Socio-economic Determinants of Childhood Overweight and Obesity in China: The Long Arm of Market Transformation

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ABSTRACT

Previous studies have widely reported that the association between childhood overweight and obesity in China and socio-economic status is significant and positive, which contradicts the fundamental cause perspective. Using multiple waves of the CHNS dataset (1997, 2000, 2004 and 2006) and continuous BMI cut-points obtained from a polynomial method, logistic regression analyses show that parental state sector, an essential SES determinant during the market transformation, has changed from a risk factor for both childhood overweight and obesity in 1997 to a protective factor in 2006. While the effects of other universal and local SES measures remain consistent with results from previous studies, our quantile regression analyses further reveal a homeostatic effect of parental state sector on childhood BMI, which is robust under different estimation strategies. A series of possibilities accounting for the effect of parental state sector is explored. This research calls for the use of multifaceted SES measures in testing the fundamental cause perspective across time, which should include meaningful SES measures retrieved from relevant sociological theories in a local context.

Keywords: Childhood overweight and obesity, Market transformation, The fundamental cause perspective, China, Body Mass Index

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INTRODUCTION

From the life course perspective, childhood obesity is important not only because it often extends into adulthood, but also because of its significant cohort influence on adulthood all-cause mortality and diseases, such as cardiovascular disease, diabetes and hypertension (Dietz, 1998; Suchindran, North, Popkin, & Gordon-Larsen, 2010). For instance, elevated morbidity and mortality was observed for adults who were overweight as adolescents, even if they had normal weight as adults (Deckelbaum & Williams, 2001). Due to its strong association with later elevated blood pressure, respiratory disease, diabetes and psychosocial disorders (Erickson, Robinson, Haydel, & Killen, 2000; Figueroa-Colon, Franklin, Lee, Aldridge, & Alexander, 1997; He, Ding, Fong, & Karlberg, 2000; Young, Dean, Flett, & Wood-Steiman, 2000), childhood obesity has been identified by researchers as one of the two major factors (the other is smoking) that can reverse the current trend of year-to-year increases of life expectancy in the U.S. (Bongaarts 2006; Olshansky et al. 2005).

There is considerable evidence that the increased prevalence of childhood obesity is not unique to developed countries. In 38 developing countries where longitudinal data were available to make direct comparisons between past and present prevalence rates of childhood obesity and overweight, researchers found that nearly half of them (16 out of 38 countries) had a trend towards increasing prevalence of obesity and overweight in preschool children (De Onis and Blossner 2000). In the global epidemic of childhood overweight and obesity, research on China can provide scholars with insights about the recent social and economic forces driving childhood obesity in both developing countries and post-socialist societies. With several waves of social and economic reforms initiated in the late 1970s and accelerated market transformation since the early 1990s, China has recently experienced an unparalleled increase in childhood obesity. For example, the prevalence of childhood obesity for urban Chinese children aged 2-6

increased from 1.5 percent in 1989 to 12.6 percent in 1997 (Luo & Hu, 2002), which is a rapid increase in a relatively short period. How such an unparalleled increase in childhood obesity can happen in the world's most populous country remains an essential question faced by scholars and policy-makers.

By bridging existing theoretical frameworks on the fundamental causes of disease and theories on market transformation, this research explores socio-economic gradients in childhood overweight and obesity in reform-era China. Based on data from consecutive waves of the China Health and Nutrition Survey (1997, 2000, 2004 and 2006), several essential SES indicators either included or overlooked by previous studies are examined in our analysis. The age- and sex-specific cut-points suggested by the International Obesity Task Force (IOTF) were adopted to determine the age-specific standards for childhood overweight and obesity (Cole, Bellizzi, Flegal, & Dietz, 2000). Because the reference cut-points offered by the IOTF were given for six months intervals, a polynomial method was applied to fit those cut-points and logistic regression analyses were performed to study SES gradients in childhood obesity and overweight. Because the Group of China Obesity Task Force has argued that measures of childhood overweight and obesity proposed by the IOTF cannot be readily applied to the Chinese population (Ji, 2005), quantile regression analyses are also conducted to complement our results.

The paper is organized as follows. The next section discusses fundamental causes of disease theory, market transition theory and relevant theoretical debates. In the next section, recent literature on socio-economic determinants of childhood obesity in reform-era China is reviewed and the following section evaluates implications of those findings for the fundamental-causes-of-disease perspective and the market-transformation perspective. Sections on data, measures of childhood obesity and overweight, variables used in the analysis, methods and findings are next. A discussion and conclusion section completes the paper.

THEORETICAL FRAMEWORK

This research draws upon two theoretical perspectives that have greatly shaped studies in medical sociology and social stratification in post-socialist societies over the last two decades: fundamental causes of disease theory and market transformation theory. Fundamental causes of disease theory (Link & Phelan, 1995; Phelan & Link, 2005) argues that socio-economic status, social support and other social factors are the fundamental determinants of disease. It is argued that scholars should not overemphasize the importance of proximate causes of diseases, but "counter the trajectory of modern epidemiology toward identifying risk factors that are increasingly proximate to disease—ones for which 'biological' plausibility can be argued " (Link & Phelan, 1995). SES and other fundamental causes of disease determine differential access to resources (such as wealth, power, prestige and social capital) for controlling diseases and knowledge to prevent diseases. Historically speaking, advances in medical technology and knowledge failed to eliminate SES gradients in health by blocking proximate risk factors. Rather, SES gradients in health persist with improved housing condition, established water and public sanitation system, and development of effective vaccines because previous risk factors are continuously replaced by new risk factors (such as smoking and pollution). Compared to the disadvantaged, those with higher socio-economic status have more timely and easier access to emerging knowledge, resources and technology in controlling diseases and preserving their health status. Consequently, SES gradients in health persist as long as socio-economic resources are distributed unequally even though proximate causes of diseases are continuously identified and regulated. However, because economic and social development is also associated with more energy intake and less energy expenditure (Barry Popkin, 2009), mixed findings have been reported regarding the association between SES status and childhood obesity across countries (Lahti-Koski, Vartiainen, Männistö, & Pietinen, 2000; Lamerz, Kuepper-Nybelen, Wehle, Bruning, Trost-Brinkhues, Brenner et al., 2005; Y. Wang, 2001; Y. Wang & Zhang, 2006). Although important questions remain as to whether higher SES is associated with knowledge about the cumulatively detrimental effect of childhood obesity and what aspects of SES predict lower or higher risks of childhood obesity in developing countries, a major goal of this research is to explore how the epidemic of childhood overweight and obesity in China is shaped by parental socio-economic status.

Indeed, the increasing controversies concerning the socio-economic determinants of childhood overweight and obesity may reflect varying concepts and operationalizations used in empirical research. We argue that multidimensional measures of SES are required to understand their effects on childhood obesity and overweight. Although certain measures of social conditions (such as education and income) are meaningful across societies, it is important to incorporate essential indicators of local social conditions as well. In this regard, market transition theory and relevant debates provide insights how socio-economic status across post-socialist societies can best be conceptualized. Although it was hypothesized that socialist states would gradually favor direct producers over redistributors with every step of the transition from redistributive to market coordination (Nee, 1989), several studies have shown that persistence of power remains salient during the market transformation (Bian & Logan, 1996; Walder, 1996). In planned economies, state and work sectors (workplaces or *danwei*) were obliged to provide housing, health care, pensions and even educational opportunities to their citizens and employees. While the provision and allocation of those public goods and benefits are still influenced by political power in reform-era China, scholars should be cautious in interpreting advantage in income and education as advantage in overall socio-economic status during market transformation. In fact, an individual's access to housing, health care, and pension remains shaped by types of work sectors, an essential indicator for social conditions in reform-era China (Bian & Logan, 1996; Zhou, 2000). Therefore, this study tries to bridge the two lines of theory by examining whether and how multifaceted measures of socio-economic status are associated with childhood overweight and obesity in reform-era China.

