisms behind this dynamic change, seeking to explain why higher educational levels contribute to a decrease in the BMI. Results from the questions investigating respondents' food preferences, physical activity, and caloric balance find changes both in the level of knowledge and behaviors that reveal a positive attitude towards a healthy lifestyle. Higher educated individuals are aware of Chinese dietary guidelines, and also about the concept of a healthy diet. These persons are also the most likely to engage in different physical activities. More highly educated individuals are also the most likely to have access to a variety of information sources regarding how to pursue a healthy lifestyle, and they are capable of translating new information into practice by bearing the costs of changing their habits. Moreover, more educated individuals may discount their future less than individuals with no education, having higher expectations towards it. We also show that, besides their self-reported behaviors and knowledge, the overall amount of total energy expenditure has changed among individuals with different educational levels. While changes in the nutritional intake of the Chinese population have undoubtedly occurred as well, the role of energy expenditure is also very important, and may change over time. Our results indicate that, the education being equal, individuals in the youngest CHNS cohorts have a healthier lifestyle than individuals in previous cohorts. This is also a sign that social norms of the younger Chinese generation are changing, and adolescents and young adults are more affected by Western lifestyle, where being slim and healthy is fashionable.

6. Conclusions

In this paper we show how the relationship between SES and obesity is not static and can change over time, as a consequence of economic development. Although the prevalence of overweight and obesity is still concentrated in the high income segments of the Chinese society, this study is the first that detects an early change in the relationship between BMI and education. Our results are also a sign that the younger Chinese people have a better health education and the value they give to healthy behaviors is a sign of their higher expectations towards their future.

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Research Highlights

Research Highlights

- We study the dynamic properties of the relationship between educational attainment and obesity in China from 1989 to 2009
- We perform OLS and IV regressions with province and time random fixed effects
- We find evidence that the relationship between educational attainment and obesity has changed over time in China
- While obesity has been traditionally found to be concentrated in the higher SES levels of population, we find that younger and more educated individuals are less likely to be obese
- We provide evidence on the mechanism behind the observed change, and find that younger individuals are more aware about healthy eating habits and are more likely to engage in physical activity

4 Table

Table 1: Summary Statistics

Variable	Description	Mean	Std. Dev.	Min	Max
BMI	= weight (KG) / height (m)^2	22.542	3.056	15.02	34.99
Overweight	= 1 if BMI>=24, otherwise =0	0.288	0.453	0	1
Obese	= 1 if BMI>=28. Otherwise = 0	0.055	0.227	0	1
Waist+	Waist circumference(cm)	79.161	9.168	60.2	104.9
Income	Per capita household income(indexed with 2009 CPI) (Yuan)	5896.195	8448.703	0	285090.2
Employed	=1 if employed, otherwise =0	0.818	0.386	0	1
Household size	No. of people in the household	4.112	1.445	1	14
Female	=1 if respondent is female, otherwise =0	0.524	0.499	0	1
Married	=1 if respondent is married, otherwise =0	0.849	0.358	0	1
Age	Age of the respondent	39.712	11.063	18	60
Education					
-Less than primary (omitted)	=1 if the highest education is below primary school graduate, otherwise = 0				
-Primary	=1 if the highest education is primary school graduate, otherwise = 0	0.220	0.414	0	1
-Junior	=1 if the highest education is junior high school graduate, otherwise = 0	0.351	0.477	0	1
-Senior	=1 if the highest education is senior high school graduate, otherwise = 0	0.198	0.399	0	1
-College	=1 if the highest education is college graduate(or above), otherwise = 0	0.037	0.190	0	1
Schooling	No. of years of schooling	7.420	3.913	0	18
Urban	=1 if respondent is in urban area; =0 if respondent is in rural area	0.323	0.468	0	1
Province dummies					
Liaoning (omitted)	=1 if province=Liaoning, otherwise = 0	0.105	0.307	0	1
Heilongjiang	=1 if province=Hei Longjiang, otherwise = 0	0.082	0.274	0	36
Jiangsu	=1 if province=Jiangsu,	0.125	0.331	0	1

