

Family Structure and Child Malnutrition in China: Three Essays

by

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Dissertation submitted in partial fulfillment of  
the requirements for the degree of Doctor of Philosophy  
in Public Policy Studies  
in the Graduate School of Duke University

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ABSTRACT

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## **Abstract**

Over the past three decades, the co-existence of overweight and underweight has characterized the phenomenon of children's health in China. As the primary institution for a child, family is an opportune place for child malnutrition intervention. By advancing a framework that addresses the contextual factors which shape the heterogeneity of socioeconomic gradients of child overweight/obesity, this dissertation has sought to understand the channels through which access to family resources influences child overweight/obesity in China. Based on these developed understandings, I identified the mechanisms by which having any younger siblings and three generation living together or in proximity affect child malnutrition in China. Using data drawn from the China Health and Nutrition Survey, this dissertation uncovered remarkable differences in multiple levels of contextual factors that shape a child's risk of overweight/obesity and underweight in China as compared to Western society. China's stage of economic development and the ever-increasing wealth disparity have created a growing socioeconomic gap in child overweight/obesity, especially after 1997. This finding confirmed the position of the Ecological System framework that access to obesogenic environment is much more important than willpower based on knowledge in shaping one's obesity-related risk behavior. Despite the tremendous economic growth and the dramatic decrease in fertility level, resource dilution effect on basic nutrition intake still existed among girls, especially for those exposed to poverty and food insecurity. Children in the care of grandparents are healthier, probably due to the generally low degree of access to obesogenic foods and a closer intergenerational

relationship that facilitates effective communication and promotes healthy lifestyle formation.

## **Dedication**

To my mother, husband and daughter

## Contents

Abstract .....	iv
List of tables .....	xiii
List of figures .....	xvi
Acknowledgments .....	xvii
Chapter 1: Introduction.....	1
1.1 The coexistence of overnutrition and undernutrition among children in China.....	1
1.1.1 The magnitude of overweight/obesity and underweight over years .....	1
1.1.2 Consequences of child malnutrition.....	1
1.2 Child malnutrition with a focus on family .....	2
1.3 Data .....	5
1.4 How this dissertation is organized .....	6
Chapter 2: The roles of family SES and family structure in child nutrition status .....	8
2.1 The role of family socioeconomic status in child overweight/obesity in Western social science literature.....	8
2.1.1 Family SES directly influences child nutritional risk behavior .....	8
2.1.2 Family SES shapes exposure to risk regulators .....	9
2.1.3 A framework for a broader context.....	11
2.2 The roles of two family structural factors in child overweight/obesity and underweight.....	14

2.2.2 The role of presence of grandparents in the household or neighborhood in child overweight/obesity and underweight.....	16
Chapter 3: Data and Measurement.....	19
3.1 Description of Study Data.....	19
3.2 Measurements .....	20
3.2.1 Health Outcomes.....	20
3.2.2 Predictor variables .....	29
3.3 Data Limitations.....	32
3.3.1 Lack of sample weights.....	32
3.3.2 Newly added sample.....	34
3.3.3 Attrition Issues .....	35
3.3.4 Missing BMI.....	40
3.3.5 Missing on independent variables and descriptive statistics .....	41
3.3.6 A comparison between CHNS and China National Health and Nutrition Survey .	46
Chapter 4: Increasing socioeconomic gap in child overweight/obesity in China .....	47
4.1 Introduction .....	47
4.2 Conceptual framework.....	48
4.2.1 Price of and general access to high-energy dense diets.....	49
4.2.2 Obesogenic Physical Inactivity Environments .....	51
4.2.3 Ideal body shape and awareness of obesity-related health problems.....	52

4.2.4 The relative importance of the contextual factors .....	52
4.3 The case of China .....	53
4.3.1 Price and Access to Energy Dense Foods .....	54
4.3.2 Urbanization and declining physical activity .....	55
4.3.3 The Super slim body ideal and obesity-related knowledge.....	56
4.4 Data and methods .....	57
4.4.1 Measurement .....	57
4.4.2 Methods.....	58
4.5 Results.....	59
4.5.1 SES trends for child overweight/obesity in China.....	59
4.5.2 The role of energy intake and expenditure .....	61
4.5.3 Trends in SES gradients of overweight/obesity by gender .....	62
4.5.4 The role of health knowledge.....	64
4.6 Discussion and conclusion.....	65
Chapter 5: The Influence of Having a Younger Sibling on Child Nutrition Status in China--Under the One Child Policy Regime .....	69
5.1 Introduction .....	69
5.2 Conceptual framework.....	71
5.3 Setting .....	74

5.4 Data .....	77
5.5 Measurement .....	77
5.5.1 Dependent variables .....	78
5.6 Methods .....	79
5.7 Results.....	84
5.7.1 Descriptive analyses .....	85
5.7.2 Having younger siblings and nutrition status .....	86
5.7.3 Having younger siblings and nutrition intake .....	92
5.8 Discussion and Conclusions.....	92
Chapter 6: Co-residence with grandparent(s) benefits child nutrition status in China....	97
6.1 Introduction .....	97
6.2 Background .....	99
6.3 Potential pathways .....	100
6.4 Data .....	105
6.5 Measurement .....	105
6.6 Methods.....	106
6.7 Results.....	110
6.7.1 Descriptive analysis.....	110
6.7.2 Causal inference analysis.....	112
6.8 Discussions and conclusion.....	120

Chapter 7: Discussions and implications.....	123
7.1 Introduction .....	123
7.2 Increasing socioeconomic gap in child overweight/obesity .....	124
7.3 Does having younger siblings matter for nutrition status? .....	129
7.4 The presence of grandparents in households or neighborhood and child nutrition status.....	132
7.5 Conclusion .....	136
Appendix.....	138
Appendix 3.1: Temporary change in prevalence of obesity in China .....	138
Appendix 4.1: Logistic regression on attrition status by characteristics at the previous wave, CHNS 1991- 2006 (robust standard error adjusted at personal ID level). .....	139
Appendix 4.2: Regress mother’s BMI on Missing status for children aged 2-18, CHNS 1991 to 2006, correcting clustering at individual level.....	139
Appendix 4.3: Descriptive statistics for children aged 2-18 with no missing values in the major variables, China Health and Nutrition Survey 1991-2006.....	140
Appendix 4.4: How nutrition intake data is collected .....	141
Appendix 4.5: Distribution of BMI for children age 2-18 by father’s education attainment and period .....	143
Appendix 4.6: Trend of child (aged 2-18) daily energy intake, daily protein intake and daily fat intake by father’s education attainment. CHNS 1991-2006.....	144
Appendix 4.7: Overweight/obesity status and SES indicators by gender, CHNS 1991-2006, Results from GEE models .....	145
Appendix 4.8: Percentage who disagree on the listed statements by SES (aged 12 to 18), China Health and Nutrition Survey 2004 and 2006 (sample size in parentheses).....	146

Appendix 5.1: Logistic regression on attrition status by characteristics at the previous wave, for first-born children age 2-18, CHNS1991- 2006 (robust standard error adjusted at personal ID level).....	147
Appendix 5.2: Regress mother’s BMI on Missing status for first born children aged 2-18, CHNS 1991 to 2006, correcting clustering at individual level.....	147
Appendix 5.3: Monetary punishments for excess fertility, China 1979-2000 .....	148
Appendix 5.4: Regress change of fine level from 1991 to 2000 on 1991 community level characteristics, correcting clustering at individual level.....	148
Appendix 6.1: Logistic regression on attrition for children aged 2-12, CHNS 1991-2006, correcting clustering at individual level.....	149
Appendix 6.2: Regress mother’s BMI on Missing status for children aged 2-12, CHNS 1991 to 2006, correcting clustering at individual level.....	149
Appendix 6.31: Ratio of (number of male siblings)/(number of siblings) for the child’s father, children 2-12, by fathers’ birth year, CHNS 2000.....	150
Appendix 6.32: Ratio of (number of male siblings)/(number of siblings) for the child’s father, children 2-12, by fathers’ birth year, CHNS 2004.....	151
Appendix 6.33: Ratio of (number of male siblings)/(number of siblings) for the child’s father, children 2-12, by fathers’ birth year, CHNS 2006.....	152
References .....	153
Biography.....	171

## List of tables

Table 3.1: International cut off points for body index for overweight and obesity by sex between 2 and 18 years, defined to pass through body mass index of 25 and 30 kg/m <sup>2</sup> at age 18, obtained by averaging data from brazil, great Britain, Hong Kong, Netherlands, Singapore and United states.....	25
Table 3.3: International cut-off points for BMI for thinness for exact ages between 2 and 18 years, defined to pass through BMI of 17 at age 18, obtained by averaging data from Brazil, Great Britain, Hong Kong, Netherlands, Singapore, and US, (Cole et al., 2007) ...	28
Table 3.4: Age distribution for each province based on 1990 census and CHNS 1989 sample.....	32
Table 3.5: Age distribution for each province in 1990 census and CHNS 1991 sample....	33
Table 3.6: Age distribution in 2000 census and CHNS 2000 sample .....	33
Table 3.7: Results of regression on BMI, children aged 2-18, CHNS 1991-2006, correcting clustering at the individual level .....	34
Table 3.8: Follow-up rate based on 1991 child sample (age<19 at 1991), children who are aged out censored .....	35
Table 3.9: Follow-up rate based on 1991 child sample (age<19 at 1991), including children who are aged out at each wave in denominator and numerator .....	36
Table 3.10: Follow-up rate from the previous wave .....	36
Table 3.12: Child participation rate for all child respondents who ever enter the survey as a child under 19 .....	37
Table 3.13: Logistic regression on attrition status, characteristics at the previous wave as the predictors of the attrition status at each wave, CHNS 1991, 1993, 1997, 2000, 2004 and 2006, for children aged 2-18, robust standard error adjusted at personal ID level.....	39
Table 3.14: Logistic regression on missing of BMI, CHNS 1991, 1993, 1997, 2000, 2004 and 2006, children aged 2-18, robust standard error adjusted at personal ID level.....	41
Table 3.15: Mean and missing pattern for children 2-18, China Health and Nutrition Survey 1991-2006.....	42

Table 4.11: Overweight/obesity status and SES indicators, CHNS 1991-2006, Children aged 2-18, Results from GEE models .....	63
Table 4.12: Overweight/obesity status and SES indicators, CHNS 1991-2006, Children aged 6-18, Results from GEE models .....	64
Table 5.1: Descriptive statistics for first-born children aged 2-18 with no missing values in major variables, China Health and Nutrition Survey 1991-2006 .....	87
Table 5.2: Results for overweight/obesity from OLS and bivariate probit models for first-born children aged 2-18, CHNS 1991-2006, clustering correction at individual level .....	89
Table 5.3: Results for underweight from OLS and bivariate probit models for first-born children aged 2-18, CHNS 1991-2006, cluster at individual level .....	90
Table 5.4: Results for underweight from OLS and bivariate probit models for first-born children aged 2-18 by residence type, CHNS 1991-2006, cluster at individual level .....	92
Table 5.5: Results on daily nutrition intake (kcal) by estimating two-stage instrument variable models for first-born children aged 2-18, CHNS 1991-2006, correcting clustering at individual level .....	94
Table 6.1: Variable means by year for children aged 2-12, CHNS 1991-2006 .....	111
Table 6.2: Difference in percent of respondents who disagree on obesity related health statements between groups aged 25-49 and groups aged 50 or above in 2004 and 2006, CHNS 2004 and 2006, gender and household fixed effects controlled .....	111
Table 6.3: Results of multivariate regressions on child nutrition status, children aged 2-12; correcting clustering at individual level .....	112
Table 6.4: Results of Univariate Probit models and Bivariate Probit models on child nutrition status, children aged 2-12; correcting clustering at individual level .....	114
Table 6.5: Results of Univariate Probit models and Bivariate Probit models on child nutrition status, children aged 2-12 whose father was born before 1971, correcting clustering at individual level.....	115
Table 6.6: Results of linear instrument variable models on child daily nutrition intake, children aged 2-12; correcting clustering at individual level .....	118

Table 6.7: Results of Linear Instrument Variable models on child nutrition intake and Probit models on child underweight for children aged 2-6; correcting clustering at individual level..... 119

## List of figures

Figure 2.1: Framework of child overweight/obesity for a broader context .....	11
Figure 4.1: Trend of child overweight/obesity prevalence from 1991 to 2006 for children aged 2-18, by father's education attainment, parental political elite status, and urban/rural residency, China Health and Nutrition Survey 1991 to 2006 .....	59
Figure 4.2: Mean difference in per capita family income (CPI-adjusted) for children Aged 2-18 between higher and lower SES groups by survey year.....	60

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# **Chapter 1: Introduction**

## ***1.1 The coexistence of overnutrition and undernutrition among children in China***

### **1.1.1 The magnitude of overweight/obesity and underweight over years**

Over the past two decades, China has witnessed the fastest economic growth in its history. During this period, owing to the nutrition transition and the decline of physical activity, child overweight/obesity has become an emerging problem (Popkin et al., 2001; Du et al., 2004). This is particularly true for young, high-income, urban children and adolescents in China (Wang et al., 2002). In 2005, among children ages 7-17, 7.73% were overweight and 3.71% were obese (Ji et al., 2009). Among children ages 2-6, the obesity prevalence is even higher in nine provinces of China (Luo and Hu, 2002).

At the same time, there has been a remarkable decrease of undernutrition among children. From 1990 to 2005, the prevalence of underweight and stunting of children under age 5 steadily decreased from 22.6% to 8.6% and 41.4% to 13.1%, respectively (Chang et al., 2006). The underweight prevalence among children ages 6-18 fell from 14.5% (Wang et al., 2002) to 9.1% (Dearth-Wesley et al., 2008) between 1991 and 2005. However, undernutrition remains high in rural area (Svedberg, 2006; Dearth-Wesley et al., 2008). For example, in 2002 the prevalence of stunting among children under age 5 was still around 20% in some rural area (Svedberg, 2006).

### **1.1.2 Consequences of child malnutrition**

Underweight and overweight both have long-term consequences on child wellbeing. Underweight contributes to long-term developmental deficits, increased risk

of mortality from infectious illness, poor school performance and poor productivity in adulthood (Jamison, 1986; Whitaker; 1997; Hannon et al., 2005; Freedman et al., 1999; Das Gupta and Ray, 1986; Maluccio et al., 2009). Overweight children and adolescents in China have a higher risk of metabolic syndrome, body dissatisfaction and depression (Li, 2007). Childhood obesity leads to hypertension, dyslipidaemia, chronic inflammation, increased blood clotting tendency, endothelial dysfunction, and hyperinsulinaemia both in early childhood and later life (Freedman et al., 1999; Ebbeling et al., 2002). Childhood overweight/obesity might have a particularly serious effect on children in developing countries because intrauterine and early malnutrition amplify the detrimental effects of later excess weight gain (Barker, 1995). In China, overweight children were 2.8 times more likely than other children to become overweight adolescents (Wang et al., 2000).

## ***1.2 Child malnutrition with a focus on family***

As the primary institution for children, family plays a key role in child nutrition status. Family socioeconomic status (SES) and family structure have long been key components in determining child nutrition status (Wang et al., 2002; Murasko, 2009; Bilaver, 2010; Balderama-Guzman, 1978; Hesketh et al., 2003; Yang, 2006; Bredenkamp, 2008). For example, it is well documented that family SES is associated with child overweight/obesity (e.g., Murasko, 2009; Bilaver, 2010). Relatively low family income is among the most powerful predictors of undernutrition for children (Ge et al., 1999; Bentley et al., 2011). The number of children in a family is an important predictor of child underweight and overweight (Balderama-guzman, 1978; Hesketh et al., 2003; Yang, 2006). Children cared for by grandparents were likely to be overweight or obese in the

United Kingdom (Pearce et al., 2010), and some Chinese literature suggests a similar effect might exist in China (Jiang et al., 2006).

To understand how the aforementioned family level factors affect child nutrition status in China and also shed light on other countries, developing countries in particular, it is important to first understand what family resources mean for child malnutrition.

Although the relationship between access to resources and undernutrition is well established, it remains a puzzle when the conversation turns to overnutrition. In developed countries, for example, relatively high SES means less obesity (Ball and Crawford, 2005; Bilaver, 2010), whereas in China and many other developing countries, the opposite is typically true (Sobal and Stunkard, 1989; Wang et al., 2002). What specific contextual factors link the stage of economic development to the sign and strength of SES-overweight association? What do we know about the relative importance of these factors? What would happen if these contextual factors were to exert contradictory influences on the SES profile of overweight/obesity when a country is undergoing rapid changes? One specific aim of this dissertation is to bring together the literature in social epidemiology and health economics on the SES profile of overweight/obesity to develop a theoretical framework that addresses these contextual factors. Under the guidance of this framework, I will examine the case of China using data drawn from the China Health and Nutrition Survey (CHNS).

With improved understanding of the role that family resources play in child nutrition status, this dissertation aims to identify the impact of two important family structure elements on child underweight and overweight status. These two factors are: 1)

being the only child versus having any younger siblings and 2) the presence of grandparents in the household or neighborhood.

In China, the drastic demographic transition from a high fertility level to a low fertility level took place in the late 1970s when the One Child Policy was implemented; the percentage of only children has been increasing every year since (Hesketh et al., 2005). This change in fertility resulted in a family structure abruptly different from that of previous generations. However, the pattern of three generations living together or proximately still characterizes a substantial portion of Chinese households (Zeng and George, 2002). Whereas the typical living arrangement for adults is a nuclear family, the typical living arrangement for the elderly with adult children is co-residing with their adult children as a three-generation family or living in the same neighborhood (Zeng and George, 2002; Chen et al., 2000).

Social demography and economic demography have long been interested in identifying the impact of family size on child nutrition status. The One Child Policy has been criticized by the media and researchers as the leading cause of childhood obesity in China because it reduced total fertility (Taylor, 2004; Ni, 2000). However, having multiple children has been found to increase the risk of malnutrition (Rao and Gopalan 1969; Balderama-guzman, 1978). One thing researchers know very little about is the effect of increasing the number of children from one to two or three.

The three-generation co-residence or living proximately might carry a broad range of consequence on a family member's financial wellbeing, work productivity, academic achievement and health outcomes. As an important substitute for maternal

care, childcare provided by grandparents alleviates the mother's role conflicts (Chen et al., 2000), but there is little conclusive evidence of its impact on child nutrition status.

One specific aim of this dissertation is to identify the impact of this family living arrangement on child nutrition. The results could provide useful information for child malnutrition intervention. Success in finding a valid estimator would also help to identify the impact of this living arrangement on the wellbeing of other family members and to justify policy interventions such as providing public pensions that ease the financial burden of caring for older family members and facilitating commercial elder care.

In sum, this dissertation focuses on important family-level factors to understand child overweight/obesity in China, and to shed light on the situation in other countries, particularly developing countries in particular. Specifically, I aim to accomplish these tasks:

- 1). Develop a framework to address contextual factors that shape the heterogeneity of SES gradients of child overweight/obesity, and to identify the dramatic change in macro-social contexts of China that have shaped the pathways in which SES has affected child overweight/obesity over the past two to three decades.

- 2). Evaluate the impact of having younger sibling(s) on the first-born child's nutrition status, and how this effect may be shaped by the decline of total fertility, son preference, gender inequality and an urban versus rural setting.