LITERATURE REVIEW: SOCIO-ECONOMIC DETERMINANTS ON CHILDHOOD OVERWEIGHT AND OBESITY IN CHINA[1]

[1] Studies reviewed here were identified by the following procedure: 1. Articles with more than 90 citations were retrieved by searching key words "China childhood obesity" in Google Scholar and reviewing the abstract of each article. Articles focusing on socio-economic determinants of childhood obesity were selected; 2. We searched the key words "China childhood obesity" within those articles citing each article retrieved at the first step. Again, articles (with more than 10 citations) focusing on socio-economic determinants of childhood obesity were selected

Using the Longitudinal data from the China Health and Nutrition Survey (CHNS) collected between 1991 and 1997, Wang and colleagues (2000) examined patterns of body mass index (BMI) and their determinants for children and adolescents. A child was assigned to the tracking group if he/she kept in the same quartile of the population from 1991 to 1997. A child was assigned to the "move-down group" if his/her BMI in 1997 belonged to a lower quartile group than his/her initial quartile in 1991 and he/she was assigned to the "move-up group" otherwise. Compared to the proportions of moving-up children from either low-income families (26.4%) or medium-income families (30.6%), they found that a larger proportion of children from high-income families (35.7%) appeared in the move up group. Meanwhile, a larger proportion of children from low-income families (32.5%) moved down than those in the medium-income (25.6%) and high-income families (28.6%). Though socio-economic determinants were not a major focus of this research, their empirical findings somewhat suggested a positive relationship between socio-economic status and childhood BMI in reform-era China.

More direct evidence was reported in Wang's follow-up study. Based on three nationwide surveys conducted in the U.S. (NHANES III, 1988-1994), China (1993), and Russia (1992), a cross-national comparison was made to reveal the relationship between childhood obesity and socio-economic status across societies (Y. Wang, 2001). Again, children (aged 6-18) from high-income families had higher rates of obesity in China and Russia, whereas a negative relationship between per capita household income and childhood obesity was observed in the U.S. Thus, the positive relationship between childhood obesity and per capita household income in both China and Russia failed to support the theory of fundamental causes of disease. Therefore, researchers subsequently studied the socio-economic determinants of childhood obesity using more comprehensive measures of both childhood obesity and socio-economic status.

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by searching the abstract of each article. At both the first and second steps, only articles published after 2000 were selected.

Based on 9,356 urban children (aged 4-16) surveyed in four eastern cities in China, the positive relationship between household income and childhood obesity remained significant even when different measures of childhood overweight and obesity were adopted (Ma, Hu, Li, & Ma, 2002). By conducting cross-sectional analyses on several consecutive waves of the China Health and Nutrition Survey (1989, 1991, 1993 and 1997), high and median household income was an independent risk factor for childhood overweight (Luo & Hu, 2002). Besides using household income as a proxy for socio-economic status, both fathers with tertiary education and households with more amenities were associated with higher BMI quartiles for boys but not for girls (Shi, Lien, Nirmal Kumar, Dalen, & Holmboe-Ottesen, 2005). By comparing Chinese seventh graders sampled in the greater Los Angeles area of and in Wuhan city in China, a positive association between parental education and risks of overweight and obesity was observed for Wuhan city children, but a negative association was observed for the Chinese children in Southern California (Johnson, Liu, Chou, Gallaher, Guo, & Gong, 2006). By using more comprehensive measures of socio-economic status (personal allowance, parental education, household income, parental employment, ownership of electronics, and financial capability), parental tertiary education was found to be positively associated with overweight for both boys and girls, net of other effects (B. Xie, Chou, Spruijt-Metz, Reynolds, Clark, Palmer et al., 2007). A summary of studies reviewed is listed in Table 1 in order of publication date.

[Table 1 about here]

From the fundamental causes of disease and the market-transformation perspectives, findings from existing research can be summarized as follows. 1. A significant positive association between SES and childhood overweight and obesity in China is widely reported and the association tends to be robust with different specifications of childhood overweight and obesity, even though certain SES measures are not always statistically significant; 2. Previous studies focus on educational attainment and

household income as socio-economic determinants of childhood overweight and obesity in China. Obviously, the positive association between SES and childhood overweight and obesity in China suggested by previous studies lends little support to the fundamental causes of diseases theory, which posits a negative association between socio-economic status and diseases. Compared to the effects of income and education, market transformation theories suggest that positional power attached to different types of work sectors and occupations is equally, if not more, important in determining socio-economic status across post-socialist societies. Work sectors and occupations have been ignored in previous studies.

DATA, MEASURES AND METHODS

Data

This research is based on data from the China Health and Nutrition Survey (CHNS), which is a collaborative project conducted by the Carolina Population Center at the University of North Carolina at Chapel Hill, the National Institute of Nutrition and Food Safety in China and the Chinese Center for Disease Control and Prevention. By covering nine provinces (*Guangxi, Guizhou, Heilongjiang, Henan, Hubei, Hunan, Jiangsu, Liaoning,* and *Shandong*) that vary substantially in geographical location, economic development, social resources, and health status, the CHNS is an ongoing open-cohort survey that provides nationally representative information on the nutrition and health status of the Chinese population. Because the CHNS was designed to examine how the social changes and economic transformation in China is affecting the health and nutritional status of its population, information on socio-economic indicators implied by market transformation theories, such as types of work sectors and categories of occupations, were collected. A series of socio-demographic characteristics were also included in the CHNS. In terms of anthropometrical measurements, body weight of subjects in light indoor clothing was measured to the nearest 0.1 kg with a beam balance scale; using a portable stadiometer, height of subjects without shoes was obtained to the nearest 0.1 cm. Following standardized protocols, all interviewers conducting anthropometrical measurements were required to take inter-observer reliability tests.

The first wave of the CHNS was collected in 1989, followed by six additional waves collected in 1991, 1993, 1997, 2000, 2004, and 2006. Because socio-economic determinants of childhood overweight and obesity from 1989 to 1997 were examined in a previous study using the same data (Luo & Hu, 2002), this study is restricted to several consecutive waves of the CHNS:1997, 2000, 2004 and 2006. More specifically, our analysis included 2001, 1655, 785 and 759 individuals in 1997, 2000, 2004 and 2006, respectively, aged 1-18 years in each survey year. Family background, parental information and other characteristics of each subject aged 1-18 were retrieved from different data files.