	otherwise = 0				
Shandong	=1 if province=Shandong, otherwise = 0	0.104	0.306	0	36
Henan	=1 if province=Henan, otherwise = 0	0.111	0.314	0	1
Hubei	=1 if province=Hubei, otherwise = 0	0.117	0.321	0	36
Hunan	=1 if province=Hunan, otherwise = 0	0.114	0.318	0	1
Guangxi	=1 if province=Guangxi, otherwise = 0	0.119	0.323	0	1
Guizhou	=1 if province=Guizhou, otherwise = 0	0.122	0.327	0	36
Wave Dummies					
1989.wave (omitted)	=1 if wave=1989, otherwise = 0	0.096	0.295	0	1
1991.wave	=1 if wave=1991, otherwise = 0	0.141	0.348	0	1
1993.wave	=1 if wave=1993, otherwise = 0	0.121	0.326	0	1
1997.wave	=1 if wave=1997, otherwise = 0	0.120	0.325	0	1
2000.wave	=1 if wave=2000, otherwise = 0	0.125	0.331	0	1
2004.wave	=1 if wave=2004, otherwise = 0	0.134	0.341	0	1
2006.wave	=1 if wave=2006, otherwise = 0	0.130	0.336	0	1
2009.wave	=1 if wave=2009, otherwise = 0	0.133	0.340	0	1
Energy intake	Daily energy intake(kcal)	2283.53	883.92	266.51	54230.39
Energy expense	Daily energy expense(kcal)	1581.71	370.34	454.49	5610.94
Energy balance	Daily energy balance(kcal)=intake-expense	622.16	840.22	-4192.03	16936.58

Note: N= 47845. CHNS 1989-2009
[+]: The information of waist is available only in waves 1993-2009.

Table 2: OLS Regressions, Before 2001 and After 2001

	Before 2001 BMI	After 2001 BMI	Before 2001 Overweight	After 2001 Overweight	Before 2001 Obese	After 2001 Obese	Before 2001 Waist	After 2001 Waist
Primary	0.202***	-0.113	0.023***	-0.011	0.004	-0.010	0.040	-0.510**
	(0.048)	(0.082)	(0.007)	(0.013)	(0.003)	(0.007)	(0.194)	(0.236)
Junior	0.162***	-0.072	0.021***	-0.012	0.004	-0.011	0.188	-0.439**
	(0.049)	(0.077)	(0.007)	(0.012)	(0.003)	(0.007)	(0.194)	(0.222)
Senior	0.190***	-0.191**	0.042***	-0.013	0.003	-0.024***	0.881***	-0.675***
	(0.056)	(0.083)	(0.009)	(0.013)	(0.004)	(0.007)	(0.222)	(0.239)
College	0.198*	-0.166	0.056***	-0.021	0.005	-0.017	1.264***	-0.374
	(0.112)	(0.122)	(0.018)	(0.019)	(0.009)	(0.011)	(0.423)	(0.343)
Ln(income)	0.181***	0.115***	0.028***	0.017***	0.006***	0.003	0.465***	0.301***
	(0.020)	(0.024)	(0.003)	(0.004)	(0.001)	(0.002)	(0.077)	(0.068)
Female	0.312***	-0.173***	0.051***	-0.029***	0.010***	0.004	-2.764***	-4.296***
	(0.032)	(0.045)	(0.005)	(0.007)	(0.002)	(0.004)	(0.127)	(0.130)
Household size	0.011	-0.000	-0.000	-0.001	0.001	0.001	-0.027	-0.026
	(0.012)	(0.017)	(0.002)	(0.003)	(0.001)	(0.001)	(0.047)	(0.050)
Employed	-0.412***	-0.470***	-0.068***	-0.066***	-0.023***	-0.020***	-0.956***	-1.366***
	(0.058)	(0.053)	(0.009)	(0.008)	(0.005)	(0.005)	(0.195)	(0.150)
Age	0.186***	0.289***	0.020***	0.032***	0.001	0.006***	0.456***	0.503***
	(0.012)	(0.017)	(0.002)	(0.003)	(0.001)	(0.001)	(0.047)	(0.050)
Age square	-0.002***	-0.003***	-0.000***	-0.000***	0.000	-0.000***	-0.003***	-0.004***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Married	0.221***	0.376***	0.016**	0.029**	0.005*	0.012**	0.811***	0.678***
	(0.051)	(0.079)	(0.007)	(0.012)	(0.003)	(0.006)	(0.203)	(0.229)
Urban	0.354***	0.124**	0.047***	0.019**	0.011***	0.012***	0.985***	0.269*
	(0.037)	(0.050)	(0.006)	(0.008)	(0.003)	(0.004)	(0.142)	(0.142)
1991.wave	0.047		0.008		0.005*			
	(0.047)		(0.007)		(0.003)			
1993.wave	0.160***		0.018**		0.002		.	
	(0.049)		(0.007)		(0.003)		.	
1997.wave	0.435***		0.049***		0.011***		1.167***	
	(0.053)		(0.008)		(0.003)		(0.154)	
2000.wave	0.754***		0.090***		0.025***		2.350***	
	(0.056)		(0.008)		(0.004)		(0.156)	
2006.wave		0.058		0.007		0.001		0.216
		(0.053)		(0.008)		(0.005)		(0.151)
2009.wave		0.099*		0.021**		0.010**		0.957***
		(0.055)		(0.009)		(0.005)		(0.157)
Hei longjiang	0.105	-0.271***	0.013	-0.032**	0.015*	-0.035***	0.294	-0.708***
	(0.095)	(0.095)	(0.015)	(0.015)	(0.008)	(0.009)	(0.323)	(0.262)
Jiangsu	-0.371***	-0.453***	-0.034***	-0.052***	-0.008	-0.041***	-1.153***	-0.946***
	(0.069)	(0.098)	(0.011)	(0.015)	(0.005)	(0.009)	(0.289)	(0.275)