3). Examine the impact of three generations living together or proximately on child overweight/obesity and underweight, and how this impact may be shaped by the Confucian patrilineal tradition and country-specific family contextual factors.

### **1.3 Data**

I draw data from waves 1991, 1993, 1997, 2000, 2002, 2004 and 2006 of the CHNS. CHNS is longitudinal, based on surveys of households, nutrition, communities, ever-married women, and physical examinations. The surveys took place over a three-day period using a multistage, random-cluster process to draw a sample in nine provinces that vary substantially in geography, economic development, public resources and health indicators. The average characteristics of these provinces are nationally representative in many cases (State Statistical Bureau of China, 2002). The detailed community data were collected in surveys of food markets, health facilities, family planning officials and other social services and community leaders. In addition to professionally collected anthropometric data, CHNS provides the richest information about household social economic status, extended family structure and nutrition intake so far, therefore best serves the purpose of this dissertation.

### **1.4 How this dissertation is organized**

The remainder of the dissertation is organized as follows. In Chapter 2, I will introduce the conceptual framework and briefly discuss the roles of family SES, having younger siblings and three generations living together or proximately, and their impact on child nutrition. In Chapter 3, I will describe the data and measurements, address the problem of missing data and selective attrition, and then present the basic descriptive

statistics of the variables. Chapter 4 will develop a new conceptual framework that integrates tenets from health economics and social epidemiology, and then analyze the impact of socioeconomic forces on observed changes in the SES gradients of child overweight/obesity in China over the past two decades using Generalized Estimating Equation models. Chapter 5 will discuss the main channels through which having younger siblings affects child nutrition status, and then analyze the impact of having younger siblings on overweight/obesity and underweight using instrument variable models. Chapter 6 will discuss impact of three-generation co-residence or living proximately on child nutrition in China, and use instrument variable models to identify the impact. Chapter 7 will present the discussions and policy implications.

## **Chapter 2: The roles of family SES and family structure in child nutrition status**

Compared to how family SES is related to child underweight, the way family SES is linked to child overweight/obesity is much more complex. Section 2.1 is devoted to a review of the literature on the relationship between family SES and child overweight/obesity. In Section 2.2, I review the literature on the roles that two family structural elements play in child nutrition status.

### ***2.1 The role of family socioeconomic status in child overweight/obesity in Western social science literature***

A PubMed search with the key words “child obesity” and “framework” generates 33 articles. Of these articles, five explicitly attempt to establish an overarching conceptual framework addressing the risk factors of obesity. The framework developed in each paper is a variation on the ecological model first suggested by Egger and Swinburn (1997). Within this set of models, family SES markers including parental education, family income and parental occupation affect how children store fat. Environmental risk factors include the physical, economic and sociocultural environments within a family, neighborhood, schools and broader society. Two major pathways through which family SES affects child overweight/obesity are identified: 1) family SES has a direct impact on a child’s risk and 2) family SES shapes a child’s exposure to multilevel risk regulators.

### **2.1.1 Family SES directly influences child nutritional risk behavior**

Family SES determines, in large part, a child's choice of foods, meal structure and sedentary versus active lifestyle (Mei et al., 1998; Anderson, 2003; Myers et al., 1996). For example, in Western literature, lower income groups consume more calorie-dense foods (obesogenic foods) (Drewnowski, 2003; Monsivais & Drewnowski, 2007), and parents exert relatively little control in monitoring or limiting children's TV watching (Myers et al., 2000). Family SES also affects the access to health knowledge related to obesity, especially when the related knowledge just began to emerge (Link and Phelan, 1995).

### **2.1.2 Family SES shapes exposure to risk regulators**

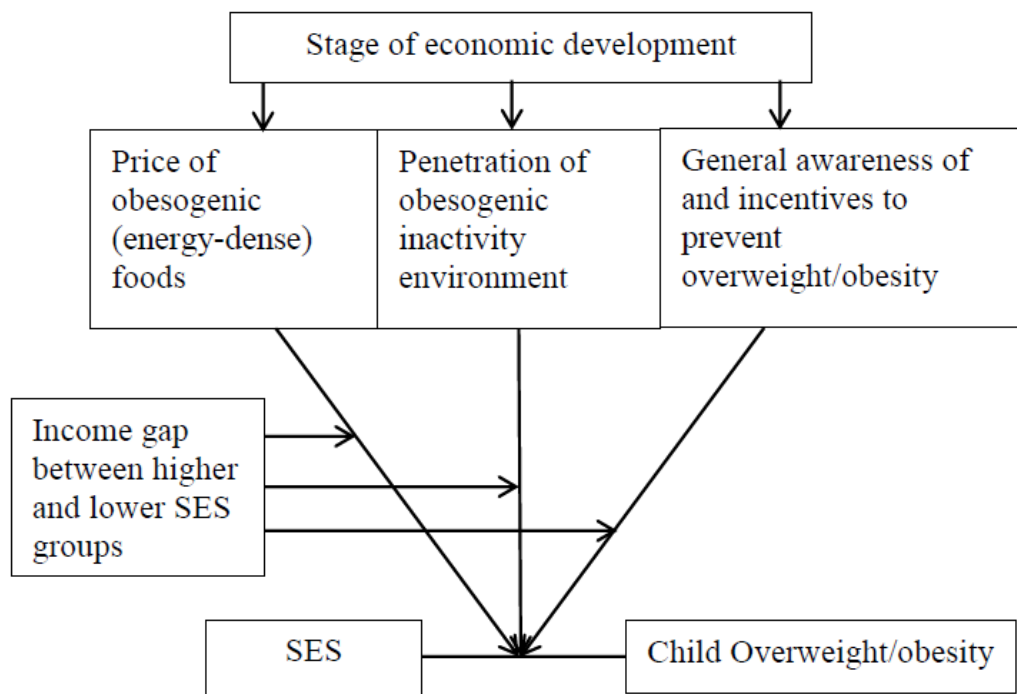
Family SES exposes a child to environmental risks by determining the child's neighborhood, school and community at large. Community-level deprivation and poverty in lower SES and ethnic minority neighborhoods could exacerbate or dampen the influence of accepted risk factors for obesity (Glass and McAtee, 2006). For example, lower family SES may mean that a family lives in an area with little to no access to markets that supply fresh foods (Baker et al., 2006). Lack of markets, transportation to markets, and even stress caused by the relatively higher crime rate and deprivation in such neighborhoods could lead to more consumption of energy-dense food (high-calorie, low-nutritional value foods) (Tuinstra, 1998; Glass and McAtee, 2006). Neighborhoods that are not safe and those that lack parks, sidewalks and trails also discourage physical activity (Gordon-Larsen et al., 2000). Furthermore, neighborhood social efficacy is usually higher in neighborhoods composed of higher SES families (Kruger et al., 2007). Social cohesion, social capital, social networks and collective efficacy are identified as

important factors that contribute to physical activity (Franzini et al., 2009). Some studies have documented the effect of these factors on children's body mass index (Kim et al., 2006; Fisher et al 2004; Cohen et al., 2004). Lastly, family SES might be related to school food environment and child's participation in costly organized sports.

In sum, these frameworks provide comprehensive perspectives to study SES-overweight relationship within the Western context. However, these perspectives have a series of assumptions pertaining to the contextual factors under which the family SES affects child overweight/obesity. For example, lower income families in Western society observe more child sedentary behaviors, because having children watch TV or play video games is relatively inexpensive compared to parents-initiated physical activities or participating costly organized sports, and access to automobiles is close to universal. However, under a developing country setting, the cost of TV, video game sets or automobiles might still prevent the lower income groups from making sedentary choices. Another example, in the US, stress from relative deprivation and poverty caused more consumption of energy dense foods (Tuinstra, 1998). One key reason is that in the United States, the price of mass-produced fast food is low, making it more affordable than fresh vegetables and fruits (Monsivais & Drewnowski, 2007). However under the context where high-energy-dense foods are more expensive, the outlet of stress should be different. Finally, Western societies idolize a thin body shape, whereas in many developing countries, the cultural norm favors a larger body (Messer 1989; Monterio, 2004; McLaren, 2007).

### 2.1.3 A framework for a broader context

Previous literature consistently found associations between a country's stage of economic development and the SES-overweight association for adults and children (Monterio, 2004; McLaren, 2007; Jones-Smith, 2011). Adding "the stage of economic development" into the framework aims to appreciate its connection with the macro-level food environment, physical activity environment and societal attitude toward overweight/obesity.



**Figure 2.1: Framework of child overweight/obesity for a broader context**

My contribution lies in developing a framework which synthesizes these contextual factors. These factors are: 1) the price of high energy dense foods (obesogenic foods), 2) the degree of penetration of obesogenic physical inactivity environments, and 3) a general awareness of, and incentives to prevent, overweight/obesity. I also theorize

about how the interaction between income inequality and environmental factors shapes the SES gap in the consumption of obesogenic foods and use of labor saving devices. See Figure 2.1 for this framework.

When a country, such as the United States, is highly developed, we observe a relative low price of mass produced high-energy-dense food and highly pervasive obesogenic physical inactivity environment (Drewnowski, 2003; Egger and Swinburn, 1997). In the US, general access to obesogenic foods is high due to the relative low price compared to fresh vegetables and fruits. The price of obesogenic foods were brought down by the economy of scale, revolution in technology and in some cases government subsidies (Drewnowski, 2003; Popkin et al., 2002, 2012). General access to labor-saving devices and automobiles is also high due to technology advancement (Egger and Swinburn, 1997).

However, when a country is in the early stages of development, food scarcity among the poor and the greater capacity of the elites in obtaining high-energy foods contribute to a positive SES-overweight association (e.g., Monterio, 2004). High-energy foods are far more expensive relative to fresh vegetables and fruits (Ge et al., 1999; Lu and Goldman, 2010). Homemade food from simple ingredients is especially cheaper in a developing country where labor costs are low. For example, in China, a very low level of away-from-home food intake has been observed because Western-style fast food and snacks are still more expensive than regular homemade foods (Wang et al., 2008). The environment for physical activity is largely related to the stage of urbanization constrained by the stage of economic development. At the initial stage of urbanization,

only higher SES groups are able to take full advantage of the transportation infrastructure and other labor-saving devices. However, even higher SES groups tend to lack incentives to eat less and exercise more in order to avoid becoming overweight/obese. Unlike the Western ideal of a thin body, the cultural norm in underdeveloped countries is more likely a larger body, for some a symbol of prosperity, of having enough to eat (Messer 1989; Monterio, 2004; McLaren, 2007). Then, too, medical knowledge and concerns about overweight are not as widespread (Cash and Pruzinsky, 2002; Luo et al., 2005).

Income inequality can shape the SES-overweight/obesity profile by interacting with the price of energy dense diets, exposure to obesogenic environments and overweight/obesity related ideology. For example, at the same per capita GNP level, larger income inequality between higher and lower SES groups means a larger gap in access to expensive goods. . If people lack awareness of the health consequences of overweight/obesity or effective measures to prevent overweight/obesity, as typically observed in developing countries, the gap in purchasing power could easily convert to a gap in consumption. Again in developing countries, larger income inequality leads to a larger gap in who can afford access to transportation and other labor saving technologies.

Admittedly, the links between the stage of development and these contextual factors are not universal. In this dissertation, I emphasize the role of the contextual factors that directly affect the way family SES is linked to child weight status.

Guided by this framework, I analyze the trend of SES gradients of child overweight/obesity in China. Over the past three decades, there has been a decline in the relative price of energy dense foods in China (Lu and Goldman, 2011), popularization of the Western body shape preferences (Luo et al., 2005) and increasing penetration of obesogenic inactivity environments. Meanwhile, income inequality between higher and lower SES groups increased at a fast pace as a result of a series of market reforms (Meng, 2004; Xing et al., 2010; Chen et al., 2010). Using CHNS data from 1991 to 2006, I will examine how the time trends of SES gradients of child overweight/obesity responded to the complex effect of the changing contextual factors. Specifically, I will first review the previous literature, and then I will make predictions about the trend of SES gradients of child overweight/obesity based on the framework I developed. Lastly, I will estimate Generalized Estimating Equation models to assess the predictions.

## ***2.2 The roles of two family structural factors in child overweight/obesity and underweight***

### **2.2.1 Having younger siblings and child overweight/obesity and underweight**

Why does having younger siblings matter for child nutrition status? The resource dilution model predicts that reducing the number of siblings reduces within-household resource competition (Becker and Lewis, 1973). In China, studies document a positive association between family resources and child overweight/obesity and a negative association between family resource and child underweight (Wang, 2002; Dearth-Wesley et al., 2008, Hsu et al., 2011; Ge et al., 2001). However, having only one child could grant the child more resources than the resource dilution model alone would predict, because

having only one child changed the within-family dynamics of decision making (McNeal and Wu, 1995; Ng, 2005). On the other hand, economies of scale in raising children (Qian, 2009) might exist. And a long birth interval is mandated (Powell and Steelman 1995; Yang, 2007), which prevents depletion of family resources. Stage of economic development also comes into play. If the expenditure of food consumption only takes a small portion of a family's budget, having one or two more children would not make any difference in basic nutrition intake.

In addition, the effect of having younger siblings might vary by gender. Girls suffer from prenatal and postnatal discrimination (Li et al. 2007; Li, 2004; Li and Cooney, 1993). A gendered body shape preference, which places higher pressure on females to be thin (Luo et al., 2005), could potentially legitimize less resource allocation to girls. "Parity Effect" and "Intensification Effect" (Das Gupta and Bhat, 1997) were adopted to understand whether girls have been treated equally since China's One Child Policy was initiated.

The few studies that touched on these topics produced inconsistent findings (Brauw and Mu, 2011; Hesketh et al., 2003; Yang, 2007; Chamrathirong, Sinhadej, & Yoddumern-Attig, 1987; Parsons, Logan, & Summerbell, 1999). So far, there hasn't been any study that attempts to identify the causal effects of having siblings on undernutrition and overweight/obesity, due to the difficulty in establishing causality. Some studies used household sibsize or the community-level, policy-sanctioned number of children per couple as instrument variable to identify the impact, but these variables are related to child nutrition status through multiple channels. Household sibsize could

be related to income untraced by the survey and informal support from family planning officials and extended family. The policy-sanctioned number of children per couple is related to the stage of local economic development and population density. Under the One Child Policy regime, the richest and most developed regions or metropolitan areas are all under the most stringent enforcement, whereas the less developed regions are under relatively relaxed enforcement (Gu et al., 2007).

In this dissertation, I will exploit the variations of monetary fine levels for an extra child across time and location as the instrument to identify whether having younger siblings affects a child's nutrition status, using CHNS data collected in 1991, 1993, 1997 and 2000, 2004, and 2006. Extensive analysis on whether the variation in fines is a valid instrument variable is conducted in Chapter 5.

### **2.2.2 The role of presence of grandparents in the household or neighborhood in child overweight/obesity and underweight**

Childcare provided by grandparents is found to be associated with a higher risk of child obesity in some Western countries (e.g., United Kingdom and Greece, 2011). In China, grandparents may play a more important role in child nutrition status because they are more actively involved in the lives of their grandchildren. They are often enlisted as childcare givers when mothers must work (Chen et al., 2000).

On one hand, grandparents could affect a child's food intake by shaping the family's food environment (grocery shopping, preparing meals, providing treats) and practicing certain parenting styles. Family food environment and caregivers' feeding practices have a lasting effect on a child's eating styles, food preference and physiologic

regulation of energy intake (Birch and Fisher, 1998; Anderson, et al., 2003). In three-generation co-resident families, grandparents normally assume responsibility for meal preparation (Jiang, 2006). Anecdotal evidence suggests that grandparents are more likely to think being overweight is healthy and more determined to make sure that children are “well fed” (Jiang, 2006), therefore, their involvement in childcare could potentially reduce the risk of underweight and increase the risk of overweight/obesity. On the other hand, grandparents in charge of family meals may contribute to a greater variety of healthier foods and reduce the incidence of eating out and missing breakfast—all behaviors that should reduce the risk of overweight/obesity (Lin et al., 1999; Rolls et al., 2004; Morgan et al. 1986).

Enjoying a more flexible schedule, grandparents living in the house or neighborhood might be better able to facilitate children’s out-door activities and take advantage of the neighborhood social efficacy. Given the close intergeneration relationship within typical Chinese families (Thornton and Lin, 1994), more effective communication between grandparents and parents on childrearing might be achieved. More importantly, in China where overweight/obesity still concentrated in higher socioeconomic groups (Wang, 2002, 2006; Li et al., 2007; Hsu et al., 2011), the vast majority of the population is under economic constraints that make it harder to access calorie-dense foods, use public transportation and other labor-saving devices, or engage in relatively expensive and sedentary forms of entertainment such as TV and video games. Thus, it may be easier to control a child’s risky eating and physical activity.

Since the direction and strength of the impact of grandparents on child overweight/obesity and underweight are unknown, I employ instrument variable models using CHNS data 1991-2006 to identify the causal inference. I will exploit the randomness of gender composition of a child's father's siblings to instrument the presence and proximity of grandparents. Specifically, I will use the number of the child's paternal uncles adjusting the total number of paternal uncles and aunts to predict the presence and proximity of grandparents. Extensive discussion on the validity of this instrument variable is conducted in Chapter 6. The instrument variable models developed in this chapter can also be used to identify the impact of three generations living together/proximately on each generation's wellbeing. As a traditional institution, the pattern of three generations co-residing or living proximately is still prevalent in countries nurtured by Confucian traditions. Compared to Western countries where researchers are more interested in comparing single-parent family/cohabiting families as opposed to families with married parents, countries nurtured by Confucian traditions are more interested in comparing extended families as opposed to nuclear families. Therefore, successfully identifying a valid instrument could be quite important.

## **Chapter 3: Data and Measurement**

### ***3.1 Description of Study Data***

In 1989, eight provinces (Guangxi, Guizhou, Henan, Hubei, Hunan, Jiangsu, Liaoning and Shandong) were selected for survey. Within each province, a multistage, random-cluster process was used to draw the sample. Counties and cities in each province were stratified by income (low, middle and high) and a weighted sampling scheme was used to randomly select four counties and two cities in each province. Among the counties selected, four villages/townships were selected randomly; among the cities selected, four urban/suburban neighborhoods were selected randomly. In each community (neighborhood), 20 households were randomly selected and all household members were interviewed. In 1997, Liaoning dropped out from the survey, and a new province Heilongjiang participated in the survey. Household follow-up levels are high, but families that migrate from one community to another are not followed. Since the 1993 survey, all new households formed from original sample households have been added. Since 1997, new households in original communities have been added to sample in order to replace households no longer participating in the study. Also since 1997, new communities in original provinces have been added to replace the sites no longer participating. Liaoning returned to the study in 2000. The procedure adopted to find replacement households randomly selects other households from the entire community if the total number of households in a community is less than 20, in order to keep at least 20 households per community. New communities in original provinces replacing communities that dropped out were selected using random stratified sampling.

In 1989-1993 there were 190 primary sampling units: 32 urban neighborhoods, 30 suburban neighborhoods, 32 towns (county or capital city), and 96 rural villages. Since 2000, the primary sampling units have increased to 216 neighborhoods including 36 urban neighborhoods, 36 suburban neighborhoods, 36 towns and 108 villages. CHNS 1989 surveyed 15,917 individuals. CHNS 1991 only surveyed individuals belonging to the original sample households, resulting in a sample size of 14,778. In CHNS 2006, a total of 18,764 individuals participated.