Measures of childhood obesity and overweight

Although BMI fails to distinguish lean versus fat body composition, BMI and related standards for overweight and obesity are used in this study given the strong reliance on BMI in population-based studies, BMI's weak association with body height and strong associations with other measures (Hu, 2008; Roche, Sievogel, Chumlea, & Webb, 1981; Ross & Mirowsky, 1983). To determine the age-specific BMI standards for childhood overweight and obesity, we adopt the age- and sex-specific cut-points proposed by the International Obesity Task Force (IOTF), which are based on populations in Brazil, Great Britain, Hong Kong, Netherlands, Singapore, and the United States. By restricting the fitted centile curves to pass through the widely used adult cut-point for obesity of 30 kg/ m^2 and overweight of 25 kg/ m^2 at age 18, the resulting curves for both childhood overweight and obesity across countries were averaged to provide age- and sex-specific cut-points for children aged 2-18 years. Since the reference cut-points offered by the IOTF are given for six-month intervals and for children above age 2, we use a polynomial method to fit those discreet age- and sex-specific cut-points proposed by the IOTF. Results from this method can readily provide BMI cut-points for a child's exact age. Using Matlab 7.0, those fitted continuous curves for both childhood overweight and obesity achieve almost a perfect fit for both boys and girls (See Figure 1: $R^2 > 0.9999$ and the sum of squared residuals <0.07 for all four figures). After retrieving each child's exact age from date of birth and date of measurement, children with BMI equal to or above their age-specific criterion for overweight and obesity are identified as overweight and obesity, respectively.

[Figure 1 about here]

Socio-economic determinants

Four variables are employed to measure the effects of socio-economic determinants on childhood overweight and obesity: parental tertiary education, per capita household income, parental state sector and parental administrative job. Parental tertiary education is a dummy variable measuring whether either parent attained a university or college degree or above. Per capita household income summarizes income of a single household during the last year from a variety of sources, which has been adjusted by both number of family members and inflation. Although the first two variables (income and educational attainment) are widely used in previous studies as proxies for socio-economic status, state sector and administrative job are regarded in market transformation research as essential indicators of social stratification in the reform era (Bian & Logan, 1996; Keister, 2009; Nee, 1989; X. Wu & Xie, 2003; Zhou, 2000). Parental state sector is a dummy variable measuring whether either parent works in a state sector (government department, state service/institute or state-owned enterprise). Likewise, parental administrative job was coded as one if either parent is an administrator, an executive, a manager, an office staff, an army officer or a police officer. This variable is coded as zero otherwise.

Demographic, geographic and parental anthropometric characteristics

A series of demographic, geographic and parental anthropometric characteristics are included as control variables. Three variables were constructed to control for regional disparity in China (X. Wang & Fan, 2004; Y. Xie & Hannum, 1996): eastern (*Heilongjiang, Liaoning, Jiangsu, and Shandong*), middle (*Henan, Hubei, and Hunan*) and southern regions (*Guangxi, Guizhou, Hubei, Hunan, and Jiangsu*). Provinces located at the western or northern regions of China are the reference group. Urban residency (urban areas=1 and otherwise=0) was introduced to control for China's rural-urban divide (Fu & Ren,

2010; Xiaogang Wu & Treiman, 2007). Children's sex, ages, ages of parents, and parental BMI control for the possible influence of biological factors on childhood overweight and obesity.

Methods

In this research, the association between socio-economic determinants and childhood overweight/obesity was primarily examined by logistic regression models and quantile regression models. Based on continuous BMI cut-points obtained from a polynomial method, we use logistic regression to examine SES gradients in childhood overweight and obesity across four waves of the CHNS. There are still debates, however, about whether the universal cut-points suggested by the IOTF can be validly applied to Asian populations. Because Asian populations have higher body-fat percentiles for the same BMI compared to Caucasians, it might be inappropriate to apply universal BMI cut-points to obesity studies in Asian populations (Deurenberg, Deurenberg Yap, & Guricci, 2002). The China Obesity Task Force (Ji, 2005) argued that the physiological characteristics of Chinese children are systematically different from the populations used to establish the cut-points provided by IOTF. Instead, they suggested that the 85th percentile and 95th percentile of age-specific BMI in the Chinese population should be used as the criteria for screening childhood overweight and obesity in China. Based on this reasoning, we also use quantile regression to estimate the effects of socio-economic determinants on childhood overweight and obesity. Due to relatively small sample sizes across percentiles, the robustness of our results is tested by different estimation strategies of quantile regression models (asymptotic estimation, kernel density estimation and bootstrap estimation).

FINDINGS

Descriptive statistics for the variables used in this study are provided in Table 2. Although the increase in average BMI from 1997 to 2006 was modest, childhood overweight more than doubled (from 4.9% to 11.2%) and childhood obesity more than tripled (from 2.4% to 8.7%) in the ten years. Both

mother's and father's BMI increased slightly from 1997 to 2004, whereas a reduction in parental BMI was observed in 2006. In terms of socio-economic determinants, there were dramatic increases in both inflation-adjusted per capita household income (from 3,500 *yuan* to 9,400 *yuan*) and parental tertiary education (from 3.1% to 9.4%) from 1997 to 2006 as a result of China's economic growth and the expansion of higher education in recent years. Nevertheless, parents assuming administrative jobs or working in state sectors increased only slightly from 1997 to 2006, suggesting that these two indicators measure different dimensions of socio-economic status in the reform era. Though there are more samples drawn from eastern regions and fewer samples drawn from urban areas and middle regions in more recent waves, the age distribution of both children and parents, and the sex compositions of children are relatively stable across waves, which illustrate the representativeness of the dataset.

[Table 2 about here]

Results from logistic regression models predicting childhood obesity are in Table 3. Net of other effects, both parental state sector (odds ratio: 2.233) and parental administrative job (odds ratio: 0.782) were significantly associated with higher risk of childhood obesity in 1997, whereas the effects of per capita household income and parental tertiary education were non-significant. While per capita household income (odds ratio: 1.022) and parental tertiary education (odds ratio: 3.834), rather than parental administrative job, were positively associated with childhood obesity in 2006, it is essential to note that parental state sector changed from a risk factor for childhood obesity in 1997 (odds ratio: 2.233) to a protective factor in 2006 (odds ratio: 0.195). Moreover, the changes in and patterns of the effects of socio-economic determinants are supported by results from logistic regression models predicting childhood overweight (see Table 4). Net of other effects, parental state sector also changed from a risk factor for childhood overweight in 1997 (odds ratio: 1.698) to a protective factor for childhood overweight in 2006 (odds ratio: 0.188). Per capita household income (odds ratio: 1.026), parental tertiary education (odds ratio: 2.584) and parental administrative job (odds ratio: 3.071) were still related to higher risk of

childhood overweight in 2006. In addition, per capita household income was positively associated with both childhood overweight and obesity in 2000.

[Table 3 and Table 4 about here]

Because some scholars argue that the BMI cut-points proposed by the IOTF are not valid for Asian populations (Deurenberg et al., 2002; Ji, 2005), we also use quantile regression models (Koenker, 2005; Koenker & Bassett Jr, 1978) to explore the relationship between socio-economic determinants and childhood BMI using the 2006 CHNS dataset (see Figure 2). Net of other effects, Figure 2.1 shows that the zero horizontal line is below the 90% confidence bounds above the 0.30 BMI percentile (except for the 0.95 percentile), suggesting that per capita household income is generally associated with an increase in BMI for children whose BMI was equal to or above the 0.30 percentile. Likewise, Figure 2.2 suggests that parental tertiary education is positively associated with an increase in BMI for overweight children (above 0.85 BMI percentile). The positive effect of parental administrative job is significant at certain upper percentiles (i.e., from 0.65 to 0.70 percentiles, and from 0.85 to 0.90 percentiles), which is shown in Figure 2.4. What is interesting about the effect of parental state sector (Figure 2.3) is that it tends to increase BMI for children below the median BMI, but reduces BMI for children above the median BMI. Though the homeostatic effect of parental state sector is significant only at lower BMI percentiles (around 0.20 to 0.40 percentiles),[2] its pattern and trend across all BMI percentiles are very similar to the homeostatic effect of breast feeding and health risk knowledge on (childhood) BMI reported elsewhere (Beyerlein, Toschke, & von Kries, 2008; Kan & Tsai, 2004).