Shandong	0.666***	0.609***	0.074***	0.079***	0.020***	0.008	2.328***	1.701***
	(0.074)	(0.096)	(0.012)	(0.015)	(0.006)	(0.010)	(0.314)	(0.268)
Henan	-0.030	0.005	0.001	-0.013	0.000	-0.023**	0.840***	0.216
	(0.071)	(0.100)	(0.011)	(0.016)	(0.005)	(0.010)	(0.299)	(0.282)
Hubei	-0.714***	-0.740***	-0.084***	-0.106***	-0.017***	-0.052***	-2.244***	-0.790***
	(0.069)	(0.099)	(0.011)	(0.015)	(0.005)	(0.009)	(0.291)	(0.275)
Hunan	-0.892***	-1.047***	-0.113***	-0.138***	-0.030***	-0.076***	-2.413***	-2.720***
	(0.067)	(0.093)	(0.011)	(0.014)	(0.005)	(0.008)	(0.310)	(0.262)
Guangxi	-1.564***	-1.583***	-0.165***	-0.199***	-0.034***	-0.084***	-3.725***	-5.041***
	(0.067)	(0.094)	(0.010)	(0.014)	(0.004)	(0.008)	(0.285)	(0.264)
Guizhou	-1.098***	-1.273***	-0.125***	-0.162***	-0.025***	-0.067***	-4.207***	-4.537***
	(0.068)	(0.098)	(0.010)	(0.015)	(0.005)	(0.009)	(0.290)	(0.276)
_cons	16.430***	16.202***	-0.457***	-0.418***	-0.061***	-0.049	62.484***	68.503***
	(0.273)	(0.404)	(0.040)	(0.061)	(0.019)	(0.033)	(1.091)	(1.169)
N	28715	18708	28715	18708	28715	18708	16924	18431
adj. R^2	0.138	0.100	0.099	0.066	0.030	0.019	0.188	0.164

Note: 1 Huber-White robust Standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$;
2 wave.1989 and wave.2004 are treated as reference groups in periods before 2001 and periods after 2001 respectively and are omitted here. Province Liaoning is also treated as reference group and is omitted here.