In the initial wave 1989, measurement of height and weight are not available for school age children, so I use data from waves 1991, 1993, 1997, 2000, 2004 and 2006 waves when the measurement of height and weight is available for children and adolescents. The sample is subjected to missing values from various sources. I discuss data limitations and then present the mean and standard deviations for the variables of interest based on the effective sample size.

## **3.2 Measurements**

### **3.2.1 Health Outcomes**

#### **3.2.1.1 Child overweight/obesity**

Obesity is defined as abnormal or excessive adipose tissue that may impair health, according to the World Health Organization (WHO). Determining obesity, the level of overweight that increases risk of mortality, involves two tasks: the first is to measure the amount of adipose tissue; the second is to define what level of adipose tissue is “abnormal.”

Composition measures could identify the amount of bone, lean and fat mass that are related to disease development. However, these methods are expensive, time consuming and complex (Goran, 1997). To measure body composition, methods including densitometry (underwater weighing), air-displacement plethysmography, dilution method (hydrometry), dual-energy x-ray absorptiometry (DXA), computed tomography (CT) and magnetic resonance imaging (MRI) could provide precise measurement in the lab but is of limited use for large sample and out-of-lab survey (Hu, 2008).

A well accepted and widely used measurement is BMI.  $BMI = \text{weight (in kg)} / \text{height}^2$  (in meters). Skinfold thickness is more related than BMI to body fat composition, but the measurement is much more expensive due to the complexity of this task that requires special training (Hu, 2008).

BMI is strongly correlated to absolute body fat and percent body fat (Gallagher et al., 1996). Keys (1972) examined various weight-height indexes and found that BMI had the highest correlations with adiposity validated by skin-fold thickness and body density measurements. The correlation between BMI and body fat varies by age, gender and ethnicity (Gallagher et al., 1996). Women generally have a higher percentage of body fat than men at the same BMI level (Janssen et al., 2005). In the process of aging, fat mass gradually takes over part of the lean mass: the reduction of muscle is first observed during the 30s, and noticeable skeleton muscle loss is first observed around age 45 (Janssen et al., 2005). Blacks have a lower percentage of body fat at the same BMI

compared to Caucasians, while Asians have higher percentage of body fat at the same BMI compared to Caucasians (Deurenberg et al., 1998)

BMI is associated with biochemical markers of obesity, cardiovascular risk and mortality (Li et al., 2006). To identify the excessive body fat that impairs health, studies basically examine the correlation between the measure of body fat and the mortality risk. The first well-accepted attempt to find the desirable body weight—the Metropolitan Life Tables—is based on insured adults (ages 25-59) in the United States and Canada from 1935-1954. The first national overweight prevalence estimates are based on the data of Health, United States for adults 20-29 years of age in 1984. Sex-specific 85<sup>th</sup> percentile is used to define overweight which resulted in BMI cut points of  $\geq 28$  (kg/m squared) for men and  $\text{BMI} \geq 35$  (kg/m (1.5power)) for women. The WHO Expert Committee on Physical Status in Geneva (1-8 November 1993) recommended that BMI ranged from 25.0 to 29.9 as the grade one overweight, 30.0 to 39.9 as the grade 2 overweight and BMI over 40 as the grade 3 overweight.

However, most studies that established the scales for underweight, normal, overweight and obese subjects had several major methodological problems: reverse causation, third factor confounding and over-adjusting. For example, smoking that is negatively related to body weight but positively related to mortality risks has a negative confounding effect if not adjusted (Calle EE, et al., 1999). Hormone use, physical activity, aspirin use, and alcohol consumption could also potentially confound the estimated effect of obesity (Li, et al., 2006).

Age, gender and ethnicity modify the mortality risk at the same level of BMI or other field metrics (Byers T, 2006). For example, some studies found a stronger relative risk of mortality associated with increasing BMI in younger participants than older ones (Byers T, 2006). Significant increase in relative risk of type 2 diabetes is detected at a BMI lower than 25 in Asians (Misra, 2003). Blacks have a lower risk of mortality at the same level of BMI compared to whites (Misra, 2003).

For children and adolescents, the precise measure such as DXA, bioelectric impedance, and densitometry might not be feasible for infants and young children because these procedures require immobile subjects (The, 2010). BMI is again the most commonly used measure, chosen by the WHO, NCHS and IOTF to define child overweight and obesity. However, for children, overweight does not necessarily mean over-fat. Dietz (2005) estimates that of the overweight children seen in the obesity clinic, 10-15% are not over-fat. For children under 18, BMI cut-offs for overweight and obesity must be age and gender specific, because for different development stages, BMI is differently associated with clinical risk factors of cardiovascular disease such as hyperlipidemia, elevated insulin and high blood pressure (Dietz, 2005). WHO (2000) further recommends conditioning the interpretation of BMI in adolescence on maturation status because body composition during adolescence is more correlated to the maturational age than chronological age, and adolescents of the same age may differ substantially in maturation status.

Waist circumference and waist-hip-ratio are also widely used measures of abdominal or central obesity. Both have been validated against DXA and CT and have

been found associated with chronic disease and mortality (Hu, 2008). Waist circumference is preferred to waist-hip-ratio because some studies found that waist circumference is a better predictor of total abdominal fat or abdominal visceral fat (Clasey et al., 1999). And waist circumference has been found associated with the development of health conditions better than waist-hip-ratio in many studies (Hu, 2008). For example, in some studies waist circumference was found to be a better predictor of elevated blood pressure than BMI, waist-hip-ratio and waist for height (Yalcin et al., 2005). However, there are no standard cut-offs for waist circumference for obesity among Chinese children and adolescents.

Aware of the above drawbacks in definitions, I will now discuss several technical definitions regarding child overweight/obesity. For children, BMI percentiles and Z score are widely used to define overweight and obesity. The U.S. Centers for Disease Control and Prevention defines “overweight” as being at or above the 95<sup>th</sup> percentile of BMI and “at risk of overweight” as being between the 85<sup>th</sup> and 95<sup>th</sup> percentiles of BMI at that age. The European Childhood Obesity Group defines overweight as being at or above the 85<sup>th</sup> percentile of BMI and obesity as being at or above the 95<sup>th</sup> percentile of BMI at that age. The cut-off points for BMI by the International Obesity Task Force (See table 3.1) for overweight and obesity are defined to pass through BMI of 25 and 30 at age 18, based on data from six countries including Singapore and Hong Kong. Many previous studies on China’s childhood obesity chose to use IOTF reference.

However, this international reference might still bias the estimate on the prevalence of overweight/obesity among Chinese children because Asians have higher

percent body fat than Caucasians at the same BMI (Misra, 2003). To establish a Chinese national reference to screen overweight and obesity, the Working Group on Obesity in

**Table 3.1: International cut off points for body index for overweight and obesity by sex between 2 and 18 years, defined to pass through body mass index of 25 and 30 kg/m<sup>2</sup> at age 18, obtained by averaging data from Brazil, Great Britain, Hong Kong, Netherlands, Singapore and United States**

Age (Years)	Body Mass Index 25 kg/m <sup>2</sup>		Body Mass Index 30 kg/m <sup>2</sup>	
	Males	Females	Males	Females
2	18.41	18.02	20.09	19.81
2.5	18.13	17.76	19.08	19.55
3	17.89	17.56	19.57	19.36
3.5	17.69	17.40	19.39	19.23
4	17.55	17.28	19.29	19.15
4.5	17.47	17.19	19.26	19.12
5	17.42	17.15	19.30	19.17
5.5	17.45	17.20	19.47	19.34
6	17.55	17.53	20.23	20.08
6.5	17.71	17.53	20.23	20.08
7	17.92	17.75	20.63	20.51
7.5	18.16	18.03	21.09	21.01
8	18.44	18.35	21.60	21.57
8.5	18.76	18.69	22.17	22.18
9	19.10	19.07	22.77	22.81
9.5	19.46	19.45	23.39	23.46
10	19.84	19.86	24	24.11
10.5	20.20	20.29	24.57	24.77
11	20.55	20.74	25.10	25.42
11.5	20.89	21.20	25.58	26.05
12	21.22	21.68	26.02	26.67
12.5	21.56	22.14	26.43	27.24
13	21.91	22.58	26.84	27.76
13.5	22.27	22.98	27.25	28.20
14	22.62	23.34	27.63	28.57
14.5	22.96	23.66	27.98	28.87
15	23.29	23.94	28.30	29.11
15.5	23.60	24.17	28.60	29.29
16	23.90	24.37	28.88	29.43
16.5	24.19	24.54	29.14	29.56
17	24.46	24.70	29.41	29.69
17.5	24.73	24.85	29.70	29.84
18	25	25	30	30

Source: Cole, T. J et al. BMJ 2000; 320:1240

China analyzed the 2000 Chinese National Survey on Students Constitution and Health data which includes 216620 primary and secondary school students aged 7 to 18, and defined percentile 85<sup>th</sup> as being overweight and percentile 95<sup>th</sup> as being obese (2004).

Table 3.2 shows the BMI cut-offs by the WGOC (2004).

**Table 3.2: BMI cut-offs for overweight and obesity for Chinese children aged 7 to 18**

Age (years)	Boys		Girls	
	Overweight	Obesity	Overweight	Obesity
7	17.4	19.2	17.2	18.9
8	18.1	20.3	18.1	19.9
9	18.9	21.4	19.0	21.0
10	19.6	22.5	20.0	22.1
11	20.3	23.6	21.1	23.3
12	21.0	24.7	21.9	24.5
13	21.9	25.7	22.6	25.6
14	22.6	26.4	23.0	26.3
15	23.1	26.9	23.4	26.9
16	23.5	27.4	23.7	27.4
17	23.8	27.8	23.8	27.7
18	24.0	28.0	24.0	28.0

Source: Working Group of Obesity in China, 2004

To verify this BMI reference, Ma et al (2006) examined the association between BMI and the average level of pediatric metabolic syndrome/abnormality which predicts adult cardiovascular diseases, diabetes and BMI percentiles (Morrison, 2007). They found that there is neither significantly increasing nor decreasing trend of biochemical parameter levels in low BMI percentile range (BMI<65<sup>th</sup> percentile), but a slight increase in a higher level (BMI>75<sup>th</sup> percentile), and a significant increase in BMI level equal to or higher than the 85<sup>th</sup> percentile. Xu and Ji (2008) compared the prevalence of obesity and the metabolic syndrome for children ages 14-16 and found that IOTF reference

generated a 30% and 50% lower prevalence estimates for obesity, for males and females, respectively as opposed to the WGOC reference.

In my dissertation, I adopt a WGOC reference for children ages 7 to 18. For children ages 2-6, there are no BMI cut-offs in the WGOC reference due to the limitation of the sample. IOTF BMI cut-offs are used to define overweight/obesity instead. For adults over age 19, I use BMI cut-offs in the WGOC survey that define overweight as  $BMI \geq 24$  and obesity as  $BMI \geq 28$ .

### **3.2.1.2 Child underweight**

Measurements of underweight include weight for age (Gomez et al., 1956), weight for height (Seoane and Latham, 1971; WHO 1983), height for age (Seoane and Latham, 1971), and BMI for age (WHO 1995, 2007; Cole et al., 2007). Among these measurements, BMI for age has been recognized as the most encompassing measurement because it makes use of the information of height, weight and age (WHO 1995, 2007; Cole et al., 2007). The advantage of BMI for age, for example, compared to weight for height is that it recognizes that the weight-height relationship varies by age. In fact, in infancy and adolescence, the weight-for-height relation is highly conditioned by age (Cole, 1986): in infancy, the ratio of weight/height is larger compared to mid-childhood because this is the period when weight grows fastest relative to height; whereas in later adolescence, as weight continues to grow but height growth stops, the ratio increases again.

In this dissertation, since there is no established reference for underweight in the Chinese population, I use the IOTF 2007 definition of thinness based on BMI for age to

**Table 3.3: International cut-off points for BMI for thinness for exact ages between 2 and 18 years, defined to pass through BMI of 17 at age 18, obtained by averaging data from Brazil, Great Britain, Hong Kong, Netherlands, Singapore and the United States (Cole et al., 2007)**

Age (in years)	Boys	Girls
2	14.12	13.9
2.5	13.94	13.74
3	13.79	13.6
3.5	13.64	13.47
4	13.52	13.34
4.5	13.41	13.21
5	13.31	13.09
5.5	13.22	12.99
6	13.15	12.93
6.5	13.1	12.9
7	13.08	12.91
7.5	13.09	12.95
8	13.11	13
8.5	13.17	13.08
9	13.24	13.18
9.5	13.34	13.29
10	13.45	13.43
10.5	13.58	13.59
11	13.72	13.79
11.5	13.87	14.01
12	14.05	14.28
12.5	14.25	14.56
13	14.48	14.85
13.5	14.74	15.14
14	15.01	15.43
14.5	15.28	15.72
15	15.55	15.98
15.5	15.82	16.22
16	16.08	16.44
16.5	16.34	16.62
17	16.58	16.77
17.5	16.8	16.89
18	17	17

Source: Cole, T. J et al. BMJ 2000; 320:1240

measure underweight. The alternative to this reference is the WHO 2007 standard, which is a reconstruction of the 1977 National Center for Health Statistics (NCHS)/WHO

reference. Specifically, the WHO 2007 reference uses the original NCHS data set, supplemented with data from the WHO child international sample for children under age 5 (Onyango et al., 2007). The drawback of the NCHS reference is that for children ages 5-18, it is only based on a U.S. sample surveyed in the early 1970s and might be less indicative of the populations of other countries.

IOTF uses a value of BMI of 17 at age 18 as the basis for an international definition of thinness in children and adolescents. This criterion is consistent with previous criteria, as Cole and colleagues indicated: “BMI 17 is the WHO Grade 2 cut-off for thinness in adults; a BMI of 17 at age 18 corresponds to a mean z score of  $-2$  using our data; and, again with our data, BMI 17 at age 18 is 80% of the median. The latter two criteria mean that in childhood the new cut-off will be similar in Z score and percentage of the median terms to those used before, notably the WHO definition of wasting—that is, weight for height below  $-2$  SD or 80% of the median.” Table 3.3 is the copy of international cut-off points for BMI for thinness for exact ages between 2 and 18 years, defined to pass through BMI of 17 at age 18, obtained by averaging data from Brazil, Great Britain, Hong Kong, Netherlands, Singapore and the United States (Cole et al., 2007).

### **3.2.2 Predictor variables**

#### **3.2.2.1 Energy intake**

I measure energy intake using CHNS constructed variables: Daily Energy Intake

as three-day average food consumption (in K calories), Daily Fat Intake as three-day average fat intake (in grams), Daily Protein Intake as three-day average protein intake (in grams) and Daily Carbohydrate Intake as three-day average carbohydrate intake (in grams).

### **3.2.2.2 Energy expenditure**

Due to lack of direct measure on total energy expenditure for the majority of the respondents, I use other measures as a proxy for energy expenditure. Time spent in reading/writing per week is supposed to be a good indicator of energy expenditure, but is only available for a limited number of samples in two waves. Previous studies show that Chinese children's participation in organized physical activity outside school was almost nonexistent as of 1997 and commuting to school has been an important indicator of energy expenditure (Tudor-Locke et al., 2003; Li et al., 2007)). Therefore survey questions on commuting mode to school by foot, by bike or by bus/car, are used to measure physical activity. Ownership of automobiles is found as a strong predictor of adult obesity (Bell and Popkin, 2002), so it is also used to measure energy expenditure.

### **3.2.2.3 Obesity-related health knowledge**

Health knowledge concerning obesity is measured by questions including: "Do you agree that lots of fruits/vegetables are better?" "Do you agree that lots of sugar is better?" "Do you agree that diet high in fat is better?" "Do you agree that lots of staple food is better?" "Do you agree that lots of animal foods are better?" and "Do you agree that being heavier is better?"

#### **3.2.2.4 Family SES indicators**

Political elite status is defined as holding both Administration or Management elite status and Redistribution system position. Administration or Management elite status is defined as holding the occupation as a factory head/government cadre. Redistributive system is defined as sectors owned by the government. High school diploma is defined using the question “What is the highest level of education attained?” If the respondent chose “high school diploma or equivalent” or “college diploma/above,” then the respondent is taken as holding high school diploma. Household place of residence is grouped into urban and rural sites. Urban site includes neighborhoods in the urban cities; rural site includes neighborhoods in the county and rural villages. Household income is a constructed variable based on various income sources including business, farming, fishing, gardening, livestock, non-retirement wages, retirement income, subsidies, and other income. Per capita household income adjusted by 2006 Consumer Price Index is used to measure the family resource accessible by a child.

#### **3.2.2.5 Family structure variables**

Grandparents are present in the household if any of the grandparents is present in the same household at the time of survey. Grandparents are proximate if any of the grandparents live in the same neighborhood at the time of survey. These measures are based on four questions to married women under age 52: “Where does your mother live?” “Where does your father live?” “Where does your mother-in-law live?” and “Where does your father-in-law live?” The measurement of number of child’s paternal uncles and aunts is based on four questions to married women under age 52: “Does your

husband have any brothers?" "How many brothers does your husband have?" "Does your husband have any sisters?" and "How many sisters does your husband have?" These questions about the siblings are only asked in year 2000 and onward, so I assign the value of these variables to previous waves when personal ID and mother ID are matched. An only child is defined as a child with no siblings in the household at the time of survey.

### 3.3 Data Limitations

#### 3.3.1 Lack of sample weights

There are no sample weights for this data, but according to the sampling strategy, the sample is supposed to be self-weighted and representative for each province. To examine if this is the case, I compared the sample age distribution of each province in 1989 with the 1990 census data, and the results shown in Table 3.4 suggest that the sample age distribution is generally close to the 1990 census distribution for each of the eight provinces surveyed in 1989.

**Table 3.4: Age distribution for each province based on 1990 census and CHNS 1989 sample**

Percentage Source	Liaoning		Jiangsu		Shandong		Henan	
	Census	Sample	Census	Sample	Census	Sample	Census	Sample
0-14	23.2	24.6	23.7	21.3	26.6	25.3	29.3	25.9
15-64	71.1	73.5	69.5	71.8	67.2	67.1	64.9	67.7
65+	5.7	2.9	6.8	6.9	6.2	7.6	5.8	6.4

Percentage Source	Hubei		Hunan		Guangxi		Guizhou	
	Census	Sample	Census	Sample	Census	Sample	Census	Sample
0-14	28.5	28.4	28.0	29.5	33.4	28.3	32.7	28.6
15-64	66.0	66.0	66.4	66.2	61.2	65.8	62.7	65.7
65+	5.5	5.7	5.6	4.3	5.4	6.0	4.6	5.8

Note: the cells represent the percentages

The 1991 sample is the initial sample I use in this dissertation. So I also compared the age distribution of the 1991 sample with the 1990 census data, and the results (Table 3.5) show that the 1989 sample distribution is very close to the 1990 census distribution.