In Figure 2, the OLS estimates[3] suggest that both per capita household income and parental tertiary education are positively and significantly associated with childhood BMI, whereas there is a significant and negative association between parental state sector and childhood BMI. However, it is

[2] Given the relatively small sample size of the 2006 CHNS dataset used in the quantile analyses (N=759), the wider 90% confidence bounds for all covariates are somewhat expected.
[3] Coefficients are marked by solid horizontal lines and 90% confidence intervals are marked by dashed lines.

worth noting that the effect of parental administrative job is statistically non-significant using OLS estimation. Therefore, statistical inference relying on OLS estimation may obscure the changing effects of socio-economic determinants across different BMI percentiles.

[Figure 2 about here]

Because the results reported in Figure 2 are based on the classical i.i.d. assumption about the error structure and asymptotic estimation, two alternative methods of estimation, kernel density estimation and bootstrap estimation (Koenker, 2005; Powell, 1991), are used to test the robustness of results from the quantile regression models given the moderate sample size (N=759). As demonstrated in Figure 3 and Figure 4, coefficients and 90% confidence bounds of socio-economic determinants across percentiles are consistent with those graphed in Figure 2. For instance, the homeostatic effect of parental state sector on childhood BMI remains salient under either kernel density estimation or bootstrap estimation. Comparing with Figure 2, higher per capita household income was associated with an increase in BMI for children with higher BMI percentiles in Figures 3 and 4, although the significant effect of per capita household income was restricted to narrower intervals of BMI percentiles. The only exception is that the positive effect of parental tertiary education at upper BMI percentiles was no longer significant. Therefore, conclusions drawn from asymptotic estimation are largely valid under different estimation strategies, which illustrates the robustness of the results from quantile regression models.

[Figure 3 and Figure 4 about here]

CONCLUSIONS AND DISCUSSION

In this research, both logistic and quantile analyses demonstrated that several SES indicators have different influences on childhood overweight and obesity. Although the significant effects of per capita household income, parental tertiary education and parental administrative job only have positive effects across waves, parental state sector becomes a protective factor for both childhood overweight and obesity in 2006. The period effect of socio-economic determinants also deserves attention, especially given rapidly changing economic and social forces during the reform era. Before 2006, the positive effect of per capita household income on both childhood overweight and obesity was significant only in 2000. Likewise, only in 1997 was parental state sector significantly associated with higher risk of childhood obesity and overweight. In 2006, all socio-economic determinants were significantly associated with childhood overweight and three out of four socio-economic determinants were significantly associated with childhood obesity. Finally, our quantile analyses imply a homeostatic effect of parental state sector on childhood obesity and overweight, whose shapes and patterns are consistent under different estimation strategies. Methodologically speaking, our results also call attention to the choice of appropriate methods for analyzing childhood overweight and obesity since logistic regression models fail to capture the dynamics of effects of socio-economic determinants across different BMI percentiles.

Given that the association between socio-economic determinants and childhood overweight and obesity in China is widely, albeit not unanimously, reported by existing studies as positive and significant, those empirical findings contradict the fundamental cause perspective in the absence of more comprehensive measures of social conditions and examination of period effects of the socio-economic determinants. Given that parental state sector's protective effect on childhood overweight and obesity and homeostatic effect on childhood BMI in the more recent wave are persistent under different estimation strategies, we interpret those results as simultaneously supporting fundamental causes of diseases and the persistence of power during market transformation. Although those advantaged in SES may temporarily show higher risk of diseases, which used to be the case for cigarette smoking in the U.S., our results show that certain advantaged SES group are less likely to have higher prevalence of diseases

once knowledge or resources for coping with diseases are available. Moreover, it is equally important to include SES indicators that are meaningful in a more local context, especially considering the fact that even those universal indicators of SES, such as income and education, may have different implications for health outcomes across different societies and the life course (Smith & Kington, 1997).

Although this research focuses on distal factors in shaping the epidemic of childhood obesity, the concrete mechanisms through which parental state sector can be a protective factor for childhood overweight and obesity also deserve attention. Therefore, we also explored a series of possibilities in additional analyses. First, since parental BMI has been controlled in both the logistic and quantile analyses, it is unlikely that selection effect (parents with normal BMI were recruited to state sectors) play a role. Next, it is plausible that the effect of state sector can be explained by the fact that state sector families tend to be one-child families. Because parents working in state sectors were under the direct surveillance of family planning officials and family planning policies were more strictly enforced in state sectors (Bongaarts & Greenhalgh, 1985), the only child of parents working in state sectors might receive more attention and care than children with siblings. However, the protective effect of state sector on childhood overweight and obesity becomes even more salient [4] when the presence of a single child within a household is taken into account.

Finally, there are several possibilities resulting from the fact that employees in state sectors face much less competition in the workplace than employees in non-state sectors (Lin, Cai, & Li, 1998; McMillan & Naughton, 1992). This fact might have two previously-unstudied implications regarding the nature of working in state sectors. On the one hand, state sectors are characterized by higher network intensity (strength of ties), which promote the flow of health knowledge within state sectors. Yet, our additional analyses show that indicators of parental diet knowledge (e.g., knowledge about the health outcomes of consuming sugar, fresh fruit and vegetables, staple foods, fatty meat, physical activity, sweaty sports and so on) collected in the CHNS do not mediate the effect of parental state sector (results

[4] Using the 2006 CHNS dataset, the odds ratio of parental state sector's effect on obesity decreased from 0.195 (standard error: 0.114) to 0.189 (standard error: 0.109) after controlling the presence of single child in a household. A similar change is observed when the dependent variable is childhood overweight.

not shown). Network intensity within state sectors can also influence childhood overweight and obesity, however, through social comparisons with similar others (Mueller, Pearson, Muller, Frank, & Turner, 2010). A dense network of individual-level ties among state sectors may affect parents' views of their children's weights and the possible need for weight control. Unfortunately this possibility cannot be tested with available data. On the other hand, the advantage of working in state sectors may be important because it decreases the disadvantages of working in non-state sectors, which are characterized by prolonged work hours, irregular working patterns and consequently weakened parental-child ties in the face of more fierce market competition over time. In turn, weakened parental-child ties may influence childhood overweight and obesity through reduced breastfeeding, less parental intervention to regulate children's diet, sedentary behaviors and irregular dietary patterns. Although most hypotheses about why working in the state-sector is beneficial cannot be tested using the CHNS, we found that the effect of parental state sector is not mediated by children's sedentary behaviors (such as watching TV and playing video games) or parents' reports of the importance of children's exercise and diet. The only weak evidence we observed is that for those children (N=278) who reported their dietary preferences in the 2006 CHNS, the effect of parental state sector was somewhat mediated by children's preferences for soft drinks and salty snacks.[5]

Our research is not without limitations. First, the relatively small sample size in our analyses does not allow a detailed comparison across different occupational categories of parents, which is essential for a comprehensive picture of SES gradients in childhood overweight and obesity. Likewise, we cannot explore the socio-economic determinants of childhood obesity separately for rural and urban areas due to the limited degrees of freedom in our analyses, although a salient rural-urban difference in childhood obesity has been documented (Luo & Hu, 2002). Finally, we also were unable to identify the exact mechanisms through which parental state sector influences childhood obesity by covariates available in the CHNS dataset, though we falsified several possible explanations by additional analyses. However,

[5] The odds ratio of the effect of parental state sector increased from 0.051 (standard error: 0.069) to 0.065 (standard error: 0.092)

these cumulative and consistent findings across models reinforce the value of continuing research into the socio-economic determinants of childhood overweight and obesity and the nature of social stratification in reform-era China, especially from the social capital and network perspectives. Without careful examination of period effects in the socio-economic determinants on childhood overweight and obesity, it is impossible for medical sociologists to monitor the emerging protective and risk factors for childhood overweight and obesity over time and then provide an empirical basis for improving children's health. Likewise, only through the use of comprehensive measures of socio-economic status can policy makers properly identify the socio-economic background that puts children at greatest risk for energy imbalance during market transformation.