Table 3: OLS Regressions, Born Before 1962 and After 1962

	Before 1962 BMI	After 1962 BMI	Before 1962 Overweight	After 1962 Overweight	Before 1962 Obese	After 1962 Obese	Before 1962 Waist	After 1962 Waist
Primary	0.142***	-0.088	0.020***	-0.021	0.002	-0.000	-0.006	-0.273
	(0.049)	(0.086)	(0.008)	(0.013)	(0.004)	(0.006)	(0.179)	(0.295)
Junior	0.255***	-0.248***	0.040***	-0.047***	0.005	-0.005	0.608***	-0.664**
	(0.051)	(0.080)	(0.008)	(0.012)	(0.004)	(0.006)	(0.184)	(0.274)
Senior	0.263***	-0.346***	0.053***	-0.042***	0.001	-0.015**	0.497**	-0.279
	(0.059)	(0.087)	(0.009)	(0.013)	(0.005)	(0.006)	(0.208)	(0.296)
College	0.290**	-0.305**	0.059***	-0.039**	0.001	-0.007	1.260***	-0.206
	(0.118)	(0.121)	(0.020)	(0.018)	(0.010)	(0.009)	(0.394)	(0.389)
Ln(income)	0.221***	0.025	0.028***	0.011***	0.009***	-0.001	0.514***	0.111
	(0.021)	(0.023)	(0.003)	(0.003)	(0.002)	(0.002)	(0.071)	(0.072)
Female	0.441***	-0.288***	0.067***	-0.040***	0.023***	-0.012***	-2.082***	-5.153***
	(0.036)	(0.038)	(0.006)	(0.006)	(0.003)	(0.003)	(0.130)	(0.127)
Household size	-0.014	0.062***	-0.004**	0.008***	0.001	0.002**	-0.105**	0.129***
	(0.014)	(0.014)	(0.002)	(0.002)	(0.001)	(0.001)	(0.048)	(0.048)
Employed	-0.519***	-0.143**	-0.072***	-0.031***	-0.027***	-0.006	-1.272***	-0.547***
	(0.052)	(0.059)	(0.008)	(0.009)	(0.005)	(0.004)	(0.161)	(0.174)
Age	0.234***	0.099***	0.028***	0.007*	0.006***	0.000	0.554***	0.340***
	(0.023)	(0.027)	(0.004)	(0.004)	(0.002)	(0.002)	(0.117)	(0.085)
Age square	-0.002***	-0.000	-0.000***	0.000	-0.000***	0.000	-0.004***	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Married	0.367***	0.273***	0.031***	0.028***	0.015***	0.007*	0.886***	0.897***
	(0.075)	(0.057)	(0.011)	(0.008)	(0.006)	(0.004)	(0.256)	(0.200)
Urban	0.367***	0.107**	0.049***	0.018***	0.011***	0.011***	0.698***	0.500***
	(0.040)	(0.044)	(0.006)	(0.007)	(0.003)	(0.003)	(0.140)	(0.143)
1991.wave	0.072	0.020	0.012	0.005	0.008**	-0.001		
	(0.061)	(0.072)	(0.009)	(0.009)	(0.004)	(0.002)		
1993.wave	0.184***	0.103	0.019*	0.018*	0.005	-0.001	.	.
	(0.065)	(0.075)	(0.010)	(0.010)	(0.004)	(0.003)	.	.
1997.wave	0.493***	0.394***	0.060***	0.042***	0.015***	0.012***	1.170***	1.449***
	(0.074)	(0.079)	(0.012)	(0.011)	(0.005)	(0.004)	(0.202)	(0.229)
2000.wave	0.854***	0.633***	0.104***	0.080***	0.028***	0.025***	2.513***	2.376***
	(0.079)	(0.082)	(0.012)	(0.011)	(0.006)	(0.004)	(0.215)	(0.227)
2004.wave	0.898***	0.662***	0.106***	0.091***	0.029***	0.032***	3.164***	3.277***
	(0.085)	(0.085)	(0.013)	(0.012)	(0.007)	(0.005)	(0.231)	(0.237)
2006.wave	0.941***	0.711***	0.110***	0.095***	0.028***	0.033***	3.233***	3.563***
	(0.088)	(0.089)	(0.014)	(0.012)	(0.007)	(0.005)	(0.240)	(0.247)
2009.wave	0.991***	0.660***	0.115***	0.104***	0.033***	0.044***	4.017***	4.158***
	(0.096)	(0.093)	(0.015)	(0.013)	(0.008)	(0.006)	(0.264)	(0.259)
Hei longjiang	-0.251***	0.102	-0.025	0.012	-0.009	-0.008	-0.537*	-0.122
	(0.094)	(0.094)	(0.015)	(0.014)	(0.009)	(0.008)	(0.296)	(0.281)

Jiangsu	-0.440***	-0.301***	-0.047***	-0.029**	-0.025***	-0.016**	-0.877***	-1.284***
	(0.074)	(0.089)	(0.012)	(0.013)	(0.006)	(0.007)	(0.269)	(0.288)
Shandong	0.548***	0.782***	0.064***	0.093***	0.017**	0.011	1.855***	2.055***
	(0.076)	(0.092)	(0.013)	(0.014)	(0.008)	(0.008)	(0.275)	(0.303)
Henan	-0.141*	0.163*	-0.010	0.004	-0.010	-0.011	0.509*	0.526*
	(0.078)	(0.089)	(0.012)	(0.013)	(0.007)	(0.007)	(0.283)	(0.290)
Hubei	-0.855***	-0.546***	-0.113***	-0.064***	-0.032***	-0.031***	-1.697***	-1.497***
	(0.074)	(0.088)	(0.012)	(0.013)	(0.006)	(0.006)	(0.267)	(0.294)
Hunan	-1.039***	-0.813***	-0.131***	-0.109***	-0.058***	-0.037***	-2.414***	-2.749***
	(0.071)	(0.086)	(0.012)	(0.012)	(0.006)	(0.006)	(0.271)	(0.294)
Guangxi	-1.833***	-1.213***	-0.211***	-0.136***	-0.060***	-0.048***	-4.486***	-4.426***
	(0.072)	(0.084)	(0.011)	(0.012)	(0.006)	(0.006)	(0.265)	(0.278)
Guizhou	-1.294***	-1.009***	-0.165***	-0.109***	-0.048***	-0.036***	-4.587***	-4.294***
	(0.075)	(0.086)	(0.012)	(0.012)	(0.006)	(0.006)	(0.274)	(0.285)
_cons	15.186***	18.843***	-0.637***	-0.120*	-0.185***	0.019	60.105***	68.011***
	(0.527)	(0.447)	(0.082)	(0.065)	(0.039)	(0.032)	(2.761)	(1.464)
N	27392	20031	27392	20031	27392	20031	19085	16270
adj. R^2	0.138	0.158	0.100	0.109	0.033	0.029	0.156	0.235