**Table 3.5: Age distribution for each province in 1990 census and CHNS 1991 sample**

Percentage Source	Liaoning		Jiangsu		Shandong		Hunan	
	Census	Sample	Census	Sample	Census	Sample	Census	Sample
0-14	23.2	26.0	23.7	20.2	26.6	23.3	29.3	24.9
15-64	71.1	72.3	69.5	72.3	67.2	68.4	64.9	68.2
65+	5.7	3.7	6.8	7.5	6.2	8.3	5.8	6.8

Percentage Source	Hubei		Hunan		Guangxi		Guizhou	
	Census	Sample	Census	Sample	Census	Sample	Census	Sample
0-14	28.5	27.8	28.0	27.7	33.4	25.9	32.7	24.6
15-64	66.0	66.6	66.4	67.4	61.2	66.5	62.7	79.6
65+	5.5	5.6	5.6	4.9	5.4	7.6	4.6	5.8

Note: the cells represent the percentages

As mentioned earlier, Heilongjiang participated in this survey since 1997 and the same sample strategy adopted in the initial wave was employed (See table 3.3). The difference between the census distribution and the sample distribution of Heilongjiang is trivial. Liaoning returned to the survey in 2000, and the sample distribution in 2000 showed only a trivial difference from the census distribution (See table 3.6).

**Table 3.6: Age distribution in 2000 census and CHNS 2000 sample**

Percentage Source	Liaoning		Heilongjiang	
	census	Sample	Census	Sample
0-14	17.7	17.1	18.9	19.3
15-64	74.5	75.6	75.7	76.3
65+	7.8	7.3	5.4	4.4

The 1990 census reported that the proportion of urban population in 1990 is about .26. The sample proportion of urban population is .26 in 1991, .24 in 1993, .28 in 1997, .26 in 2000, .28 in 2004 and .28 in 2006.

Overall, the analysis suggests that the initial sample is representative within each province owing to the random stratified sampling strategy within each province.

According to State Statistical Bureau of China (2002), the selected provinces host 45% of China's total population and fairly represent the substantial demographic and socioeconomic variations comparable to the national average in many instances.

### 3.3.2 Newly added sample

Sample added to the survey are from two sources: 1) children born into the existing households and 2) the replacements randomly drawn from the original community, or in case the whole original community was lost to follow up, the replacements randomly drawn from a new community that was selected to replace the original community.

**Table 3.7: Results of regression on BMI, children ages 2-18, CHNS 1991-2006, correcting clustering at the individual level**

	BMI
Being a new comer	-.101
Age	-.223***
Boy	.231*
R2	.092
Sample size	17535

\*: P<0.1, \*\*: P<0.05, \*\*\*: P<0.01

Note: Survey year is controlled in the model.

Results from multivariate regression showed that the newcomers do not differ from the original sample regarding BMI after controlling for age, gender and wave (See

table 3.7). However, because of an important source of newcomers in the sample are recently-born children, the newcomers in the data are on average 4.28 (SD=.781) years younger than the observations remaining in the children's sample from the previous wave.

### 3.3.3 Attrition Issues

#### 3.3.3.1 The magnitude of attrition

According to Popkin et al. (2010), the percent follow-up from 1989 for adults and children in 2006 was 63%. Follow-up from the previous wave ranged from 80% to 88%. Based on my examination, however, the follow-up rate among children is far lower than for adults.

**Table 3.8: Follow-up rate based on 1991 child sample (age<19 at 1991), children who are aged out censored**

Year	1991	1993	1997	2000	2004	2006
N (age<19 all obs include new sample)	4868	4347	3974	3857	2441	2039
Denominator (age<19 at the current wave and available from 1991)	4868	4288	3210	2393	1388	757
Numerator (age<19 at the current wave and available both from 1991 and the current wave)	4868	3942	2361	1852	510	162
Follow-up from 1991	NA	0.92	0.74	0.77	0.37	0.21

The follow-up rate from 1989 to 2006 for children is 21%, and from the previous wave it ranged from 61% to 92%. 62% participated in at least four rounds and an additional 15% participated in at least 3 rounds. Overall, the follow-up rate from 1991 and the previous wave suggest that attrition is less of a concern before 2004, whereas in 2004 and 2006 it is more of a concern (See Table 3.8-3.12).

**Table 3.9: Follow-up rate based on 1991 child sample (age<19 at 1991), including children who are aged out at each wave in denominator and numerator**

Year	1991	1993	1997	2000	2004	2006
Denominator (age <19 at 1991 sample)	4868	4868	4868	4868	4868	4868
Numerator (available both in 1991 and the wave indicated)		4423	3363	3234	1157	821
Follow-up rate from 1991	NA	0.91	0.69	0.66	0.24	0.17

**Table 3.10: Follow-up rate from the previous wave**

	1991	1993	1997	2000	2004	2006
For all respondents who ever enter as a child	NA	0.91	0.73	0.83	0.46	0.59
For respondents who are under 19 at both previous wave and the current wave	NA	0.92	0.78	0.88	0.61	0.65

**Table 3.12: Child participation rate for all child respondents who ever enter the survey under age 19**

	All six round	Five rounds	Four rounds	Three Rounds	Two rounds	One round
Percentage	0.05	0.10	0.26	0.17	0.22	0.20
Cumulative percentage	0.05	0.15	0.41	0.58	0.80	1.00

### 3.3.3.2 Causes of attrition

Regarding the low follow-up rate, especially in 2004 and 2006, Popkin et al. (2010) suggested several causes: (1) the school-age children’s participation in boarding school greatly accelerated in 2004 and 2006; (2) middle school-age migrant workers were lost to follow-up; (3) when the children are 18 or older, they went to college or work in a different place. Another reason for the low follow-up in 2004 and 2006 could be that the respondents who are still under 19 in 2004 and 2006 are younger than 6 and 4 year old respectively, in 1991, and their parents might be more likely to move due to their younger age.

Attrition due to refusal is not a big concern because refusal was very low. According to Du (2010), no students living at home refused to participate. The provincial CDC or county CDC representative contacted each community before data collection to determine which participants were still living in the same community and which participants had moved. If a household is still in the same community, all household members who are still at home are asked to participate in the new survey. If a family moved or a family member works out of the county or out of the province, the team will

not follow them due to funding constraints. Usually the interview team stayed in a community for four to seven days. If a student lives at school but comes home during the data collection period, the team will interview him or her; if the student does not come home, interviewers attempt to interview the student at school. However, this may not be possible because many schools do not permit interviewing students at school. It is possible that the children who are missed are not random regarding overweight status, residency, parents' education status, family income, etc.

### **3.3.3.3 The pattern of attrition**

According to Rubin (1976) and Little and Rubin (2002), there are three patterns of attrition: "Missing Completely at Random" (MCAR), attrition is not related to any variable; "Missing at Random" (MAR), attrition is not related to the dependent variables conditioning on the observable independent variables; and "Missing Not at Random" (MNAR), attrition is related to the dependent variables conditioned on the observable independent variables, which means attrition is related to some unobserved characteristics correlated with dependent variables. MCAR does not bias any parameter estimate. MAR does not bias the regression coefficient estimate if the set of independent variables are adjusted. However, MNAR would bias the parameter estimate.

Since the dependent variable of interest at the time of dropping out is not observable, a conventional way to test the pattern of attrition is to examine if the variable of interest at the previous wave is related to attrition status. In this dissertation I tested to see if the BMI at the previous wave is related to the attrition. Results from univariate regression of BMI at the closest previous wave on attrition status, adjusting

for clustering at individual level, show that attrition is not completely random (not MCAR). For example, when they were last observed, respondents who dropped out have an average BMI 1.02 (SD=.058) higher higher than those who stayed in the following wave. I further examined if the attrition is conditionally at random.

The results (Table 3.13) show that after controlling the major covariates, the attrition is not related to BMI at the previous wave, suggesting missing is conditionally at random. However, children whose parents have more years of education are more likely to drop out. Aging out is an important source of attrition. Girls are more likely to drop out. Different provinces have significantly different rates of dropping out. Later waves have a higher attrition rate.

**Table 3.13: Logistic regression on attrition status, characteristics at the previous wave as the predictors of the attrition status at each wave, CHNS 1991, 1993, 1997, 2000, 2004 and 2006, for children ages 2-18, robust standard error adjusted at personal ID level.**

	Attrition
Gender	-.097*
Age	.125***
BMI	.027
Per capita family income	-6.38e-06
Liaoning	1.64 ***
Heilongjiang	-.840 ***
Jiangsu	-.169
Shandong	-.214**
Henan	-.259**
Hubei	-.283 ***
Hunan	-0.432***
Guangxi	-0.451***
Urban residence	-.083
Father years of school	.015***
Mother years of school	.032***
Pseudo R2	0.1750
N	13016

\*: P<0.1, \*\*: P<0.05, \*\*\* P<0.01;

Note: survey year is controlled

These results have three implications: 1) the unadjusted prevalence of overweight/obesity is a biased estimate; 2) the simple correlation between any variable and overweight/obesity is a biased estimate; 3). Any model aiming to estimate the impact of independent variable of interest should include the independent variables examined above to reduce the source that biases the estimate. The analyses suggest missing at random but do not rule out all the possibility of missing on unobserved variables, therefore the estimate of impact should still be taken cautiously.

### **3.3.4 Missing BMI**

Item non-response in measures of height and weight and extreme value of BMI (BMI<5 and BMI>50) contribute to missing the key variable, BMI. The proportion missing in measures of BMI in each wave ranges from 11.5% to 20.9% through survey years. Since there is no way to examine if missing on BMI is related to the value of BMI, I estimate if parental BMI is related to missing on BMI for the children, based on the fact that parental BMI is always a good predictor of child BMI (Li, 2007; Benton, 2004; Veugelers & Fitzgerald, 2005). Results from univariate regressions of mother's BMI and father's BMI on missing status adjusting clustering at individual level show that missing on BMI is not related to mother's BMI or father's BMI. Conditional on the set of independent variables of interest, parents' BMI is not associated with child missing of BMI (See Table 3.14). However, girls, older children and children whose fathers have higher education are more likely to miss BMI.

### 3.3.5 Missing on independent variables and descriptive statistics

The missing pattern of the independent variables regarding BMI is testable by examining if missing on these variables is significantly related to BMI. Mother's BMI is used as approximate measure of the child BMI if the child's BMI is missing. Table 3.15 (a, b, c and d) presents the descriptive statistics and missing pattern of all the variables.

**Table 3.14: Logistic regression on missing of BMI, CHNS 1991, 1993, 1997, 2000, 2004 and 2006, children aged 2-18, robust standard error adjusted at personal ID level**

	Missing of BMI
Father BMI	0.007
Mother BMI	0.006
Gender	-0.17***
Age	0.13***
Ln per capita family income	0.08**
Liaoning	-0.56***
Heilongjiang	-0.50***
Jiangsu	-0.14
Shandong	-0.04
Henan	0.63***
Hubei	0.43***
Hunan	0.21**
Guangxi	0.51***
Father's highest degree	0.07*
Mother's highest degree	-0.02
Pseudo R2	0.1206
N	13439

\*: P<0.1, \*\*: P<0.05, \*\*\* P<0.01;

Note: survey year is controlled

The results show that all the variables are either missing completely at random (MCAR) or conditionally at random (MAR) regarding child's BMI. Among the variables of missing conditionally at random, the adjusting variables are age, gender, year fixed effects and province fixed effects, except in the case of the four measures of daily energy intake where I control parental education and place of residency in addition.

Analysis on these missing patterns suggests that the estimate on the impact of independent variables would not be biased by the missing pattern if the model is correctly specified. However, any unadjusted prevalence or univariate estimate of the impact of certain variables on overweight/obesity is very likely to be biased.

**Table 3.15 a: Mean and missing pattern for children 2-18, China Health and Nutrition Survey 1991-2006**

Variables	Missing Pattern	1991	1993	1997	2000	2004	2006
Male	MCAR	.52 (4630)	.52 (4181)	.53 (3787)	.53 (3718)	.54 (2267)	.54 (1913)
Percentage of Missing		0	0	0	0	0	0
Age (years)	MCAR	10.5 (4630)	10.7 (4181)	11.4 (3787)	11.9 (3718)	11.3 (2267)	10.5 (1913)
Percentage of Missing		0	0	0	0	0	0
BMI	MCAR	16.9 (4094)	17.0 (3642)	17.2 (3112)	17.6 (2955)	18.4 (2029)	18.3 (1720)
Percentage of missing		0.12	0.13	0.18	0.21	0.10	0.10
Overweight/Obese	MCAR	.078 (4094)	.097 (3642)	.091 (3112)	.101 (2955)	.153 (2029)	.170 (1720)
Percentage of missing		0.12	0.13	0.18	0.21	0.10	0.10
Underweight	MCAR	.059 (4094)	.064 (3642)	.054 (3112)	.057 (2955)	.046 (2029)	.073 (1720)
Percentage of missing		0.12	0.13	0.18	0.21	0.10	0.10
Being the only child	MCAR	.26 (4301)	.26 (3784)	.35 (3253)	.45 (3053)	.53 (2144)	.51 (1803)
Percentage of missing		0.07	0.09	0.14	0.18	0.05	0.06
Grandparents co-resident	MCAR	.244 (3993)	.255 (3583)	.255 (3277)	.272 (3048)	.298 (1865)	.343 (1545)
Percentage of missing		0.14	0.14	0.13	0.18	0.18	0.19
Grandparent(s) present or as neighbor	MCAR	.552 (3993)	.549 (3583)	.529 (3269)	.556 (3032)	.547 (1863)	.560 (1544)
Percentage of missing		0.14	0.14	0.14	0.18	0.18	0.19

**Table 3.15 b: Mean and missing pattern for children 2-18**

Variables	Missing Pattern	1991	1993	1997	2000	2004	2006
CPI adjusted Family income (¥)		9686 (4019)	10991 (3589)	13617 (3029)	16264 (2859)	19972 (1981)	22540 (1680)
Percentage of missing	MAR	0.13	0.14	0.20	0.23	0.13	0.12
Urban	MCAR	.263 (4630)	.240 (4181)	.276 (3787)	.263 (3718)	.283 (2267)	.289 (1913)
Percentage of missing		0	0	0	0	0	0
Father high school	MAR	.18 (4374)	.21 (3922)	.25 (3470)	.28 (3295)	.30 (1585)	.36 (1140)
Percentage of missing		0.06	0.06	0.08	0.11	0.30	0.40
Mother high school	MAR	.12 (4466)	.13 (3979)	.17 (3517)	.20 (3411)	.20 (1949)	.22 (1566)
Percentage of missing		0.04	0.05	0.07	0.08	0.14	0.18
Father political elite	MAR	.058 (4359)	.051 (3916)	.057 (3424)	.043 (3188)	.031 (1223)	.031 (979)
Percentage of missing		0.06	0.06	0.10	0.14	0.46	0.49
Mother political elite	MAR	.012 (4228)	.009 (3801)	.011 (3267)	.015 (3064)	.013 (1279)	.010 (1146)
Percentage of missing		0.09	0.09	0.14	0.18	0.44	0.40
Daily protein intake (g)	MAR	57.66 (4024)	56.07 (3637)	54.42 (3117)	55.99 (3007)	52.95 (1971)	50.64 (1675)
Percentage of missing		0.13	0.13	0.18	0.19	0.13	0.12
Daily energy intake (Kcal)	MAR	2011 (4024)	1946 (3638)	1836 (3117)	1906 (3010)	1769 (1976)	1637 (1675)
Percentage of missing		0.13	0.13	0.18	0.19	0.13	0.12
Daily fat intake (g)	MAR	48.4 (4019)	49.1 (3632)	51.4 (3113)	60.3 (2992)	57.7 (1970)	51.8 (1675)
Percentage of missing		0.13	0.13	0.18	0.20	0.13	0.12
Daily Carbohydrate intake (g)	MAR	336 (4020)	317 (3635)	288 (3117)	277 (3000)	258 (1976)	245 (1675)
Percentage of missing		0.13	0.13	0.18	0.19	0.13	0.12
Daily energy expenditure in physical activity	MCAR			349 (442)	341 (638)		
Percentage of missing				0.88	0.83		
Commute by foot or bike	MAR			.941 (2655)	.939 (2160)	.923 (1626)	.912 (1312)

**Table 3.15 c: Mean and missing pattern for children 2-18**

Variables	Missing Pattern	1991	1993	1997	2000	2004	2006
Own a Car(s)		.015 (4521)	.020 (4106)	.032 (3612)	.042 (3595)	.044 (2243)	.057 (1910)
Percentage of missing	MCAR	0.02	0.02	0.05	0.03	0.01	0.00
Minutes in reading and writing before/after school/week				455 (2005)	211 (1224)		
Percentage of missing	MCAR			0.47	0.67		
Number of colored TV	MCAR	.206 (4536)	.283 (4116)	.491 (3637)	.719 (3632)	1.04 (2247)	1.17 (1911)
Percentage of missing		0.02	0.02	0.04	0.02	0.01	0.00
Father's height (cm)	MCAR	165 (3719)	165 (3293)	166 (2837)	167 (2652)	167 (1435)	167 (1044)
Percentage of missing		0.20	0.21	0.25	0.29	0.37	0.45
Mother's height (cm)	MCAR	155 (4212)	155 (3762)	155 (3228)	156 (3118)	156 (1842)	157 (1487)
Percentage of missing		0.09	0.10	0.15	0.16	0.19	0.22
Father's BMI	MCAR	21.5 (3719)	21.8 (3293)	22.3 (2837)	22.9 (2652)	23.5 (1435)	23.6 (1044)
Percentage of missing		0.20	0.21	0.25	0.29	0.37	0.45
Mother's BMI	MCAR	21.9 (4212)	22.0 (3762)	22.4 (3228)	22.9 (3118)	22.9 (1842)	23.0 (1487)
Percentage of missing		0.09	0.10	0.15	0.16	0.19	0.22
Minority	MCAR	.158 (4471)	.155 (4175)	.130 (3753)	.150 (3698)	.157 (2266)	.170 (1913)
Percentage of missing		0.03	0.00	0.01	0.01	0.00	0.00
Average 10 year fine since born for first-order children in years of income	MAR	1.19 (1832)	1.46 (1424)	1.51 (1084)	1.93 (931)	2.14 (379)	2.10 (170)
Percentage of missing		0.24	0.25	0.34	0.41	0.63	0.79
Average 7 year fine since born for first-order children in years of income	MAR	.977 (1832)	1.24 (1428)	1.45 (1227)	1.78 (1112)	2.15 (567)	2.26 (320)
Percentage of missing		0.24	0.25	0.26	0.30	0.44	0.61
Number of father's siblings					4.54 (2994)	4.26 (1865)	4.01 (1548)
Percentage of missing					0.19	0.18	0.19
Number of father's brothers					1.79 (2994)	1.59 (1865)	1.49 (1548)

**Table 3.15 d: Mean and missing pattern for children 2-18**

Variables	Missing Pattern	1991	1993	1997	2000	2004	2006
Percentage of missing					0.19	0.18	0.19
Liaoning		.101 (4630)	.098 (4181)	0 (3787)	.098 (3718)	.093 (2267)	.083 (1913)
Percentage of missing		0	0	0	0	0	0
Heilongjiang		0 (4630)	0 (4181)	.105 (3787)	.100 (3718)	.107 (2267)	.107 (1913)
Percentage of missing		0	0	0	0	0	0
Jiangsu		.085 (4630)	.089 (4181)	.095 (3787)	.086 (3718)	.093 (2267)	.086 (1913)
Percentage of missing		0	0	0	0	0	0
Shandong		.109 (4630)	.110 (4181)	.103 (3787)	.084 (3718)	.061 (2267)	.070 (1913)
Percentage of missing		0	0	0	0	0	0
Henan		.133 (4630)	.134 (4181)	.140 (3787)	.127 (3718)	.157 (2267)	.126 (1913)
Percentage of missing		0	0	0	0	0	0
Hubei		.137 (4630)	.139 (4181)	.143 (3787)	.126 (3718)	.106 (2267)	.092 (1913)
Percentage of missing		0	0	0	0	0	0
Hunan		.125 (4630)	.132 (4181)	.124 (3787)	.100 (3718)	.090 (2267)	.111 (1913)
Percentage of missing		0	0	0	0	0	0
Guangxi		.149 (4630)	.147 (4181)	.149 (3787)	.145 (3718)	.148 (2267)	.153 (1913)
Percentage of missing		0	0	0	0	0	0
Guizhou		.159 (4630)	.151 (4181)	.140 (3787)	.133 (3718)	.142 (2267)	.169 (1913)
Percentage of missing		0	0	0	0	0	0

Chapter 4, 5 and 6 each focuses on a different subsample and uses a different set of variables. Therefore the pattern of attrition and missing in the sample specific to a topic will be discussed in detail in each chapter.