Table 1 A summary of research in socio-economic determinants of childhood/adolescent obesity in China (published after 2000)

Author	Year	Sample population	Location	Measures of socio-economic status	Measures of obesity
Wang, Ge and Popkin	2000	CHNS (1991 and 1997): a cohort of 975 Chinese children aged 6-13	Eight provinces in China	Household income	Overweight and obesity: BMI between 85th and 95th percentiles & above 95 percentiles of the National Center for Health Statistics/WHO reference (2000)
Wang	2001	CHNS 1993: 3,028 Children aged 6-18	Eight provinces in China	Household income per capita	The same as Wang, Ge and Popkin (2000)
Ma, Hu, Li and Ma	2002	9,356 urban children & adolescents aged 4-16 y	Guangzhou, Shanghai, Jinan, and Harbin	Household income per capita and parental education	Overweight ≥ 110% normal weight (WHO 1997) ; Obesity ≥ 120% normal weight;
Luo and Hu	2002	CHNS: Children aged 2-6 y: 944 (1989), 1058 (1991), 903 (1993), 483 (1997) for cross-sectional analysis; 944 for longitudinal analysis	Eight provinces in China	Household income and parental education	Age- and sex-specific BMI cut-off points proposed by International Obesity Task Force (2000)
Shi, Lien, Kumar et al.	2005	824 students aged 12 to 14 years (data collected in 2002)	Two prefectures in Jiangsu province (Zhenjiang and Xuzhou)	Parental education and Possession of 11 household amenities;	The same as Wang, Ge and Popkin (2000)
Johnson, Xie, Liu et al.	2006	1,896 healthy adolescents aged 12 and 13 y (Data collected in 1999)	Wuhan	Parental education	Age- and sex-specific BMI cut-off points proposed by the U.S. National Center for Health Statistics (2002) and International Obesity Task Force (2000)
Xie, Chou, Spruijt-Metz et al.	2007	6,863 middle and high school students (7th graders to 11th graders), and their parents (data collected in 2002)	Hangzhou, Wuhan, Kunming and Chengdu	Personal allowance, Parental education, household income, Parental employment, Ownership of Electronics, and financial capability	Age- and sex-specific BMI cut-off points proposed by and International Obesity Task Force (2000) and the Group of China Obesity Task Force (2004)

Table 2 Characteristics of surveyed Chinese children aged 1-18 years across waves

	1997		2000		2004		2006	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
BMI (kg/ m^2)	17.2	2.8	17.5	3.2	18.0	4.9	18.1	4.9
Obesity (%)	2.4		3.2		5.5		8.7	
Overweight (%)	4.9		5.8		8.8		11.2	
Age (years)	10.5	4.2	11.1	4.2	10.5	4.6	10.1	4.5
Male (%)	53.4		52.7		54.4		55.2	
Mother's age (years)	36.5	6.2	37.0	6.1	36.6	5.8	36.5	5.6
Father's age (years)	38.1	6.6	38.5	6.5	37.9	6.1	37.7	5.9
Mother's BMI (kg/ m^2)	22.3	2.8	22.9	3.2	23.2	7.5	22.9	4.2
Father's BMI (kg/ m^2)	22.3	2.6	22.8	2.9	23.7	7.6	23.4	6.3
Urban residency (%)	29.8		27.7		28.3		26.2	
Eastern regions (%)	32.9		42.4		40.0		41.9	
Middle regions (%)	36.3		29.7		25.0		23.1	
Southern regions (%)	63.9		56.4		63.1		57.2	
Per capita household income (1,000 *yuan*)	3.5	2.7	4.6	4.4	6.1	5.9	7.2	9.4
Parental tertiary education (%)	3.1		5.7		7.5		9.4	
Parental state sector (%)	20.1		22.8		23.7		22.7	
Parental administrative job (%)	12.6		12.7		14.0		14.1	
Number of cases	2001		1655		785		759	

Table 3 Logistic analyses of obesity among individuals aged 1-18 years from 1997 to 2006

	1997 (N=2,001)		2000 (N=1,655)		2004 (N=785)		2006 (N=759)	
	O. R. (S. E.) [a]	P-value [b]	O. R. (S. E.)	P-value	O. R. (S. E.)	P-value	O. R. (S. E.)	P-value
Control variables								
Age	0.782 (.045)	0.000**	0.772 (.040)	0.000**	0.793 (.045)	0.000**	0.947 (.043)	0.228
Male	1.531 (.490)	0.183	1.356 (.406)	0.308	0.998 (.337)	0.996	1.489 (.443)	0.180
Mother's age	0.972 (.061)	0.655	0.996 (.064)	0.956	0.956 (.072)	0.555	0.857 (.057)	0.021*
Father's age	1.025 (.055)	0.654	1.024 (.057)	0.673	1.080 (.075)	0.270	1.055 (.063)	0.368
Mother's BMI	1.036 (.055)	0.499	1.002 (.049)	0.965	0.999 (.022)	0.979	1.061 (.027)	0.019*
Father's BMI	1.118 (.060)	0.037*	1.074 (.051)	0.132	1.003 (.019)	0.859	1.023 (.014)	0.097†
Urban residency	1.604 (.599)	0.206	0.553 (.186)	0.078†	0.463 (.175)	0.042*	0.798 (.265)	0.497
Eastern regions	2.496 (1.238)	0.065†	1.185 (.650)	0.758	2.896 (1.806)	0.088†	7.026 (5.076)	0.007**
Middle regions	1.066 (.556)	0.902	1.147 (.605)	0.795	1.342 (.850)	0.642	5.948 (4.096)	0.010*
Southern regions	0.817 (.296)	0.577	0.386 (.162)	0.023*	0.368 (.167)	0.028*	0.380 (.156)	0.018*
Socio-economic determinants								
Per capita household income	1.006 (.054)	0.903	1.044 (.022)	0.040*	1.012 (.030)	0.675	1.022 (.012)	0.068†
Parental tertiary education	1.252 (.481)	0.558	0.782 (.458)	0.675	1.293 (.739)	0.653	3.834 (2.235)	0.021*
Parental state sector	2.233 (.907)	0.048*	1.488 (.571)	0.301	1.112 (.497)	0.812	0.195 (.114)	0.005**
Parental administrative job	0.782 (.045)	0.000**	0.605 (.292)	0.298	0.486 (.268)	0.190	1.757 (.896)	0.269
Pseudo R^2	0.164		0.160		0.177		0.216	

[a] O.R. = Odds Ratio; S. E. = Standard Error

[b] Statistical significance: † $p < 0.10$; * $p < 0.05$; ** $p<0.01$ (two-tailed tests)

Table 4 Logistic analyses of overweight among individuals aged 1-18 years from 1997 to 2006