Note: 1 Huber-White robust Standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$;
2 wave.1989 is treated as reference group and is omitted here. Province Liaoning is also treated as reference group and is omitted here.

Table 4. OLS Regressions, with Interactions between SES and Wave

	(1) BMI	(2) Overweight	(3) Obese	(4) Waist
Schooling	0.029***	0.005***	0.000	0.174***
	(0.008)	(0.001)	(0.001)	(0.040)
Ln(income)	0.249***	0.039***	0.011***	0.725***
	(0.033)	(0.005)	(0.002)	(0.175)
Schooling* year[1]	-0.005***	-0.001***	-0.0002*	-0.030***
	(0.002)	(0.000)	(0.000)	(0.007)
Ln(income)* year	-0.019***	-0.003***	-0.001**	-0.061**
	(0.006)	(0.001)	(0.001)	(0.029)
Female	0.137***	0.022***	0.008***	-3.487***
	(0.027)	(0.004)	(0.002)	(0.093)
Household size	0.002	-0.001	0.001	-0.041
	(0.010)	(0.002)	(0.001)	(0.035)
Employed	-0.416***	-0.061***	-0.022***	-1.108***
	(0.040)	(0.006)	(0.003)	(0.120)
Age	0.212***	0.023***	0.003***	0.493***
	(0.010)	(0.001)	(0.001)	(0.035)
Age square	-0.002***	-0.000***	-0.000***	-0.004***
	(0.000)	(0.000)	(0.000)	(0.000)
Married	0.292***	0.021***	0.007**	0.683***
	(0.045)	(0.007)	(0.003)	(0.156)
Urban	0.247***	0.036***	0.011***	0.654***
	(0.030)	(0.005)	(0.002)	(0.102)
1991.wave	0.239***	0.039***	0.018***	
	(0.066)	(0.010)	(0.004)	
1993.wave	0.540***	0.079***	0.027***	.
	(0.104)	(0.016)	(0.008)	.
1997.wave	1.024***	0.142***	0.048***	1.919***
	(0.147)	(0.022)	(0.011)	(0.258)
2000.wave	1.567***	0.216***	0.074***	3.865***
	(0.195)	(0.029)	(0.015)	(0.457)
2004.wave	1.809***	0.252***	0.087***	5.420***
	(0.245)	(0.037)	(0.019)	(0.681)
2006.wave	2.085***	0.291***	0.100***	6.420***
	(0.298)	(0.045)	(0.023)	(0.922)
2009.wave	2.351***	0.340***	0.121***	7.977***
	(0.358)	(0.054)	(0.028)	(1.186)
Heilongjiang	-0.114*	-0.012	-0.010	-0.379*

[1] We redefine the order of wave as year: i.e. year=1 if wave = 1989.

	(0.069)	(0.011)	(0.006)	(0.212)
Jiangsu	-0.429***	-0.044***	-0.024***	-1.054***
	(0.059)	(0.009)	(0.005)	(0.204)
Shandong	0.625***	0.075***	0.014**	2.117***
	(0.061)	(0.010)	(0.006)	(0.210)
Henan	-0.020	-0.004	-0.011**	0.577***
	(0.061)	(0.009)	(0.005)	(0.210)
Hubei	-0.730***	-0.093***	-0.033***	-1.530***
	(0.059)	(0.009)	(0.005)	(0.205)
Hunan	-0.969***	-0.126***	-0.051***	-2.529***
	(0.057)	(0.009)	(0.005)	(0.207)
Guangxi	-1.582***	-0.181***	-0.056***	-4.397***
	(0.057)	(0.009)	(0.004)	(0.199)
Guizhou	-1.168***	-0.141***	-0.043***	-4.344***
	(0.059)	(0.009)	(0.005)	(0.206)
_cons	15.592***	-0.575***	-0.110***	61.484***
	(0.282)	(0.042)	(0.020)	(0.991)
N	45526	45526	45526	33991
adj. R^2	0.145	0.103	0.030	0.202

Note: 1. Huber-White robust Standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$;
2. Wave.1989 is treated as reference group and is omitted here. Province Liaoning is also treated as reference group and is omitted here.