### **3.3.6 A comparison between CHNS and China National Health and Nutrition Survey**

Although this dissertation does not aim to document the trends of national prevalence of child obesity/overweight in China, a comparison of the trend obtained from a nationally representative study, the China National Health and Nutrition Survey (CNHNS), and that from CHNS data suggests that the general trends from the two samples are similar. The exception is that the CHNS sample demonstrates higher prevalence of overweight/obesity among girls (See Appendix 3.1). This comparison suggests that the quality of the CHNS sample is fair even without adjusting for aging, attrition and item non-response.

In sum, despite the limitations of these data, with proper specification of statistical models, CHNS data provide a good opportunity to answer the questions of this dissertation.

# **Chapter 4: Increasing socioeconomic gap in child overweight/obesity in China**

## **4.1 Introduction**

It is well documented that family SES (socioeconomic status) is associated with child overweight/obesity (Wang et al, 2012; Bilaver, 2010; Murasko, 2009). However, the pathways that link SES with overweight/obesity are highly conditioned by stage of economic development. An inverse relationship between SES and obesity is typically observed among children in developed countries (Bilaver, 2010, Ball K & Crawford, 2002), whereas within China and many other developing countries, overweight/obesity is concentrated among socioeconomic elites (Wang et al, 2012, Sobal, 1991; Jones-Smith et al, 2011). What contextual factors connect the stage of economic development with the sign and strength of the association between socioeconomic status (SES) and child overweight/obesity? What is the relative importance of these factors? What happens when these contextual factors exert contradictory influences on the SES profile of overweight/obesity as a country undergoes rapid socioeconomic changes? The changing contexts in China provide an opportunity to explore these questions.

Positive SES-child overweight/obesity association has been identified in majority of previous studies based on single year data in China (Wang et al, 2012; Wang and Lobstein, 2006; Li et al, 2007; Xie et al, 2007; Shankar, 2010; Lee et al, 1993). Until now, the only study of the change of SES-overweight/obesity association among Chinese children focused on the annual change of overweight by income (Dearth-Wesley, 2008) and found that overweight increased fastest among the high-income group between

1991 and 2004. However, no study has thoroughly explored the contextual factors that contribute to the change of SES gradients of overweight/obesity among children and adolescents in China or other developing countries. Moreover, previous studies of heterogeneity in SES gradients in developing countries have focused on adults (Jones-Smith et al, 2011; McLaren, 2007; Subramanian et al, 2011; Neuman et al, 2011). It is arguably easier to interpret the direction of causality between SES and obesity for children since their SES status is predetermined by that of their parents (Wang et al, 2012), while among adults, the causality could run in either direction (Sobal 1991; Stunkard and Sorensen, 1993).

This chapter aims to identify the macro and meso level social contexts in China that have shaped the pathways through which socioeconomic status (SES) affects child overweight/obesity. In particular, I focus on the 1990s and 2000s, a time of dramatic macro-level social and economic changes in China. I begin by advancing a conceptual framework addressing the specific contextual factors that may shape SES-child overweight/obesity gradients. Then, I test the tenets of this framework using data from the China Health and Nutrition Survey (CHNS) collected from 1991 to 2006. This study also contributes to the literature on income inequality and population health literature by investigating how income inequality interacts with other contextual factors to alter gradients between SES and overweight/obesity.

## ***4.2 Conceptual framework***

Previous literature on the SES gradients for overweight/obesity consistently suggests that a country's stage of economic development is key to understanding the

SES-overweight association in adults. (Jones-Smith et al, 2011; Monteiro et al, 2002; McLaren, 2007) With this in mind, I synthesize the findings from previous literature that touched upon SES-overweight association, and developed a framework addressing the contextual factors that link a country's stage of economic development with its observed SES gradients for overweight/obese (See Figure 2.1). These contextual factors are: 1) price of high energy dense diets (obesogenic foods), 2) the degree of penetration of obesogenic physical inactivity environments, and 3) general awareness of, and incentives to prevent overweight/obesity. I also theorize how income inequality interacts with the aforementioned factors to reshape the SES gap in consumption of obesogenic foods and access to labor saving devices.

#### **4.2.1 Price of and general access to high-energy dense diets**

When a country is in advanced stage of development, there is a high level of general access to energy-dense diets, as compared to fruit and vegetables, due to the relative low price of mass-produced dairy, fast food and processed foods (Putnam and Allshouse, 1999; Drewnowski and Specter, 2004). The price is low because of the economy of scale, advancement in technology in producing, processing and storing these foods, and in some cases government subsidies (Drewnowski, 2003; Popkin, 2001). For example, in the US, the relative price of sweets and soft drinks decreased disproportionately between 1985 and 2000 compared to fresh vegetables and fruit (Putnam and Allshouse, 1999). Under the context of low price of energy dense foods, low-income groups who experience more food insecurity and consume more high energy density foods, are more likely to become overweight (Drewnowski and Specter,

2004; Neumark-Sztainer et al, 1996). In contrast, when a country is in the early stage of development, general access to these high-energy density diets is low because they are more expensive relative to vegetables, grains and meals made at home from simple ingredients (Ge K, 1999; Lu and Goldman D, 2010). And food scarcity among the poor, plus a greater capacity of the economic elite to purchase high-energy foods, contributes to the positive association between SES and overweight (Monteiro, 2004).

Income inequality can also shape the SES - overweight/obesity profile by interacting with the price of high-energy density diets. When the price of high-energy density diets is high, at the same per capita GNP level, higher income inequality implies a larger gap between higher and lower SES groups in access to these expensive goods. If there lacks awareness to the health consequence of overweight/obesity, the gap of purchasing power could easily convert to gap in consumption and leads to gap in overweight/obesity. Subramanian (Subramanian, 2009), for example, found that high income inequality was associated with overconsumption among privileged groups, in India, and food insecurity among poor. Also, in some developing countries, high income inequality was associated with a significantly greater increase, over time, in overweight among the wealthy, as compared to the poor (Jones-Smith et al, 2011); whereas in other developing countries with a similar level of economic development, but less income inequality, the greatest increase in overweight/ obesity was seen among lower-income individuals ((Jones-Smith et al, 2011).

## 4.2.2 Obesogenic Physical Inactivity Environments

Obesogenic-physical inactivity environments refer to an environment that discourages or restricts activities that demand high energy expenditures (Egger and Swinburn, 1997). The penetration of obesogenic environments is highly related to a country's level of urbanization, its transportation infrastructure, and acquisition of new technology (Monda et al, 2007).

With a higher penetration of obesogenic environments, higher SES groups are better able to countermand their negative effects (World Health Organization, 2000). For example, in the United States, higher SES groups are more likely to live in neighborhoods with lower crime rates, proximity to outdoor recreational activities, and higher social efficacy for physical activity (Morland et al, 2000; Kawachi et al, 2008). When a country is in the early stages of urbanization, only higher SES groups are able to take full advantage of the transportation infrastructure; thus, they are at greater risk than the poor of becoming overweight (Jones-Smith, 2011; Monteiro et al, 2004). In societies dominated by agriculture, for example, rural children are expected to contribute to the family's wellbeing by providing free labor on the farm (Patrinos, 1997; Bhalotra et al, 2003). In addition to the stage of economic development, income inequality plays an important role in determining exposure to obesogenic environments. For example, in developing countries, at the same per capita GNP level, higher income inequality leads to a larger SES gap in access to obesogenic inactivity environment brought by access to labor-saving devices and transportation infrastructure.

### **4.2.3 Ideal body shape and awareness of obesity-related health problems**

When a country is underdeveloped, a cultural norm favoring larger body sizes is also more likely to be observed (McLaren, 2007; Monteiro, 2004; Messer, 1989). The medical knowledge and concerns about overweight are only now reaching many developing countries (Cash et al, 2002; Luo et al, 2005). Phelan and Link (2004) suggest higher SES groups have advantage in access to health related knowledge, especially when certain epidemic just began to spread. However, for children, who usually prefer sweet and fatty foods (Popkin et al, 2012), educational efforts typically produces weak results (Bandura, 2004), therefore whether the advantage in knowledge could be transferred to child health behavior remains a question.

### **4.2.4 The relative importance of the contextual factors**

When a country is in advanced development stage, such as US, the advantage that higher SES groups have in knowledge and access to healthy goods (or environment) conversely predict an inverse association between SES and risk of overweight/obesity, therefore it is difficult to tell the relative importance of will-power-based-on-knowledge and access to healthy goods (or environment) in shaping risk behavior of overweight/obesity. In contrast, when a country is in the early stage of development, only the society's upper echelon has easy access to expensive unhealthy foods and lifestyles predictive of obesity/overweight; hence, at least for a while, the poor are protected from obesity-related disorders without having to marshal resources or take special preventive actions. In such a case, for the groups rich of resource, possession of

knowledge and access to obesogenic goods (or environment) could exert contradictory influences on developing overweight/obesity.

The ecological obesity framework (Egger G and Swinburn, 1997) posits that willpower based on knowledge may have only a minor effect on eventual behavior in obesity intervention as compared to environment. Body fat is a “settling point” that is determined not only by energy intake/expenditure, but also by physiological adjustment, a mechanism to maintain a constant volume of body fat. Only after an individual is exposed to a change of environment for a sufficiently long time will this settling point change in response. From this perspective, at least for a short period of time, the power of knowledge alone might only have limited impact on the SES profile of overweight/obesity.

### **4.3 The case of China**

Guided by this framework, I analyze the case in China, exploring how the SES-child overweight/obesity gradients changes over time as response to the change of the contextual factors. With rapid economic growth, China has seen declining relative price of energy dense foods (Lu and Goldman, 2010), the spread of Western body shape ideology (Luo et al, 2005) and increasing penetration of obesogenic inactive environment as urbanization proceeds and more labor saving devices become accessible. More importantly, China also observed increasing income inequality as a result of a series of market reforms (Meng, 2004; Xing et al, 2012; Chen et al, 2010). What is the combined implication on the SES gradients of child overweight/obesity? Analysis based on our framework and the literature review on the documented trends of the aforementioned

contextual factors produces testable hypothesis which will be tested using CHNS data 1991 to 2006.

### **4.3.1 Price and Access to Energy Dense Foods**

China's oil and dairy products are generally much more expensive than vegetables and fruits (Ge et al, 1992; Lu and Goldman, 2010). For this reason, snacking and consuming excessive amounts of fried foods were much more prevalent among higher-income, urban, and educated populations (Wang et al, 2008; Du et al, 2004). Recently, a decline in the relative price of fatty foods compared to fruits and vegetables was documented (Lu and Goldman, 2010). Also, Du et al. (2004) found that income elasticity on energy-dense-food consumption is higher for the poor during the years when income has generally been increasing. This finding suggests as income gradually increases across all groups, lower-income groups seek to catch up to the level of energy-dense diets consumed by higher-income groups, and this should lead to a narrowing of the SES gap for overweight/obesity. However, I reason that if the SES gap of purchasing power increases much faster, the SES gap in consumption could still increase.

The SES gap in purchasing power is largely a result of SES gap in income. In China, recent market reforms have increased the income gap which is evident in all socioeconomic indicators: education, political elite status and residence type (Meng, 2004; Xing et al, 2012; Nee, 1989; Zhou, 2000; Zhang, 2005; Li, 2003; Zheng and Li, 2009). The years 1997 to 2000 were a landmark period in China's market reforms when drastic large-scale layoffs within public enterprises took place as a means to intensify industrial restructuring. Since 2001 when China was admitted to the World Trade Organization,

China's market reforms entered a new era, and the lack of effective measures to contain income inequality further increased the income gap (Meng, 2004; Xing et al, 2012). National Gini coefficients changed from .35 to .37 between 1991 and 1997, but then increased from .38 to .44 between 1998 and 2004, remaining around .44 through 2006 (Chen, 2010). These numbers might still underestimate the magnitude of inequality, because the grey income, an important source of income and welfare benefit attached to the higher socioeconomic groups are not captured by the income measures.

#### **4.3.2 Urbanization and declining physical activity**

The vast majority of China was still in early stage of urbanization from 1991 to early 2000. With better access to public transportation, the activity patterns for urban Chinese adults in urban areas shifted to a more sedentary pattern, whereas no such transition observed among the rural adults as of 1997 (Popkin and Doak, 1998). Among children in both rural and urban areas, participation in organized physical activity outside school was almost nonexistent in 1997 due to increasing academic pressure (Tudor-Locke, 2007). Commuting to school has been an important indicator of energy expenditure in China. Studies typically found that over 80% of students walk or bike to school (Shi et al, 2005; Tudor-Locke, 2007) and ownership of a motorized vehicle is associated with much higher odds of being obese among Chinese adults (Bell et al, 2002). But access to car is far from universal. With the increasing SES gap in income, the gap in access to cars would increase correspondingly, and as a result the gap in energy expenditure in commuting would increase.

### **4.3.3 The Super slim body ideal and obesity-related knowledge**

In China, a large portion of the population, especially the older cohort continues to perceive that child being chubby is a sign of health and prosperity (Watson, 2000). Meanwhile the higher price of calorie-dense foods together with traditional views that connects affluence with overweight has made fast food consumption a sign of success. However, the Western ideal of a “slim” body shape signifying beauty and self-discipline has begun to spread in China (Cash and Pruzinsky, 2002). This ideal made its first foray among higher SES groups and women (Luo et al, 2005). This change suggests that the gap in the prevalence of overweight/obesity between higher and lower SES groups might narrow. Particularly, women have more social pressure to lose weight than men (Luo et al, 2005). Li et al (2005) found that among Chinese children and adolescents, girls were less satisfied with their body shape.

In sum, the declining cost of energy-dense foods and the spread of obesity-related health knowledge and the idealization of the Western body shape among higher SES groups suggest a narrowing of the SES-obesity gap over time. But the increasing income disparities and subsequent gaps in purchasing power, together with the relative high price of energy-dense foods and labor-saving devices, suggest a widening of the SES-obesity gap over time. According to the ecological obesity framework (Monda, 2007), access to certain environment is much more important than the will-power-based-on-knowledge. So at least for a short period of time, the advantage that higher SES groups have in ideology and knowledge might only have limited impact, which implies

that the positive SES gradients of child overweight/obesity in China could increase as the result of the drastic increase in income gap.

#### **4.4 Data and methods**

I draw waves 1991, 1993, 1997, 2000, 2002, 2004 and 2006 data from China Health and Nutrition Survey (CHNS). For more information of the survey, please refer to Section 3.1 in Chapter 3 and Popkin et al (2010). Like many longitudinal data, CHNS data is also subjected to attrition problem. A close check shows that the overweight status in the previous wave is not related to the attrition status conditional on the set of observables, suggesting that the attrition is conditionally at random (See Appendix 4.1). I obtain a sample size of 11086 with no missing values in major variables used in the study. Analysis on missing caused by item-non-response is presented in Appendix 4.2 which suggests that missing is completely at random. Descriptive statistics are presented in Appendix 4.3.

##### **4.4.1 Measurement**

For measurement of child overweight/obesity, please see Section 3.2.1.1 at Chapter 3. For measurement of energy intake and energy expenditure, please see Section 3.2.2.1 and 3.2.2.2 in Chapter 3. Active commuting is defined as commuting by foot/bike and non-active commuting is defined as commuting by bus/car. Obesity-related health knowledge was measured by a set of questions listed in Section 3.2.2.3 in Chapter 3. Wave 2000 and beyond is considered the period when market reforms were intensified.

Per capita family income adjusted by 2006 Consumer Price Index is used to measure the resource accessible by a child in his/her family. For how the income measure is constructed, please refer to Section 3.2.2.4 in Chapter 3. Political elite is defined as holding both Administration or Management elite status and Redistribution system position. For how Administration or Management elite status and Redistribution system are defined, please refer to Section 3.2.2.4 in Chapter 3.

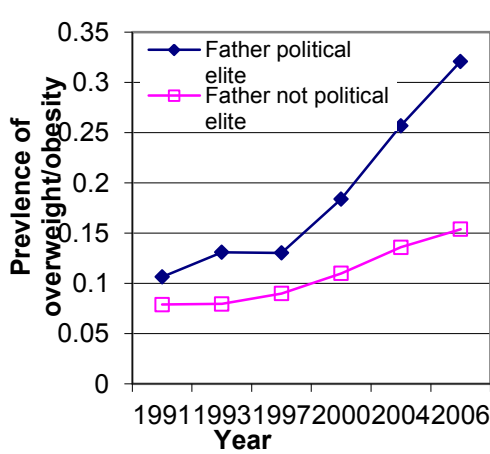
#### **4.4.2 Methods**

First, I calculated the prevalence of overweight/obesity for higher and lower socioeconomic groups defined by parental education, parental political elite status, per capita family income and residency type respectively, among children ages 2-18 adjusted for 2000 census age distribution. Then Generalized Estimating Equations (GEE) controlling a child's demographic and socioeconomic characteristics, parental height and province fixed effects were estimated to identify the SES gradients and the interaction effect of the post-1997-period and SES indicators. GEE models were used because the time-varying error terms within each unit (child) were correlated which violates the independence assumptions of traditional regression procedures. GEE estimators adjusted for the correlation among repeated measures. The advantage is that under the assumption of missing at random, and the number of clusters (number of repeated individuals in this case) is bigger than 40, it can provide consistent parameter estimation even if the correlation structure is mis-specified (Zeger and Liang, 1986).