	1997		2000		2004		2006	
	O. R. (S. E.) [a]	P-value [b]	O. R. (S. E.)	P-value	O. R. (S. E.)	P-value	O. R. (S. E.)	P-value
Control variables								
Age	0.849 (.034)	0.000**	0.820 (.031)	0.000**	0.916 (.040)	0.048*	0.958 (.037)	0.262
Male	0.239 (.061)	0.000**	0.449 (.104)	0.001**	0.371 (.104)	0.000**	0.592 (.149)	0.038*
Mother's age	0.958 (.044)	0.346	0.958 (.043)	0.339	1.033 (.065)	0.607	0.875 (.050)	0.020*
Father's age	1.029 (.041)	0.481	1.077 (.042)	0.055†	0.956 (.055)	0.435	1.084 (.055)	0.115
Mother's BMI	1.096 (.041)	0.013*	1.050 (.036)	0.153	0.993 (.022)	0.763	1.048 (.025)	0.051†
Father's BMI	1.052 (.044)	0.223	1.131 (.041)	0.001**	0.990 (.022)	0.644	1.020 (.015)	0.174
Urban residency	1.045 (.264)	0.861	1.021 (.265)	0.935	0.528 (.160)	0.035*	0.756 (.215)	0.326
Eastern regions	2.170 (.848)	0.047*	1.664 (.664)	0.201	1.514 (.703)	0.372	2.705 (1.375)	0.050†
Middle regions	1.082 (.427)	0.841	1.369 (.517)	0.406	1.214 (.537)	0.661	3.587 (1.622)	0.005**
Southern regions	0.506 (.137)	0.012*	0.695 (.204)	0.215	0.490 (.177)	0.049*	0.438 (.156)	0.020*
Socio-economic determinants								
Per capita household income	1.023 (.041)	0.559	1.051 (.020)	0.010*	0.997 (.025)	0.911	1.026 (.012)	0.025*
Parental tertiary education	0.423 (.251)	0.147	1.139 (.497)	0.764	1.202 (.540)	0.683	2.584 (1.276)	0.054†
Parental state sector	1.698 (.466)	0.054†	0.902 (.276)	0.735	1.716 (.602)	0.124	0.188 (.092)	0.001**
Parental administrative job	1.334 (.397)	0.334	1.110 (.380)	0.761	0.641 (.263)	0.279	3.071 (1.360)	0.011*
Pseudo R^2	0.176		0.130		0.112		0.148	

[a] O.R. = Odds Ratio; S. E. = Standard Error

[b] Statistical significance: † $p < 0.10$; * $p < 0.05$; ** $p<0.01$ (two-tailed tests)

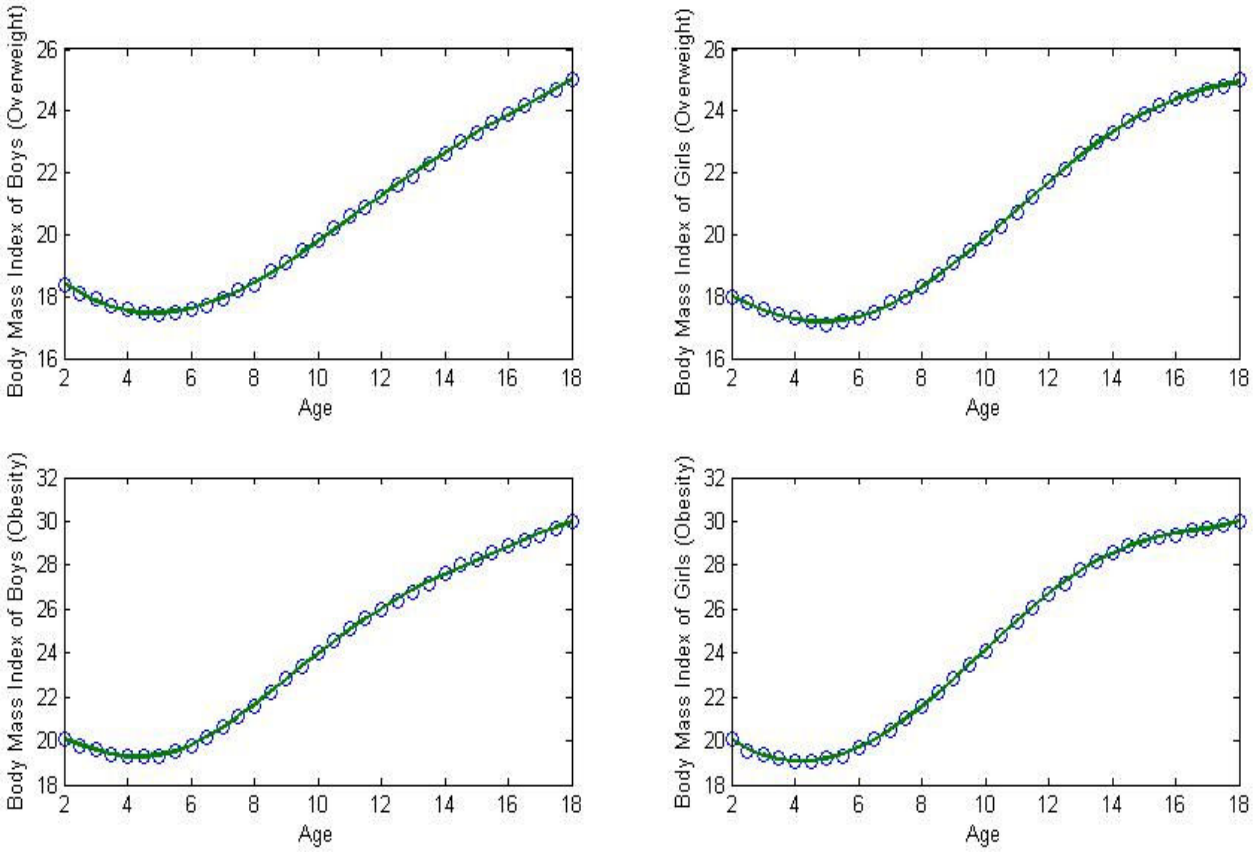

Figure 1 Fitting the IOTF age- and sex-specific cut-points by a polynomial method (R2 > 0.9999 and the sum of squared residuals <0.07 for all four figures)