Table 5. OLS Regressions, with Interactions between SES and Birth Year

	(1) BMI	(2) Overweight	(3) Obese	(4) Waist
Schooling	5.437***	0.716***	0.016	5.065**
	(0.681)	(0.101)	(0.051)	(2.327)
Ln(income)	23.360***	2.066***	0.737***	47.391***
	(2.447)	(0.361)	(0.179)	(8.009)
Schooling* birth-year	-0.003***	-0.0004***	-0.0001	-0.003**
	(0.000)	(0.000)	(0.000)	(0.001)
Ln(income)* birth-year	-0.012***	-0.001***	-0.0004***	-0.025***
	(0.001)	(0.000)	(0.000)	(0.004)
Female	0.139***	0.022***	0.008***	-3.488***
	(0.027)	(0.004)	(0.002)	(0.093)
Household size	0.012	-0.000	0.001	-0.027
	(0.010)	(0.002)	(0.001)	(0.035)
Employed	-0.402***	-0.060***	-0.021***	-1.074***
	(0.040)	(0.006)	(0.003)	(0.120)
Age	0.089***	0.011***	0.000	0.270***
	(0.013)	(0.002)	(0.001)	(0.045)
Age square	-0.002***	-0.000***	-0.000***	-0.004***
	(0.000)	(0.000)	(0.000)	(0.000)
Married	0.227***	0.014**	0.006**	0.603***
	(0.045)	(0.007)	(0.003)	(0.157)
Urban	0.258***	0.037***	0.011***	0.665***
	(0.030)	(0.005)	(0.002)	(0.102)
1991.wave	0.336***	0.038***	0.015***	
	(0.052)	(0.008)	(0.003)	
1993.wave	0.685***	0.072***	0.019***	.
	(0.062)	(0.009)	(0.004)	.
1997.wave	1.451***	0.153***	0.043***	2.099***
	(0.090)	(0.013)	(0.006)	(0.194)
2000.wave	2.158***	0.232***	0.067***	3.990***
	(0.116)	(0.017)	(0.008)	(0.263)
2004.wave	2.705***	0.286***	0.082***	5.707***
	(0.151)	(0.022)	(0.011)	(0.375)
2006.wave	3.032***	0.318***	0.089***	6.384***
	(0.170)	(0.025)	(0.012)	(0.438)
2009.wave	3.472***	0.370***	0.109***	7.822***
	(0.202)	(0.030)	(0.015)	(0.538)
Heilongjiang	-0.115*	-0.013	-0.010*	-0.400*
	(0.068)	(0.011)	(0.006)	(0.212)
Jiangsu	-0.427***	-0.044***	-0.024***	-1.051***

	(0.059)	(0.009)	(0.005)	(0.204)
Shandong	0.642***	0.077***	0.014**	2.122***
	(0.061)	(0.010)	(0.006)	(0.210)
Henan	-0.009	-0.003	-0.011**	0.572***
	(0.061)	(0.009)	(0.005)	(0.210)
Hubei	-0.717***	-0.091***	-0.033***	-1.521***
	(0.059)	(0.009)	(0.005)	(0.204)
Hunan	-0.967***	-0.125***	-0.051***	-2.531***
	(0.056)	(0.009)	(0.005)	(0.207)
Guangxi	-1.583***	-0.181***	-0.056***	-4.405***
	(0.057)	(0.009)	(0.004)	(0.199)
Gansu	-1.172***	-0.141***	-0.044***	-4.377***
	(0.058)	(0.009)	(0.005)	(0.205)
_cons	20.030***	-0.090*	0.020	70.814***
	(0.329)	(0.048)	(0.024)	(1.227)
N	45526	45526	45526	33991
adj. R^2	0.149	0.105	0.030	0.202

Note: 1. Huber-White robust Standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$;

2. Wave.1989 is treated as reference group and is omitted here. Province Liaoning is also treated as reference group and is omitted here.