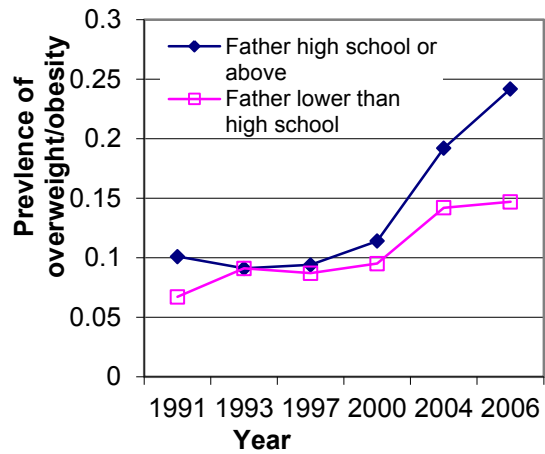
## 4.5 Results

### 4.5.1 SES trends for child overweight/obesity in China

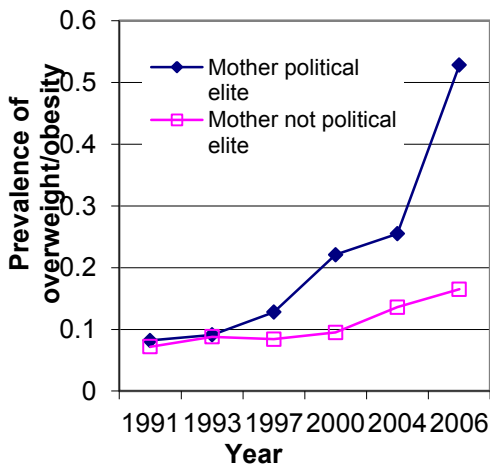
I used China's 2000 age distribution to compute the age-adjusted prevalence of overweight/obesity for each SES group. As Figure 4.1 shows, overweight/obesity prevalence rate has been increasing among all groups between 1991 and 2006, but the rate of increase is greater among higher SES groups (i.e., children from higher educated



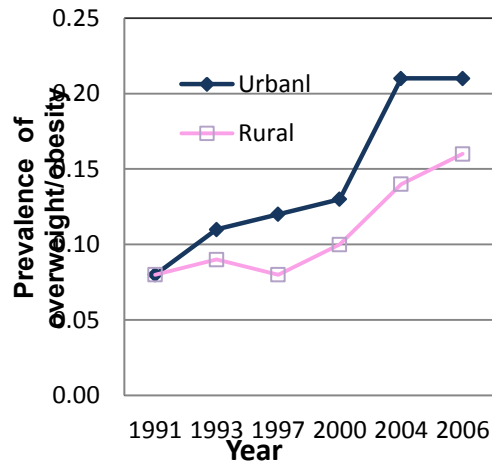
a. by father's education attainment



b. by father's political elite status

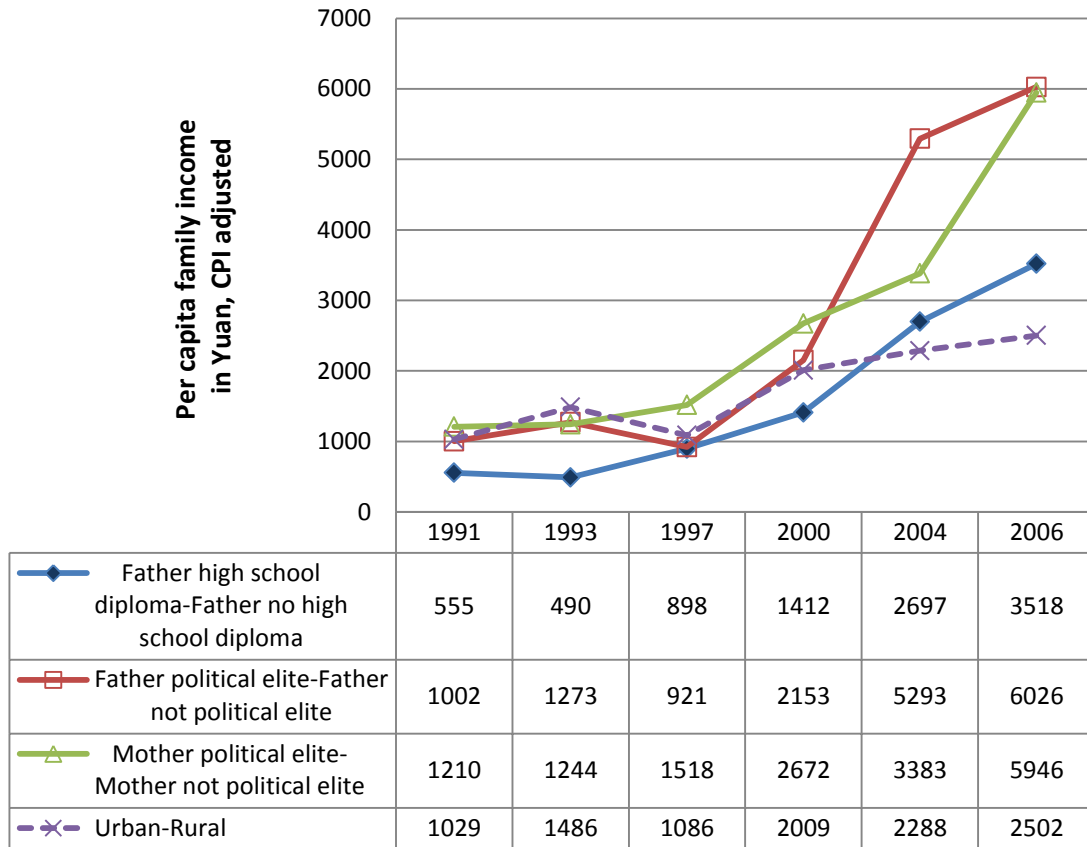


c. by mother's political elite status



d. by urban/rural residency

**Figure 4.1: Trend of child overweight/obesity prevalence from 1991 to 2006 for children aged 2-18, by father's education attainment, parental political elite status, and urban/rural residency, China Health and Nutrition Survey 1991 to 2006**



**Figure 4.2: Mean difference in per capita family income (CPI-adjusted) for children Aged 2-18 between higher and lower SES groups by survey year**

family, political elite family or urban areas) than lower SES groups (i.e., children from lower educated family, non-political elite family or rural areas), especially after 1997, which led to widened gap in overweight/obesity across SES groups. The increasing gaps observed are in line with the rapid increase in income gap between higher and lower SES groups defined by residency, political elite status and highest educational degree (see Figure 4. 2). Before 1997, the income gap for each indicator was relatively small; however, after 1997, the gap increased at a remarkable pace.

To identify the most robust socioeconomic predictors of child overweight/obesity and how the SES gap changed after 1997, I estimated a set of GEE models. In Model 1 of Table 4.11, I only included child's age, gender, parental height, logged per capita family income, post-1997 period, parents' highest degree and political elite status, urban/rural residency and province fixed effects. As expected, the results show that logged per capita family income was positively associated with risk of overweight/obesity. Being an urban resident increased the risk of becoming overweight/obese; the risk of overweight/obesity also increased after 1997.

In Model 2, I added the interaction terms of the socioeconomic indicators with post-1997-period. The results show that compared to 1997 and before, father's high school degree, or above, had stronger positive effects on the likelihood of being overweight /obese. These results suggest that purchasing power outperformed the contradicting forces. Since I observed a pronounced effect of father's education level in elevating the risk of overweight/obesity after the reforms deepened and income inequality surged, I compared the BMI distribution by father's education attainment before and after 1997. Appendix 4.5 shows that the upper tail of the BMI distribution moved to the right after 1997 for children whose fathers earned a high school diploma, but not so for children whose fathers had not.

#### **4.5.2 The role of energy intake and expenditure**

To identify proximate mechanisms, I examined trends in energy intake. Appendix 4.6 shows that the gaps in total daily energy, protein and fat intake by father's education increased, especially after 1997. In model 3 of Table 4.11, I controlled energy intake. As a

result, the coefficient and the significance level of father's education\*post-1997-period were reduced to some extent. Then I control on energy expenditure. Commuting pattern is used as proxy for energy expenditure. However, unfortunately, these measures are only available for children 6-18 surveyed in waves 1997, 2000, 2004 and 2006. Hence, I first examined children aged 6-18 through all survey years (see Models 4 and 5 in Table 4.12) and found a similar set of coefficients except that for this group I observed gender difference in overweight/obesity. More specifically, boys were more likely to be overweight/obese in this age group, consistent with findings by Hsu et al (2011). I subsequently restricted the sample to include only observations from 1997 and onward (See Models 6 and Model 7 in Table 4.12). The results showed that active commuting either by foot/bike reduced the risk of being overweight or obese. For this particular sample, after controlling active commuting pattern, the interaction effect of father's education and post-1997-period lost statistical significance. This finding suggests that physical activity played a prominent role in differentiating the BMI status for children and adolescents.

#### **4.5.3 Trends in SES gradients of overweight/obesity by gender**

Gender specific analyses (Appendix 4.7) revealed that the effects observed for the entire sample were mainly driven by boys. For males, income was positively associated with overweight/obesity conditioned on other covariates. For females, income was no longer a risk factor. After 1997, the risk of being overweight/obese increased for boys, but not for girls. Importantly, the increase in the effect of father's education level on overweight/obesity after 1997 was significant for boys, but only marginally significant

for girls. Energy intake did not explain the observed associations between the SES indicators and overweight/obesity.

**Table 4.11: Overweight/obesity status and SES indicators, CHNS 1991-2006, Children aged 2-18, Results from GEE models**

	Children 2-18			
	Model 1	Model 2	Model 3	Model 4
Boys	.070	.075	.086	<b>.203**</b>
PC Family income logged	<b>.083**</b>	<b>.081**</b>	<b>.080*</b>	<b>.123**</b>
Father high school or above	.029	-.108	-.128	-.049
Mother high school or above	.078	.071	.059	.006
Urban residency	<b>.284***</b>	<b>.254***</b>	<b>.224***</b>	<b>.363**</b>
Father political elite	.190	.169	.159	.160
Mother political elite	.018	.097	.206	-.497
After 1997	<b>.365***</b>	<b>.203**</b>	<b>.153**</b>	<b>.231**</b>
Father high school or above*after 1997		<b>.456***</b>	<b>.424**</b>	<b>.465**</b>
Mother high school or above*after 1997		-.046	-.069	-.004
Urban *after 1997		.088	-.031	-.016
Father political elite* after 1997		.078	.039	.142
Mother political elite* after 1997		-.191	-.376	.115
Energy intake (kcal)			<b>.0002***</b>	
Active commuting				
N of observations	10186	10186	10186	8053
N of groups	5295	5295	5295	4740
Wald chi2	487.75	497.31	508.01	356.61

\*: P<0.1, \*\*: P<0.05, \*\*\* P<0.01;

Child's age, parental height, province fixed effects are controlled in all models

**Table 4.12: Overweight/obesity status and SES indicators, CHNS 1991-2006, Children aged 6-18, Results from GEE models**

	Children 6-18		
	Children 6-18	at 1997, 2000, 2004, 2006	
	Model 5	Model 6	Model 7
Boys	<b>.186**</b>	<b>.289**</b>	<b>.254**</b>
PC Family income logged	<b>.119**</b>	<b>.034**</b>	<b>.026*</b>
Father high school or above	-.045	-.195	-.199
Mother high school or above	.048	.177	.406
Urban residency	<b>.340**</b>	<b>.343**</b>	<b>.324*</b>
Father political elite	.136	.360	.379
Mother political elite	.048	-1.36	-1.36
After 1997	<b>.216**</b>	.173	.081
Father high school or above*after 1997	<b>.431*</b>	<b>.437*</b>	.424
Mother high school or above*after 1997	-.082	-.418	-.401
Urban *after 1997	-.065	-.054	-.099
Father political elite* after 1997	.112	.077	.067
Mother political elite* after 1997	-.144	-.142	-.122
Energy intake (kcal)	<b>.0002**</b>	<b>.0002**</b>	<b>0.0002**</b>
Active commuting			<b>-.377*</b>
N of observations	8053	3414	3414
N of groups	4740	2482	2482
Wald chi2	369.93	182.67	187.30

\*: P<0.1, \*\*: P<0.05, \*\*\* P<0.01;

Child's age, parental height, province fixed effects are controlled in all models.

#### 4.5.4 The role of health knowledge

I examined obesity-related health knowledge by SES and gender using CHNS 2004 and 2006 survey data in which measures on the relevant health knowledge were available for respondents aged 12 and older. Appendix 4.8 indicates good acceptance of diet knowledge concerning obesity among children aged 12-18. Significant SES gradients

are observed, in that higher SES groups were more likely to disagree that “heavier is better,” “more high-fat food is good for your health,” and “more sugar is good for your health.” However, a larger increase in child overweight/obesity during 2004 and 2006 was found for the higher SES groups compared to the lower. This suggests that knowing what to do to earn good health, and taking steps to do so, are different matters, especially for boys for whom I observe a significant elevation in the effect of father’s education level on risk of overweight/obesity after 1997.

#### ***4.6 Discussion and conclusion***

This chapter synthesized the findings from various disciplines and developed a framework regarding the contextual factors that shape the pathways through which SES links to overweight/obesity in children. Using China Health and Nutrition data 1991-2006, I found that the prevalence of child overweight/obesity has increased across all SES groups, but the rate of increase was faster for higher SES groups, leading to an increasing SES gap in child overweight/obesity. This was especially true after 1997 when income inequality in China began to accelerate. Due to the fact that grey income and welfare benefit contribute to a significant portion of resource in China and the measure of income used in this study does not capture this part of income, I did not find that income measure explains away all the effect of socioeconomic indicators. Overall, this finding suggests that the increasing SES gap in purchasing power on obesogenic goods (environment) caused by rising income inequality outperformed other factors, especially for boys. The social pressure toward a super slim body ideal and health knowledge may have played a more important role for girls than boys. The different findings by gender

confirm previous studies that gender makes difference in perceived ideal body shape among children and adolescents, as girls are under greater pressure toward keeping a slim body shape (Luo et al, 2005; Li et al, 2005).

This study questions the universality of a key assumption of the Fundamental Social Cause of Diseases (FSCD) perspective, namely, that taking action to prevent elevated disease risks always requires resource mobilization. Circumstances in China would seem to run counter to this assumption. Unhealthy, obesogenic goods are more expensive in China; hence, the poor are “protected” since they are less able to afford these goods. Under the condition where possession of health knowledge and access to obesogenic goods have contradictory influence on the SES profile of overweight/obesity, I observed a stronger effect of obesogenic environment over and against health knowledge.

In current study, the findings of discrepancy between health knowledge and health outcome observed for children is consistent with predictions from the ecological framework (Egger and Swinburn, 1997); namely, that the exposures to obesogenic environments are much more crucial than will-power-based-on-knowledge. However, Dearth-Wesley et al (2008) found that between 1991 and 2004 overweight increased fastest among adults in the low-income group which implies that the burden of overweight is shifting to poor adults. The different trends between adults and children might be due to the fact that for children, educational efforts for healthy behavior usually produce weak results (Bandura, 2004). In China, there is now a shift in the control of food choice from parents to children who typically prefer sweet and fatty

foods. One recent study concluded that, in Chinese families, children could influence as much as 70 percent of the family expenditure, compared to 40 per cent in the United States (McNeal, 1995).

Therefore, policies should focus on enhancing individual self-efficacy by altering obesogenic environments. China's school systems traditionally overemphasize on academic achievement, so education policies should strive to change this norm in order to facilitate child physical activity. Policies and campaigns could also help build neighborhood collective efficacy to facilitate children's extra-curricular physical activity.

An important limitation of this study is that although the sensitivity check suggests the attrition is conditionally random after controlling the set of variables (See Appendix 4.1), it does not hold if the attrition is related to unobservables that are related to overweight status. Another limitation is that the survey covers only 9 of China's 34 provinces. Although the characteristics of these provinces are nationally representative in many cases (State Statistical Bureau of China, 1990, 2005), it would be interesting, nevertheless, to see if this pattern applies to other regions of China, especially those at different stages of urbanization and development. Another limitation is that, a longer follow-up for a few more decades might reveal that the FSCD argument does hold in China, as the power of knowledge keeps changing the environment.

Despite these limitations, this study provides a useful framework to study contextual factors relating to how stage of economic development shapes the pathways through which SES affects overweight/obesity, and how income inequality additionally influences the contributions of these contextual factors. I am unaware of any previous

studies that developed a comprehensive framework addressing the contextual factors that contribute to the changing SES gradients of overweight/obesity among children and adolescents in developing countries. The findings for children and adolescents in China may have important implications for similar social processes now occurring in other rapidly developing countries which may be configured in ways that are somewhat different from what occurred in developed countries.

# **Chapter 5: The Influence of Having a Younger Sibling on Child Nutrition Status in China---Under the One Child Policy Regime**

## ***5.1 Introduction***

The One Child Policy that significantly reduced the fertility level is thought to be a leading cause of child overweight/obesity in China (Taylor, 2004; Ni, 2000). Studies on fertility and child nutrition status have established that large family size leads to child malnutrition (Rao and Gopalan 1969; Balderama-guzman, 1978), and falling fertility significantly contributes to improved nutrition intake (Hatton and Martin, 2010). These studies mainly focused on comparing the impact of having multiple children as opposed to having one or two. We know very little about the effects of increasing the number of children from one to two or three. In China fertility had decreased to 2.9 children per family in the late 1970s before the One Child Policy took place (Hesketh et al., 2005) and continued to decline to 1.55 in 2011 (UN Population Division, 2011). As many families throughout Asia, and particularly China, began having fewer children (Jones, 2007), the opportunity arose to compare the impact on child nutrition of having an only child to having two or three. Results could also measure the impact of the birth quota on child nutrition status.

One theory is that having multiple children affects child nutrition status by competition for household resources. Reducing the number of siblings reduces competition for those resources (Becker, and Lewis, 1973). Further, abundance of family resources is known to contribute to child overweight/obesity in China (Wang, 2002;

Dearth-Wesley et al., 2008, Hsu et al., 2011). Household income is also a powerful predictor of undernutrition for Chinese children (Ge et al., 2001). Previous literature has documented that children with no siblings tend to consume a higher percentage of animal foods, but a lower proportion of vegetables and fruits compared to children with siblings (Ng, 2005). They are also more likely to be overweight or have higher height for age (Hesketh et al., 2003; Yang, 2006; Bredenkamp, 2008). Having multiple siblings is related to undernutrition in rural China (Zheng et al., 2011). However, it is difficult to identify the impact of being an only child as opposed to having any younger siblings on health outcomes. Some studies used household sibsize or the community-level, policy-sanctioned number of children per couple as instrument variable to identify the impact, but both variables are problematic because they are related to child nutrition status through multiple channels.

There are many reasons to suspect household-level heterogeneity. For example, those parents who chose to have two children, authorized or not, might have more sources of untraced income, and more informal support from the family planning officials and extended family. A greater threat to the validity of some models is that these unobserved factors could change over time. For example, families might decide to have another child when their general conditions improve. Or, if they experience a downturn in financial wellbeing, a couple might decide to have another child to ensure elder care, a reflection of the absence of a pension system and the cultural norm that despite recent rapid socioeconomic changes and urbanization children continue to serve as the primary caregivers for their aged parents and even grandparents, (Chow and

Zhao 1996; Meulenberg 2004). At the community level, the policy-sanctioned number of children per couple is tightly related to local economic development and population density. Chongqing, Sichuan, Jiangsu, Beijing, Shanghai and Tianjin are among the most densely populated regions and subject to the most stringent policy enforcement. Also subject to stringent policy enforcement are the richest and most developed regions or metropolitan areas, while the less developed regions are extended some leniency (Gu et al., 2007).

Using the CHNS data collected in 1991, 1993, 1997 and 2000, 2004 and 2006, I examine the amount in monetary fines levied for an extra child across time and location as the instrument to identify whether having younger siblings affects a child's underweight and overweight status under the One Child Policy. Extensive analysis on whether the variation in fines is a valid instrument is conducted in the method section.