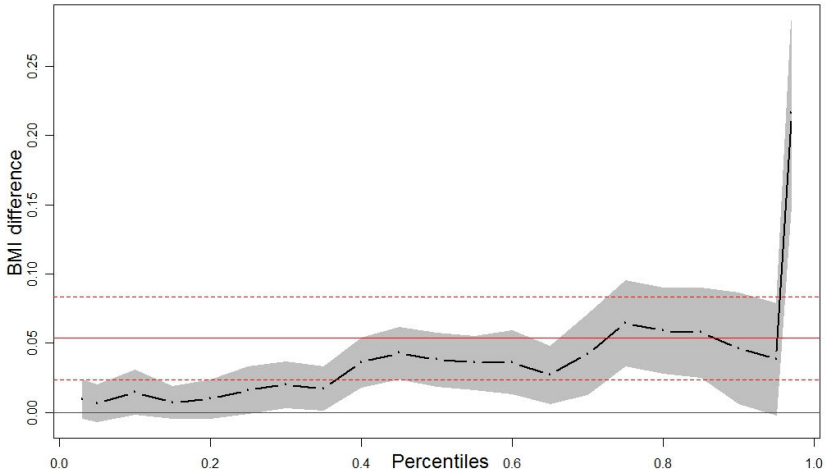

Figure 2.1 Effects of per capita household income

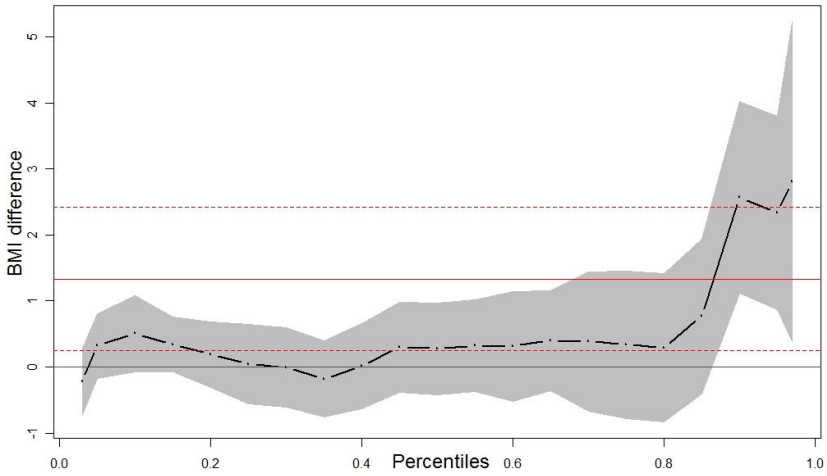

Figure 2.2 Effects of parental tertiary education

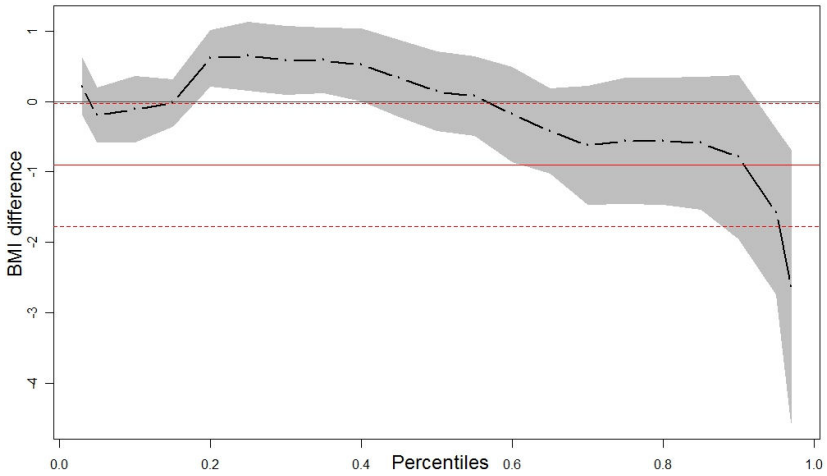

Figure 2.3 Effects of parental state sector

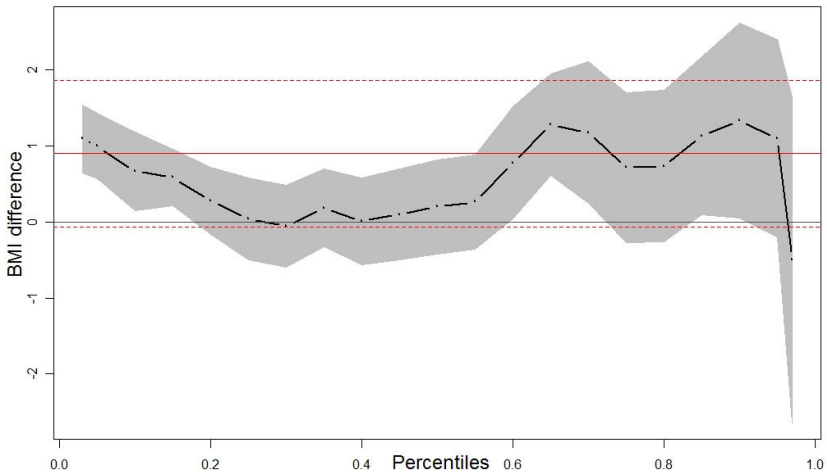

Figure 2.4 Effects of parental administrative job

Figure 2 Coefficients of socio-economic determinants and 90% confidence bounds for childhood BMI differences from quantile analyses controlling for sex, (high order terms of) age, parental ages, parental BMI, urban residency and regions in 2006: asymptotic estimation