Table 6: IV Regressions

	(1) BMI	(2) Overweight	(3) Obese	(4) Waist
College	-10.544***	-0.821***	-0.149	-9.123
	(2.260)	(0.245)	(0.104)	(5.643)
Ln(income)	0.405***	0.044***	0.008***	0.635***
	(0.058)	(0.006)	(0.003)	(0.163)
Female	-0.032	0.006	0.006***	-3.673***
	(0.045)	(0.005)	(0.002)	(0.117)
Household size	-0.010	-0.002	0.001	-0.052
	(0.012)	(0.002)	(0.001)	(0.038)
Employed	-0.084	-0.036***	-0.016***	-0.824***
	(0.084)	(0.010)	(0.005)	(0.222)
Age	0.234***	0.025***	0.003***	0.488***
	(0.013)	(0.002)	(0.001)	(0.036)
Age square	-0.002***	-0.000***	-0.000**	-0.004***
	(0.000)	(0.000)	(0.000)	(0.000)
Married	0.010	-0.001	0.003	0.489**
	(0.078)	(0.009)	(0.004)	(0.216)
Urban	0.858***	0.085***	0.019***	1.232***
	(0.131)	(0.015)	(0.006)	(0.355)
1991.wave	0.095*	0.013*	0.007***	.
	(0.056)	(0.007)	(0.003)	.
1993.wave	0.160***	0.020***	0.005*	-4.331***
	(0.056)	(0.008)	(0.003)	(0.192)
1997.wave	0.490***	0.058***	0.017***	-3.013***
	(0.061)	(0.008)	(0.003)	(0.192)
2000.wave	0.890***	0.106***	0.031***	-1.754***
	(0.067)	(0.009)	(0.004)	(0.171)
2004.wave	0.922***	0.111***	0.034***	-0.998***
	(0.067)	(0.009)	(0.004)	(0.169)
2006.wave	1.190***	0.134***	0.037***	-0.630***
	(0.090)	(0.011)	(0.005)	(0.166)
2009.wave	1.137***	0.139***	0.045***	.
	(0.081)	(0.011)	(0.005)	.
Heilongjiang	-0.126	-0.014	-0.010	-0.315
	(0.087)	(0.011)	(0.006)	(0.213)
Jiangsu	-0.920***	-0.085***	-0.029***	-1.508***
	(0.125)	(0.015)	(0.007)	(0.297)
Shandong	0.253**	0.044***	0.009	1.701***
	(0.106)	(0.013)	(0.007)	(0.247)
Henan	-0.308***	-0.029**	-0.014**	0.279
	(0.093)	(0.012)	(0.006)	(0.238)
Hubei	-1.206***	-0.132***	-0.038***	-1.997***
	(0.121)	(0.014)	(0.007)	(0.296)

Hunan	-1.289***	-0.150***	-0.054***	-2.795***
	(0.098)	(0.012)	(0.005)	(0.233)
Guangxi	-2.061***	-0.218***	-0.062***	-4.815***
	(0.123)	(0.014)	(0.006)	(0.287)
Guizhou	-1.603***	-0.177***	-0.048***	-4.740***
	(0.111)	(0.013)	(0.006)	(0.266)
_cons	14.588***	-0.591***	-0.094***	66.505***
	(0.524)	(0.059)	(0.026)	(1.282)
N	47423	47423	47423	35355
adj. R^2	.	.	0.015	0.163
First-stage robust F statistic		40.002 .		28.737

Note: 1. Huber-White robust Standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$;
2. Wave.1989 is treated as reference group and is omitted here. Province Liaoning is also treated as reference group and is omitted here.