## ***5.2 Conceptual framework***

It is well documented that increase in access to resources contributes to diminishing child undernutrition (Svedberg, 2006). Less intuitively, access to resources is positively related to child overweight/obesity in China (Wang, 2002; Dearth-Wesley et al., 2008, Hsu et al., 2010). One major reason could be that the ability to buy expensive obesogenic goods such as calorie-dense foods and labor saving devices plays a key role in a child's risk of overweight/obesity in China. Energy-dense foods continue to have higher relative prices compared to energy light foods (Ge et al., 1999; Lu and Goldman, 2010), therefore higher SES groups have more access to these goods. Empirically, higher income groups consume more snacks, and the income gap in consumption of snacks and

fried foods during 1991-2004 increased (Wang et al., 2012; Wang et al., 2008).

Commuting to school as a source of physical activity has been identified as the most important predictor of child overweight in one study (Li et al., 2007), but automobile ownership, which is strongly correlated to risk of obesity (Bell et al., 2002), might only affect higher SES families' commuting patterns. In addition to the purchasing power, traditional views on children being chubby as a sign of health still prevail in some populations (Watson, 2000). And for children, access to and knowledge of Western food have become a status symbol used to develop networks and position among peers (Chee, 2000; Ng, 2005). In the family domain, letting children rather than parents influence food choices is likely to undermine the benefits of obesity-related health knowledge as children respond poorly to education efforts directed at promoting healthy lifestyles (McNeal and Wu, 1995; Bandura, 2004).

According to the resource dilution model, a decrease in sibsize reduces resource competition (Becker and Lewis, 1973; Becker and Tomes, 1976; Blake 1981; Steelman et al., 2002), so children with fewer siblings receive more resources. The China-India difference in malnutrition rates was largely attributed to the difference in fertility rates (Svedberg, 2007). However, under the One Child Policy, there are reasons to suspect that having siblings might affect the allocation of resources in a different way. On the one hand, having an only child changes the dynamics of decision making within the household, which is evidenced by findings that only children in Beijing determine as much as 70 percent of a family's overall spending compared to 40 percent in the United States (McNeal and Wu, 1995; Ng, 2005). In such cases, having no siblings might give a

child more access to resources than the resource dilution hypothesis alone would predict. However, on the other hand, it is equally reasonable to assume there are economies of scale in raising children (Qian, 2009). In addition, childrearing norms have been reshaped during the longstanding campaigns of “quality childrearing” (*you sheng you yu*). Children with a few siblings might still be able to have equal nutrition intake at the cost of their parents’ consumption. Another factor that might moderate the competition for resources is that the One Child Policy mandates a long birth interval to protect parents’ resources from being depleted (Powell and Steelman 1995; Yang, 2007). As a result, the second-birth interval during 1980-2000 was ranged from 3.5 to 5 years (Chen et al., 2011). Lastly, the stage of economic development matters. If expenditures for food consumption only take a small portion of the family’s budget, resource dilution effect should still exist, but might be more pronounced in consumption of more luxury goods, not in basic nutrition intake. Thus, having one or two more children might not affect the firstborn’s nutrition intake in a significant way. However, it is still a question if this occurs in China, especially in less developed rural areas.

Whether having siblings affects resource allocation within families may also vary by gender of the child. Girls suffer from discriminatory treatment in both prenatal and postnatal periods (Li et al. 2007; Li 2004; Li and Cooney, 1993). The reluctance to invest resources in girls was especially prevalent among older generations (Fond, 2002). Evidence shows that boys are more likely to receive breast-feeding, quality food and medical treatment than girls (Li 2004). Addressing the gender inequality in nutrition intake as fertility is falling remarkably, “Parity Effect” (Das Gupta and Bhat, 1997)

hypothesizes that fewer children means girls are likely to receive equal care. If girls are treated as equal to boys, the dilution effect of having siblings should also be equal across gender. “Intensification Effect” (Das Gupta and Bhat, 1997), on the other hand, argues that boys are even more treasured because the decline of fertility is faster than the decline of son preference. Concerning the effect of having siblings on nutrition status, “Intensification Effect” would suggest boys would not suffer as much from dilution effect as girls. Some findings on center-based childcare enrollment suggest that if family resources are scarce, parents often invest more in the eldest son regardless of the gender of his sibling(s) (Zhai and Gao, 2010).

Furthermore, gendered ideal body shape, which encourages girls to be thin, could potentially legitimize less resource allocation in nutrition for a girl, particularly if she has a younger sibling. Women in China are under much greater pressure to lose weight than men (Luo et al., 2005) as the ideal of a thin body type—implying beauty, health and self-discipline—has spread from Western countries to Asia (Cash and Pruzinsky, 2002; Watts, 2002; Wong, Bennink, Wang and Yamamoto, 2000).

While there have been a few studies attempting to identify the association between number of children and child nutrition status, the evidence is mixed. Number of siblings is positively associated with risk of underweight for children ages 2-6 in rural areas (Brauw and Mu, 2011). No difference in underweight between children with siblings and children without siblings was found in Zhejiang, China in 1999 in the survey of adolescents (Hesketh et al., 2003). For child overweight/obesity, studies consistently found that being an only child is associated with a higher risk of overweight

in China and some other Asian countries (Hesketh et al., 2003; Yang, 2007; Chamrathirong, Sinhadej, & Yoddumern-Attig, 1987; Parsons, Logan, & Summerbell, 1999). I am not aware of any study that attempts to identify the causal impact of having siblings on undernutrition and overweight/obesity.

### **5.3 Setting**

This study is conducted under the context of One Child Policy regime. This unique setting in China provides an opportunity to identify the impact of having siblings on child nutrition status in the low fertility era. I exploit a policy variable, monetary fine level, for unsanctioned births as instrument variable to achieve this goal. Background information on the One Child Policy helps to explain the method employed in this chapter.

The One Child Policy has undergone great decentralization since 1984 (Greenhalgh, 1986). The localization of the national policy was a response to China's highly heterogeneous demographic and social conditions, and was designed to facilitate better policy implementation (Gu, et al., 2007). The regional variation of policy-sanctioned number of children per couple varies by regional economic conditions, population density, resistance, as well as minority composition, etc. For example, resistance in poor rural areas is especially high, therefore a second child is allowed under certain conditions (Greenhalgh, 1986). Gu et al. (2007) calculated the policy fertility levels across regions and categorized three groups as of the late 1990s: 1) "1-child policy: in Beijing, Tianjin, Shanghai, Chongqing, Jiangsu and Sichuan where fertility ranges from 1.06 to 1.27; 2) "1.5-children" policy in 19 provinces where rural

residents may obtain a permit to have a second child if the firstborn is a girl. The fertility level varies in these areas from 1.38 to 1.67; 3) “2-children” policy in five provinces, Hainan, Ningxia, Qinghai, Yunnan and Xinjiang where minorities make up the majority of the population and the fertility rate is 2.01 to 2.37.

The fact that the number of policy-sanctioned children per family is not randomly assigned but related to regional characteristics makes it less than ideal as an instrument variable. Regional characteristics, themselves, can be directly related to child nutrition status. For example, fast food restaurants are more densely located in more developed regions, and rural residents are more likely to be less informed about optimal nutrition status and healthy feeding practice.

The One-Child Policy is a complex system that provides for compulsory abortion, reduction of land allotment, demotions if working in the public system, denial of public services for the child and monetary fines for violators. Fine levels vary by location and time, for example, Heilongjiang levied a one-time monetary fine of 120% of annual income in 1983, but in 1989 the fine was raised to 10% of income every year for 14 years (Scharping, 2003).

How have the birth quota and strength of enforcement changed over time? Since the 1990s, compulsory abortion and sterilization have been gradually abandoned as a growing concern about the social, political, physical and economic consequences of these crude enforcement methods spread (Merli and Smith, 2002). However, there is no reason to believe that enforcement was relaxed. In 1991, adoption of the “cadre responsibility for family planning system” (*yi piao fou jue*) further strengthened

enforcement. Under the cadre responsibility system, the cadres' level of remuneration and their tenure in office and opportunity for promotion are determined by how well their communities comply with birth limits set by officials higher up in the family planning system. In 2000, the "three unchangeable (*san bu bian*)," an official parlance reinforces: 1) no change of the present policy, 2) nor the birth limits, 3) nor the cadre responsibility system (Merli and Smith, 2002).

However, China's transformation from a centrally planned economy to one dominated by the marketplace had an impact on the family planning system (Merli and Smith, 2002). Since the 1990s, the central government began to retreat from funding local family planning offices. One major strategy adopted by the local offices was to increase fines for non-compliance. Therefore, whether the change of provincial monetary fine level is exogenous to the fertility level or other characteristics that could be related to child nutrition status might become a concern. I will address this issue in the method section.

## **5.4 Data**

I draw data from CHNS waves 1991, 1993, 1997, 2000, 2002, 2004 and 2006. Like many longitudinal data, CHNS data is also subject to attrition. A close check shows that BMI in the previous wave is not related to the attrition status conditional on a set of observables, suggesting that the attrition is random (See Appendix 5.1). There are 4,293 observations of the eldest children with non-missing values for the main model estimation. I dropped nine observations with BMI values greater than 50 or less than 10

and obtained an effective sample size of 4,284. Then I checked to see if missing was related to mother's BMI; results showed that missing is also random (See Appendix 5.2).

## **5.5 Measurement**

### **5.5.1 Dependent variables**

#### **5.5.1.1 Overweight/obesity and underweight**

I measure overweight/obesity using a composite scale based on the Working Group of Obesity in China (WGOC) reference and the International Obesity Task Force (IOTF) reference. For detailed information regarding to this scale, please refer to Section 3.2.1.1 in Chapter 3. I use International Obesity Task Force (IOTF) reference to measure underweight. For detailed information, please refer to Section 3.2.1.2 in Chapter 3.

#### **5.5.1.2 Instrument variable: monetary fine level**

Monetary fine level for an unsanctioned birth varies by year and location. To measure the total amount of monetary fines parents believe they will incur if they have an unsanctioned birth, I consider four measures based on the information of the mean length of second-birth intervals and the provincial fines levied on unsanctioned birth each year. The mean length of second-birth intervals ranged from 3.5 to 5 years from 1975 through 2005 (Chen et al., 2011). So the first measure of perceived fine level is the fine five years after a first child is born; and the second measure is the fine level at the third year since a first child is born. The third measure is the 10-year average fine since the birth of a first child. The fourth measure is the seven-year average fine level since the first child was born. Because the first two measures only use one year of information, they may not have much influence for parents who chose to have a second child five

years after the first child was born or less than four years since the first child was born, therefore I use the latter two measures.

I obtained records of provincial fines from 1979 to 2000 (See Appendix 5.3) collected by Scharping (Scharping, 2003; Ebenstein, 2009). Monetary fine is levied as a percentage of annual household income. To calculate the perceived fine levels, I first calculated the present value of the fine for each year in each province. For example, if the fine in 1980 is 10 percent of household income for 14 years, a present value of 1.2283 years of income is calculated for an unsanctioned birth in 1980, with a 2 percent discount rate. Then I average the present value of the fine for each year in each province through 7 and 10 years, respectively, to obtain two measures of perceived fine level.

## **5.6 Methods**

Maximum likelihood bivariate probit (BP) models (Heckman, 1978; Greene, 1998) correcting for clustering at the individual level are used to identify the impact of having siblings on a child's risk of being overweight and underweight in the low fertility era. Linear instrument variable models are not chosen when overweight and underweight are the outcome variables because in the case that the outcome variable and the endogenous predictor are both binary variables, maximum likelihood bivariate probit models tend to perform better than linear IV models; this is especially true for smaller sample sizes (below 5,000) when the model specification includes additional covariates (Chiburis, Das and Lokshin, 2011). In addition, when the instrument is weak, two-stage IV model could be seriously biased (Bound et al., 1995).

Models control child's demographic variables age, gender, minority status and family socioeconomic status. Community fixed effects is controlled to capture the time-invariant community characteristics that could be related to the general fine level and simultaneously affect the outcome of interest, such as general socioeconomic development, political environment, traditional value and son preference fixed within the community. Year fixed effects is controlled to capture the national trends over years that might be related to the change of fine levels and child obesity as well. Community-level-allowed number of children per couple, average per capita family income, average parental height, percentage of parents holding a high school diploma and community children's gender ratio are controlled to capture the time-varying characteristics that might be related to the change in fine levels and child nutrition status.

The equations for BP models are set up, where Y denotes outcome variable overweight/obesity, or underweight; S denotes whether having siblings; Z denotes the average fine level after the first child was born; and X is a vector of covariates including child's age, gender, minority status, family income adjusted by CPI, urban/rural residency, parental education, parental age, parental height, community-level average family income, community-level percentage of boy among children, community-level percentage of parents holding a high school diploma, community-level parents' height, community-level allowed number of children per family, community fixed effects and year fixed effects.

$$S_i = 1[\alpha_{10} + \beta_{11}Z_i + \beta_{12}X_i > \xi_{1i}] \quad 1)$$

$$Y_i = 1[\alpha_{20} + \beta_{21}S_i + \beta_{22}X_i > \xi_{2i}] \quad 2)$$

Error terms  $\xi_{1i}$  and  $\xi_{2i}$  jointly distributed as standard bivariate normal with correlation  $\rho$ . The joint probability of  $(P_i=1, Y_i=1)$  follows bivariate cumulative distribution and bivariate probit models estimate the parameters by maximizing the joint log-likelihood of the two jointly determined variables.  $\xi_{1i}$  and  $\xi_{2i}$  contain common components such as preference/taste, informal social connections or unobserved wealth and health endowment that affect both having younger siblings and child nutrition status. If  $\rho=0$ , then  $S_i$  is exogenous after taking into account the influence of the set of covariates. In such case the results from univariate probit models and bivariate probit models should be qualitatively the same, and the model can be simplified to a univariate probit model. If  $\rho$  is different than 0, a univariate probit model is subject to omitted variable bias. To test this exogeneity hypothesis, likelihood ratio test (Wald test) (Greene, 1998, 2000) will be conducted. The ratio of the log likelihood for the bivariate probit model versus the sum of the log likelihood of the two univariate probit models, follows chi-square distribution with one degree of freedom under the null hypothesis  $\rho=0$ .

In addition, to examine the proximate mechanisms, I also estimate two-stage linear least squares models to identify if having sibling(s) affects nutrition intake measured as total caloric intake, fat intake and protein intake as well as percentage of calories from fat and protein. The model specification is listed below.

$$S_i = \mu_{10} + \pi_{11}Z_i + \pi_{12}X_i + \varepsilon_{1i} \quad 3)$$

$$Y_i = \mu_{20} + \pi_{21}S_i + \pi_{22}X_i + \varepsilon_{2i} \quad 4)$$

$$\text{Cov}(\varepsilon_{1i}, \varepsilon_{2i}) \sim 0.$$

Is fine level a good instrument? Ideally, fine level only affects a child's weight status through the size of the child's younger siblings after controlling for all community-level effects and national trend. However, having unsanctioned births usually means loss of a portion of disposable income which exacerbates the resource dilution effect on child nutrition status. The treatment effect is the sum of loss of income and resource dilution, which is the effect of having younger sibling(s) under the One Child Policy regime.

Is the change in level of fines exogenous? As discussed previously, the general increase of fine level was driven by revenue-generating incentives since the central government stopped funding local family planning offices. The revenue-generating incentive might be related to local economic conditions. If change in fine level is related to local economic conditions, then the validity of the instrument variable is compromised. In addition, the validity of the instrument could also be threatened if the change in fine level is responsive to the community-level fertility rate. To address these concerns, I examined the change in fine levels from 1991 to 2000 to see if it was a response to the local economic conditions or the previous fertility level in 1991. Results show that after adjusting a set of community-level characteristics, neither the community-level average number of children nor the average per capita income in 1991 predicts the change in fines from 1991 to 2000 (See Appendix 5.4). How strictly was the fine assessed? Family planning officials report that about 90% of families who violated the birth quota actually paid the penalty in the 1991 and 1993 waves where these questions were asked.

For first-order girls, one more concern is that the fines could be related to the parents' preference for a son. China observes a gender imbalance at birth and it is arguably a result of underreporting or non-registration and prenatal/neonatal discrimination (Merli and Smith, 2002; Hesketh, 2005; Ebenstein, 2009). The sex ratio at birth has been increasing since 1980s, from 108.5 boys per 100 girls in 1982, 113.8 in 1989 (Gu and Roy, 1995), to 121.18 in 2004 (SSBC, 2005). Fine level has been found to causally increase the sex ratio (Ebenstein, 2009). CHNS data is collected by China's Center of Disease Control, so it is possible that respondents hide first-born girls from the government interviewers, and the probability of a first-born girl being observed (or being reported in the survey) depends on a couple's preference for a son or daughter and a high or low fine level. For example, when the fine level is low and son preference is low, the probability of first-born girls being observed is the highest; whereas when the fine level is high and son preference is high, the probability of a girl being observed is the lowest.

Below I consider two scenarios. In the first scenario, assuming in the population the community level son preference is not related to the level of fine, that is, the communities facing high fine regime and the communities under low fine regime have the same level of average son preference. Then in the community with high fine level, the parents who have above-average-level son preference might be more likely to underreport their first-born girls than the community facing low fine level as a response to the higher fine, therefore, in the high-fine-community, for the girls observed in the sample, the average level of their parents' son preference should be lower than the

observed girls in low-fine community. In such case, son preference might be negatively related to fine level among the observed girls. The second scenario assumes the population son preference is not randomly distributed among communities, for example, the high fine communities have higher son preference than the low fine community. In such case, how community level son preference and fine level are related in the sample would be uncertain.

Both scenarios suggest that fine levels could be related to son preference. The threat to the validity of the instrument for the girls' sample is due to the fact that son preference and poverty affect girls' nutrition and health, resulting in marked gender disparity in height and morbidity (Graham, Larsen, and Xu 1998; Burgess and Zhuang, 2000). Since son preference is not directly observed, the instrument may be affected by unobservable factors related to weight status. I also might encounter that problem of missing by unobserved variable. Specifically, if the assumption about random distribution of son preference among the population is true, I would attribute the effect of son preference to having siblings and bias the estimate upward. The missing pattern per se might bias the estimate downward if the parents of the missing girls direct more resources to younger siblings or ignore their first daughter's nutrition needs due to their higher level of son preference.

In order to mitigate these potential problems, I control the determinants of son preference at the community level and the individual level. I control residency type because urbanization and industrialization are negatively related to son preference (Murphy et al., 2011). Community-level patrilineal norm (Murphy et al., 2011) is

controlled by community fixed effects and time-varying community child gender ratio.

Individual-level determinants of son preference such as parental education level and age (Li and Lavelly, 2003; Chuang, 1985; Yan, 2003; Murphy et al., 2011) are also controlled.

In analysis, I first control the set of community-level determinants of son preference and then control individual-level determinants of son preference to see if adding these controls makes a difference in the estimates.

## **5.7 Results**

### **5.7.1 Descriptive analyses**

Descriptive analysis on main variables of interest by survey year is presented in Table

5.1. The proportion boys in the first-born children and adolescents samples have increased over the years, consistent with previous studies on all-order children (Gu and Roy 1995; SSBC 2005). The average age in this sample is 11 to 12 before 2000, but increased to 15 and 16 in 2004 and 2006. This is because observations have to be born in 1991 or before to have available values on 10-year average fine levels after they were born. The prevalence of overweight/obesity among this sample increased from around 7.0% in 1991 to 13.3% in 2006. The prevalence of underweight remained about the same, from 5.1% to 6.5%. The proportion having siblings steadily declined from 50.6% to 27.3%. Annual family income steadily increased from 10,100 Yuan to 26,300 Yuan. Urban firstborn children make up 31.0% of the sample in 1991 and 46.8% in 2006, a larger portion compared to all-order children because most of the second-born children are rural residents. Percentage of parents holding high school diplomas has increased over time as has average parental height. The prevalence of children subject to the 1.5-child

policy declined over years, so did the prevalence of children subject to the two-child policy. The mean of the 10-year average fine level after the respondent was born increased steadily from 1.23 years of annual family income in 1991 to 2.15 in 2006. Percentage of ethnic minorities among the first-born sample declined over the years. Total daily energy intake remained at a similar level over years, but daily protein intake and fat intake increased.