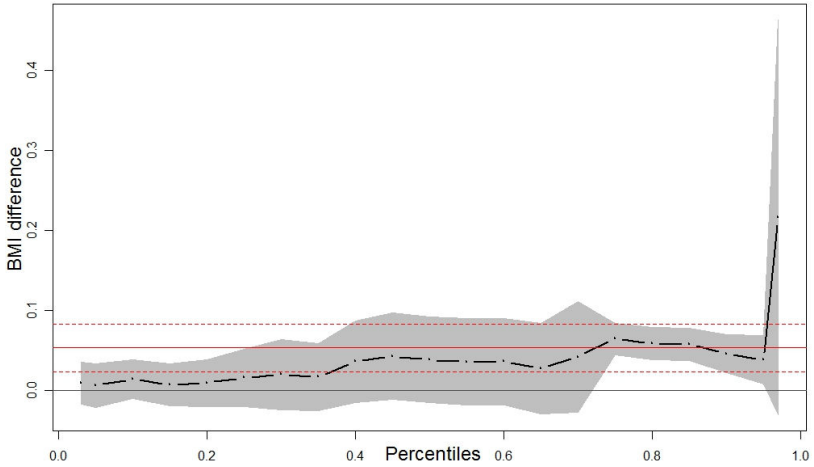

Figure 3.1 Effects of per capita household income

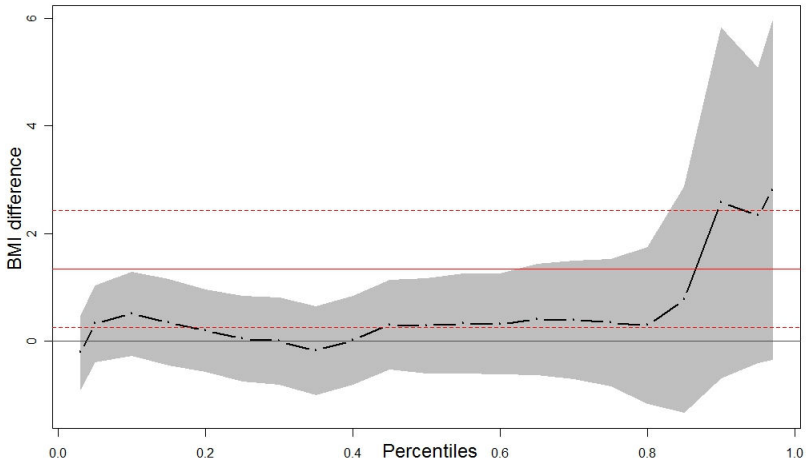

Figure 3.2 Effects of parental tertiary education

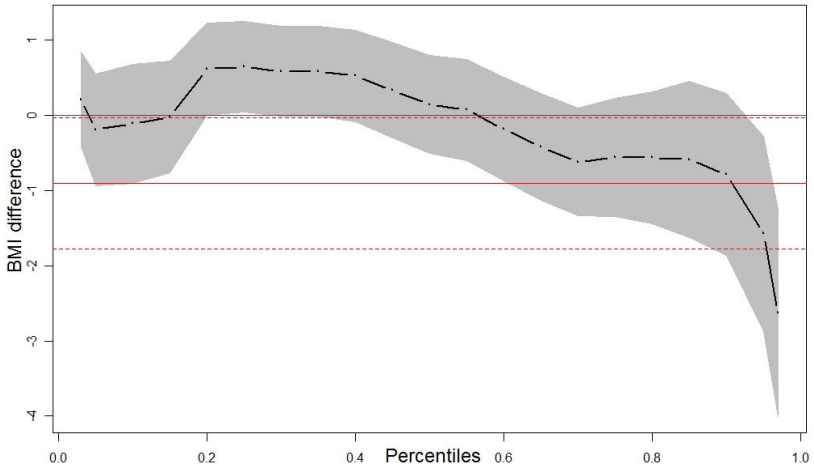

Figure 3.3 Effects of parental state sector

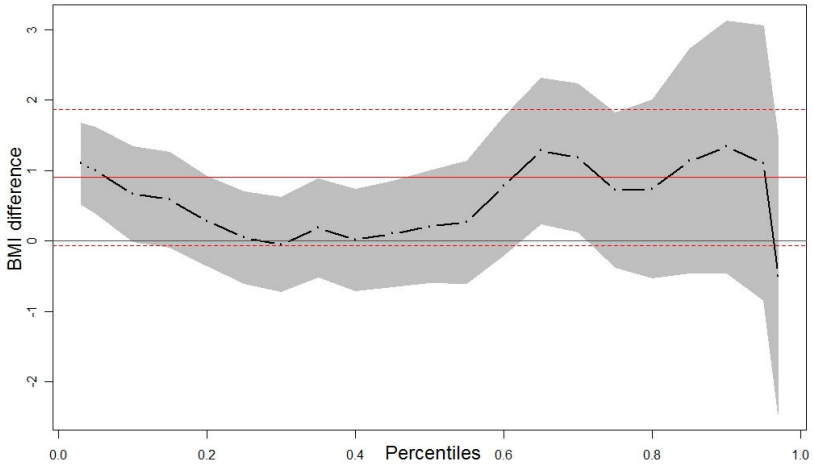

Figure 3.4 Effects of parental administrative job

Figure 3 Coefficients of socio-economic determinants and 90% confidence bounds for childhood BMI differences from quantile analyses controlling for sex, (high order terms of) age, parental ages, parental BMI, urban residency and regions in 2006: kernel density estimation

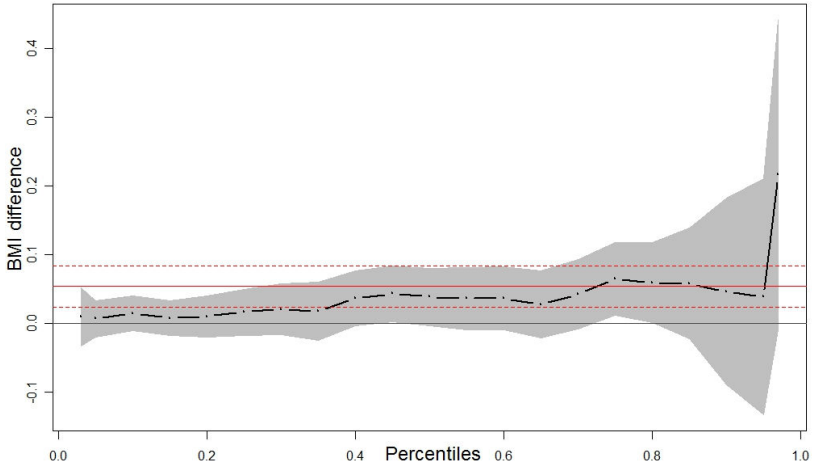

Figure 4.1 Effects of per capita household income

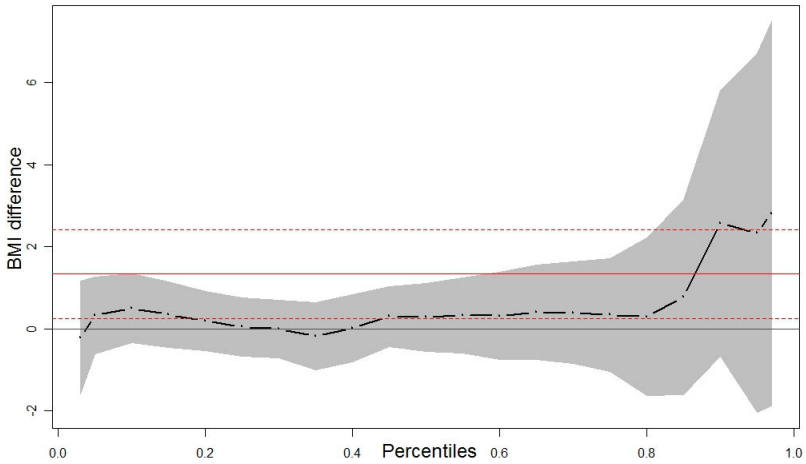

Figure 4.2 Effects of parental tertiary education

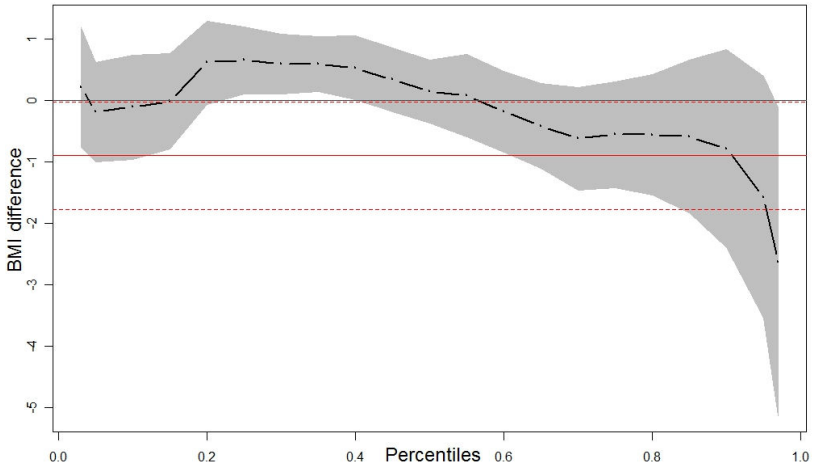

Figure 4.3 Effects of parental state sector

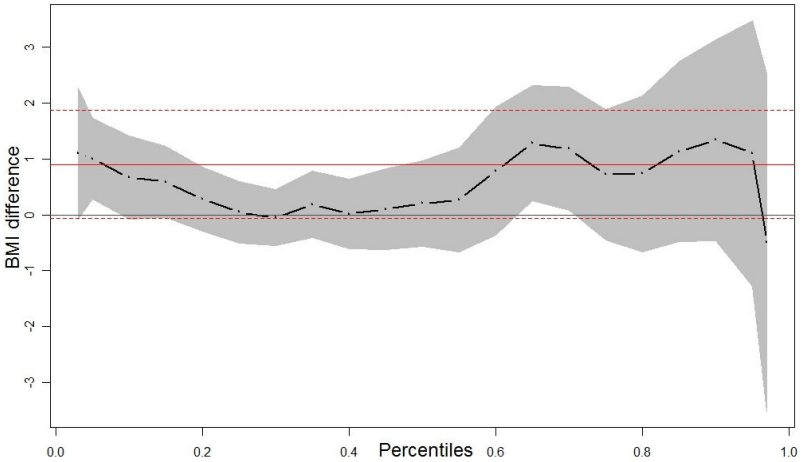

Figure 4.4 Effects of parental administrative job

Figure 4 Coefficients of socio-economic determinants and 90% confidence bounds for childhood BMI differences from quantile analyses controlling for sex, (high order terms of) age, parental ages, parental BMI, urban residency and regions in 2006: bootstrap estimation

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