Table 7: Explore the Mechanisms

	(1) Preference for unhealthy food	(2) Knowledge about healthy diet	(3) Energy intake	(4) Energy expenditure	(5) Energy balance
Primary	-0.035***	0.013**	-3.831	-10.901	28.125
	(0.011)	(0.006)	(20.420)	(10.925)	(27.948)
Junior	-0.053***	0.028***	-57.651***	18.019*	-48.590*
	(0.011)	(0.006)	(19.278)	(10.446)	(26.026)
Senior	-0.047***	0.044***	-114.818***	62.028***	-160.074***
	(0.012)	(0.006)	(22.020)	(11.575)	(28.159)
College	-0.023	0.079***	-178.963***	72.843***	-231.320***
	(0.018)	(0.009)	(29.097)	(21.763)	(46.911)
Ln(income)	0.001	0.007***	26.487***	14.669***	14.328*
	(0.003)	(0.002)	(5.784)	(3.522)	(8.253)
Female	-0.030***	0.007*	-373.380***	-223.820***	-135.821***
	(0.007)	(0.003)	(13.107)	(8.652)	(21.964)
Household size	0.006***	-0.002	-19.093***	-45.393***	30.696***
	(0.002)	(0.001)	(4.350)	(3.066)	(6.982)
Employed	0.011	0.001	117.102***	100.417***	29.370
	(0.008)	(0.004)	(13.230)	(7.859)	(19.563)
Age	-0.030***	-0.002	14.449***	55.847***	-47.846***
	(0.003)	(0.001)	(4.939)	(3.354)	(7.667)
Age square	0.000***	0.000	-0.166***	-0.680***	0.605***
	(0.000)	(0.000)	(0.059)	(0.038)	(0.089)
Married	-0.063***	0.011*	52.899**	-49.690***	107.093***
	(0.012)	(0.006)	(20.631)	(14.193)	(33.291)
Urban	-0.016**	0.018***	-71.626***	41.716***	-108.633***
	(0.007)	(0.004)	(14.852)	(7.820)	(21.061)
2006.wave	-0.160***	0.425***	-77.912***	4.068	-85.614***
	(0.008)	(0.004)	(13.425)	(8.236)	(21.057)
2009.wave	-0.159***	0.406***	-109.148***	49.546***	-194.937***
	(0.008)	(0.004)	(16.132)	(8.449)	(21.320)
Heilongjiang	-0.039***	-0.021***	-27.496	-32.730**	25.230
	(0.014)	(0.007)	(21.464)	(12.950)	(32.080)
Jiangsu	0.087***	0.006	322.091***	-17.410	359.551***
	(0.014)	(0.006)	(23.599)	(14.580)	(34.780)
Shandong	0.082***	-0.009	238.031***	53.340***	170.401***
	(0.014)	(0.006)	(25.746)	(15.250)	(39.548)
Henan	0.087***	-0.031***	174.468***	-30.696**	200.235***
	(0.014)	(0.007)	(36.300)	(15.173)	(33.544)
Hubei	0.083***	-0.023***	385.061***	-61.926***	483.870***
	(0.014)	(0.006)	(23.064)	(14.425)	(34.380)
Hunan	0.086***	-0.039***	145.111***	-71.554***	270.526***
	(0.013)	(0.007)	(21.541)	(14.628)	(34.619)

Guangxi	0.121***	-0.029***	111.598***	-132.575***	263.940***
	(0.013)	(0.006)	(22.606)	(14.567)	(31.628)
Guizhou	0.107***	-0.035***	159.628***	-149.150***	331.635***
	(0.014)	(0.007)	(23.895)	(14.345)	(34.514)
_cons	3.256***	3.132***	1879.702***	697.925***	1206.871***
	(0.061)	(0.030)	(113.390)	(78.814)	(173.905)
N	18566	18549	18435	9472	9363
adj. R^2	0.102	0.462	0.080	0.236	0.072

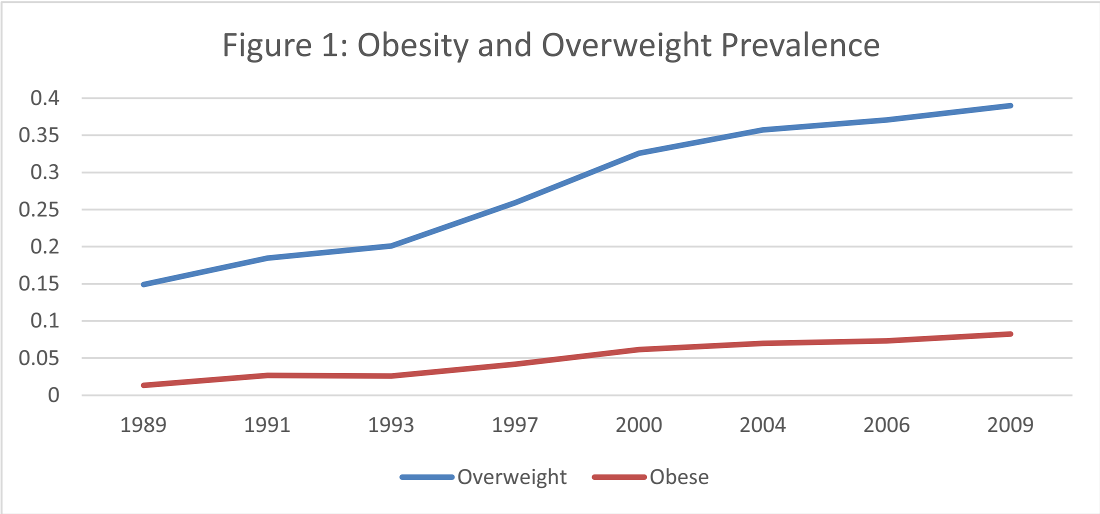
Note: 1. We use 2004-2009 data in all the regressions in this table;

2. Huber-White robust Standard errors are in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$;

3. Wave.2004 is treated as reference group and is omitted here. Province Liaoning is also treated as reference group and is omitted here.

5 Figure

Figure 1. Obesity and Overweight Prevalence (Percentage)



Source: Our elaboration from the China Health and Nutrition Survey (Waves 1989-2009)