### **5.7.2 Having younger siblings and nutrition status**

Initially, I estimated OLS model (Model 1) and Bivariate Probit model (Model 2) on the sample of first-born children ages 2-18 using overweight/obesity as the dependent variable (See panel A of Table 5.2), correcting clustering at the individual level. I also explore whether the estimates differ by gender (See Model 3 and Model 4). These models do not include individual level son preference determinants parental age and parents' education. In the OLS model, the estimated coefficient on the younger sibling

**Table 5.1: Descriptive statistics for first-born children ages 2-18 with no missing values in major variables, China Health and Nutrition Survey 1991-2006**

	1991		1993		1997		2000		2004		2006	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Male	.476	.500	.499	.500	.514	.500	.519	.500	.527	.499	.514	.499
Age (years)	11.2	4.94	11.0	4.49	12.36	3.50	13.7	2.55	15.7	1.67	16.8	1.12
Overweight/Obese	.070	.256	.087	.282	.078	.268	.091	.288	.116	.308	.133	.340
Underweight	.051	.219	.058	.234	.065	.247	.058	.234	.052	.221	.062	.240
Have younger sibling(s)	.506	.500	.511	.500	.486	.500	.366	.482	.333	.472	.273	.446
Family real income (in thousand Yuan)	10.1	7.11	11.4	10.0	13.7	10.5	16.1	12.5	21.6	19.8	26.8	28.5
Urban resident	.310	.462	.356	.479	.339	.473	.396	.489	.412	.493	.468	.500
Father high school	.233	.423	.278	.448	.306	.462	.347	.477	.303	.460	.403	.492
Mother high school	.156	.363	.207	.406	.225	.418	.269	.443	.267	.431	.248	.433
Father's height (cm)	166	6.36	166	6.13	167	6.08	168	6.28	168	7.12	168	10.7
Mother's height (cm)	155	5.68	156	5.56	156	5.48	157	5.80	157	8.31	157	9.82
Allow 1.5 children	.420	.494	.334	.471	.350	.477	.350	.477	.430	.495	.316	.466
Allow two children	.189	.390	.112	.316	.220	.414	.229	.420	.038	.192	.015	.121
Seven year average fine	1.01	.621	1.24	.650	1.39	.501	1.67	.688	1.98	.762	2.01	.834
Ten year average fine	1.23	.719	1.45	.749	1.53	.510	1.93	.769	2.17	.835	2.15	.906
Minority	.162	.368	.149	.355	.127	.333	.137	.343	.103	.304	.107	.310
Daily energy intake (1000 kcal)	2.13	.773	2.02	.763	1.98	.630	2.10	.794	2.20	.746	2.03	.626
Daily Fat (gram)	53.2	33.6	54.9	33.8	57.9	33.3	68.9	37.8	71.6	31.9	64.7	35.1
Daily Protein(gram)	60.3	22.9	59.6	23.5	57.7	21.4	62.0	23.5	68.8	27.7	64.3	23.3
Number of obs.	1122		1159		881		634		330		158	

variable is insignificant. Age is negatively related to overweight/obesity. Family income is positively associated with overweight/obesity.

The results from the maximum-likelihood Bivariate models in panel A shown in Table 5.2 suggest that the 10-year average provincial fine level strongly predicts the chance of having younger siblings for the firstborn children's sample ( $t=5.73$ ), firstborn boys' sample ( $t=4.22$ ) and firstborn girls' sample ( $t=4.28$ ). I also estimated the models using seven-year average provincial fine levels as instrument variable, but the results show that seven-year average fine levels are only weakly related to having siblings after controlling for covariates, so it is not used as valid instrument variable here. The results from the bivariate probit models also show that the correlation between the error terms of the two equations significantly different than zero ( $\rho \neq 0$ ), which suggests that there are unobserved characteristics related to both nutrition status and siblings that OLS or ordinary probit models would fail to control.

The estimates from bivariate probit models in panel A (Model 2, Model 3 and Model 4) show that having younger siblings does not predict the risk of being overweight/obese. Results from gender specific models in Table 5.2 show that family income increases boys' risk of being overweight/obese but does not affect girls' chance of being overweight/obese. After adjusting for individual-level son preference determinants including parental age and education level, there is little change in the results (See Panel B of Table 5.2), suggesting the bias that could come from uncontrolled son preference might be small, if it exists at all.

**Table 5.2: Results for overweight/obesity from OLS and bivariate probit models for first-born children ages 2-18, CHNS 1991-2006, clustering correction at the individual level**

Overweight/obesity	OLS	Bi-Probit	Bi-Probit	Bi-Probit
	All first-borns	All first-borns	First-born boys	First-born girls
<b>Panel A</b>				
	Model 1	Model 2	Model 3	Model 4
<b>Having younger siblings</b>	<b>-.003(.009)</b>	<b>-.177(.322)</b>	<b>.103(.641)</b>	<b>-.363(.277)</b>
Age	-.008(.001)***	-.055(.011)***	-.064(.016)***	.003(.005)
Boy	.009 (.008)	.013(.071)	N/A	N/A
Family income logged	.011(.005)**	.014(.013)	.024 (.006)***	-.002(.012)
Community PB	-.101(.069)	-.200(.134)	-.208(.104)*	.024(.123)
Allow 2 children	.013(.017)	.002(.020)	.024(.026)	-.006(.039)
Allow 1.5 children	-.022(.018)	-.007 (.023)	-.041(.027)	-.012(.021)
Marginal effect of IV		-.083(.018)***	-.094(.023)***	-.076(.018)***
Correlation of errors		.100 (.052)*	-.123 (.077)*	-.140 (.076)*
P value: rho=0		.019	.030	.047
<b>Marginal effect of younger siblings</b>		<b>-.010(.009)</b>	<b>.004(.006)</b>	<b>-.021(.030)</b>
<b>Panel B: adjusting parental age and education</b>				
	Model 5	Model 6	Model 7	Model 8
<b>Having younger siblings</b>	<b>-.003(.010)</b>	<b>-.184(.414)</b>	<b>.101(.687)</b>	<b>-.356(.278)</b>
Age	-.007(.001)***	-.049(.013)***	-.065(.018)***	.003(.006)
Boy	.009 (.009)	.013(.083)	N/A	N/A
Family income logged	.011(.006)*	.013(.015)	.024(.008)***	-.002(.011)
Community PB	-.095(.067)	-.133(.091)	-.178(.104)*	.028(.122)
Allow 2 children	.010(.023)	.002(.023)	.024(.027)	-.004(.037)
Allow 1.5 children	-.017(.017)	-.007 (.022)	-.042(.026)	-.013(.024)
Marginal effect of IV		-.082(.019)***	-.093(.025)***	-.076(.019)***
Correlation of errors		.101 (.054)*	-.134 (.077)*	-.142 (.073)*
<b>Overweight/obesity</b>	<b>OLS</b>	<b>Bi-Probit</b>	<b>Bi-Probit</b>	<b>Bi-Probit</b>
P value: rho=0		.021	.034	.043
<b>Marginal effect of younger siblings</b>		<b>-.009(.009)</b>	<b>.004(.006)</b>	<b>-.020(.031)</b>
Number of observations	4284	4284	2155	2129

\*, P<0.1, \*\*, P<0.05, \*\*\* P<0.01; Parents' height, rural/urban residency, minority status, community level average income, community average parental height, community percentage of parents holding high school diploma, community fixed effects and year fixed effects are controlled in all models. Community PB is community percentage of boys; Correlation of errors is correlation of the errors of two equations.

Then using underweight as the dependent variable, I estimated OLS model and Bivariate Probit models on the sample of first-born children aged 2-18 (See Model 9, Model 10 and Model 11 in Panel A of Table 5.3). Again, these models in panel A do not include individual level son preference determinants parental age and education. OLS estimates show that having younger siblings does not affect the first-born child's risk of underweight. However, Bivariate Probit models show that having younger sibling(s) has a pronounced effect on underweight and this effect is driven by girls. The Wald test on the endogeneity of having younger siblings suggests that the OLS model is biased by omitted variables. Results in Model 12 suggest that family income reduces the risk of underweight only for girls. After adjusting individual-level son preference determinants including parental age and education level, there is little change in the estimates (See Panel B of Table 5.3).

To further explore the role potentially played by son preference, I divide the sample by one of the most important indicators of son preference: the type of residence (Yan, 2003; Murphy et al., 2011). Results are shown in Table 5.4 and indicate that in urban areas with low son preference (Li and Lavelly, 2003; Chuang, 1985), there is no effect of having siblings on a child's underweight status. Whereas in rural areas where son preference is higher, a larger effect on a girls' underweight status is observed but no effect on boys' underweight status is found. These results suggest the effect on girls is driven by rural population. One important reason could be that son preference

**Table 5.3: Results for underweight from OLS and bivariate probit models for first-born children aged 2-18, CHNS 1991-2006, cluster at individual level**

Underweight	OLS	Bi-Probit	Bi-Probit	Bi-Probit
	All first-borns	All first-borns	First-born boys	First-born girls
<b>Panel A</b>				
	Model 9	Model 10	Model 11	Model 12
<b>Having any younger sibling</b>	<b>.015(.013)</b>	<b>.301(.145)**</b>	<b>.087(.235)</b>	<b>.348(.183)*</b>
Age	.001(.001)	-.006(.004)	.006(.004)	-.016(.006)
Boy	.024(.019)	.073(.047)		
Family income logged	-.011(.007)	-.008(.007)	.002(.009)	-.024 (.011)**
Community PB	.069(.068)	.035(.076)	.011(.106)	.011(.134)
Allow 2 children	-.023 (.030)	.037(.028)	.008(.039)	.051(.041)
Allow 1.5 children	.039 (.025)	.013(.021)	-.004(.031)	.054(.030)
Marginal effect of IV		-.084(.019)***	-.095(.023)***	-.077(.018)***
Correlation of errors	N/A	.300 (.045)***	0.017(.022)	-.436 (.122)***
P value: rho=0		.000	.129	.000
<b>Marginal effect of younger siblings</b>		<b>.021(.012)*</b>	<b>.001(.013)</b>	<b>.046(.029)*</b>
<b>Panel B: adjusting parental age and education</b>				
	Model 13	Model 14	Model 15	Model 16
<b>Having any younger sibling</b>	<b>.013(.014)</b>	<b>.298(.144)**</b>	<b>.087(.235)</b>	<b>.345(.181)*</b>
Age	.001(.001)	-.006(.004)	.006(.004)	-.016(.006)
Boy	.022(.016)	.071(.046)		
Family income logged	-.009(.007)	-.008(.007)	.002(.009)	-.024 (.011)**
Community PB	.066(.069)	.035(.076)	.011(.106)	.011(.134)
Allow 2 children	-.020 (.032)	.035(.029)	.008(.039)	.051(.041)
Allow 1.5 children	.037 (.023)	.011(.022)	-.004(.031)	.054(.030)
Marginal effect of IV		-.082(.019)***	-.093(.025)***	-.076(.019)***
Correlation of errors	N/A	.299 (.043)***	0.017(.022)	-.436 (.122)***
P value: rho=0		.000	.136	.000
<b>Marginal effect of younger siblings</b>		<b>.020(.011)*</b>	<b>.001(.015)</b>	<b>.044(.025)*</b>
Number of observations	4284	4284	2155	2129

\*: P<0.1, \*\*: P<0.05, \*\*\* P<0.01; Parents' height, rural/urban residency, minority status, community level average income, community average parental height, community percentage of parents holding high school diploma, community fixed effects and year fixed effects are controlled in all models. Community PB is community percentage of boys; Correlation of errors is correlation of the errors of two equations.

significantly modifies the effect of having younger siblings. To explore how much this effect on girls might be modified by son preference, I also compared the underweight status of girls who have younger siblings by the provincial average community-level percentage of boys among total children's population. Four provinces that have a percentage of boys higher than .537 are treated as high-son-preference provinces. Results show that those girls with younger siblings and residing in high-son-preference provinces have an underweight prevalence of .0794, whereas those with younger siblings in low-son-preference provinces have a prevalence of .0677, but still higher than the girls without any younger siblings and whose prevalence of underweight is .0579. These comparisons did not control for any other factors, but suggest that son preference to some extent modifies the effect of having younger siblings for girls.

### **5.7.3 Having younger siblings and nutrition intake**

To understand the relationship between having younger siblings and risk of malnutrition, I examine the impact of having younger siblings on the first-borns' nutrition intake. The results from two-stage least squares models show that having younger siblings only affects the total caloric intake for girls (See Table 5.5).

## **5.8 Discussion and Conclusions**

No previous study has identified the impact of having younger siblings on child nutrition status under the One Child Policy regime. This chapter exploits the variation of

**Table 5.4: Results for underweight from OLS and bivariate probit models for first-born children ages 2-18 by residence type, CHNS 1991-2006, cluster at the individual level**

Underweight	OLS	Bi-Probit	Bi-Probit	Bi-Probit
	All first-borns	All first-borns	First-born boys	First-born girls
<b>Panel A: Urban children</b>				
	Model 17	Model 18	Model 19	Model 20
<b>Having any younger sibling</b>	<b>-.021(.016)</b>	<b>-.101(.103)</b>	<b>-.170(.224)</b>	<b>-.059(.199)</b>
Age	.004(.009)	-.011(.006)	.005(.005)	-.019(.011)
Boy	.022(.017)	.077(.054)		
Family income logged	-.009(.008)	-.012(.009)	.002(.009)	<b>-.022 (.011)**</b>
Community PB	.070(.066)	.033(.065)	.045(.129)	.025(.104)
Allow 2 children	-.028 (.024)	-.034(.029)	.001(.007)	-.040(.051)
Allow 1.5 children	.011 (.014)	.033(.027)	-.002(.020)	.051(.041)
Marginal effect of IV		-.091(.039)***	-.099(.040)***	-.087(.029)***
Correlation of errors	N/A	-.033 (.037)	-.011(.024)	-.040 (.101)
P value: rho=0		.221	.389	.206
<b>Marginal effect of having siblings</b>		<b>-.013(.014)</b>	<b>-.015(.022)</b>	<b>-.005(.017)</b>
Sample size	1469	1469	740	729
<b>Panel B: Rural children</b>				
	Model 21	Model 22	Model 23	Model 24
Having any younger sibling	.015(.009)*	<b>.376(.194)*</b>	-.009(.009)	<b>.487(.251)*</b>
Age	.002(.002)	.007(.004)	.008(.005)	-.021(.022)
Boy	.009(.008)	.089(.056)		
Family income logged	-.003(.005)	-.006(.006)	.004(.010)	<b>-.028(.013)**</b>
Community PB	.014(.033)	.036(.086)	.015(.110)	.017(.141)
Allow 2 children	.012 (.014)	-.034(.036)	.011(.069)	.055(.081)
Allow 1.5 children	.010 (.010)	.024(.042)	-.007(.044)	.059(.070)
Marginal effect of IV		-.075(.029)***	-.101(.041)***	-.046(.020)***
Correlation of errors	N/A	.140 (.051)**	0.007(.011)	.312 (.172)*
P value: rho=0		.001	.209	.015
<b>Marginal effect of younger siblings</b>		<b>.041(.022)*</b>	-.001(.013)	<b>.057(.030)*</b>
Number of observations	2815	2815	1431	1384

\*. P<0.1, \*\*. P<0.05, \*\*\* P<0.01; Parents' height, minority status, parental age and parental high school diploma, community level average income, community average parental height, community percentage of parents holding high school diploma, community fixed effects and year fixed effects are controlled in all models. Community PB is community percentage of boys; Correlation of errors is correlation of the errors of two equations.

**Table 5.5: Results on daily nutrition intake (kcal) by estimating two-stage instrument variable models for first-born children ages 2-18, CHNS 1991-2006, correcting clustering at the individual level**

	2SLS Model 25 All first-born children	2SLS Model 26 First-born boys	2SLS Model 27 First-born girls
<b>Having any younger sibling</b>	<b>-62.3(68.9)</b>	<b>3.09(34.9)</b>	<b>-110(49.7)**</b>
Age	104(4.00)***	110(8.34)***	95.4(10.5)***
Boy	78.5(21.1)***		
Family income logged	16.23(4.01)***	20.1(7.22)***	11.8(6.01)*
Community PB	23.0(19.7)	31.4(29.0)	
Allow 2 children	-12.5(20.4)	-15.7(31.9)	-3.45(12.1)
Allow 1.5 children	13.8(43.2)	19.1(78.3)	12.7(33.0)
Wald F statistic for weak instrument	25.4	11.4	10.4
Number of observations	4284	2155	2129

\*: P<0.1, \*\*: P<0.05, \*\*\* P<0.01;

Parents' age, parents' holding high school diploma, parents' height, rural/urban residency, minority status, community level average income, community average parental height, community percentage of parents holding high school diploma, community fixed effects and year fixed effects are controlled in all models. Community PB is community percentage of boys.

fine level on unsanctioned birth by location and time to instrument whether the first-borns have any younger sibling to identify its impact on child nutrition status. Using China Health and Nutrition Survey 1991, 1993, 1997, 2000, 2004 and 2006, I found that under the low fertility era, having younger sibling(s) do not affect a firstborn child's risk of overweight/obesity, but increases the risk of underweight only for girls. This effect is mainly driven by girls in rural areas where son preference is more consequential than urban areas. I also found that having younger siblings does not affect daily energy intake for first-born boys, but reduces the energy intake from protein for first-born girls.

This collective evidence suggests that from 1990s to mid-2000s, under the low fertility era in China, having more than one child still has resource dilution effects on the

first-born child's nutrition status. This effect is less pronounced for boys but evident in girls' underweight status, implying girls' lower parity hasn't eliminated the discriminating treatment on them. One additional and very interesting finding is that family income increases the risk of overweight for boys but not girls, whereas family income decreases girl's risk of underweight but not boys. This contrast might result from girls being under greater pressure to keep thin (Luo et al., 2005). Therefore, they do not respond to the increase in access to resource when there is risk of overweight; but, at the same time, when the risk is underweight, increase in income protects the first-born girls from underweight. This does not make much difference to first-born boys, however, suggesting that boys are protected from underweight regardless, and this could be at the cost of other family members' nutritional status or other consumption.

Explanations regarding the lack of significant findings for overweight/obesity, overall, are also interesting. For first-born boys, although their risk of overweight/obesity responds to family income, it is not affected by the presence or absence of younger siblings. It could be that other family members absorbed this cost. For first-born girls, we observed that their obesity status did not respond to family income; nor did it respond to resource dilution from having a younger sibling.

In this study I found little evidence for economy of scale in nutrition intake, but I did find evidence suggesting the importance of stage of economic development. Although the economy in China grew rapidly during the years under survey, it grew unequally. Regional inequality and urban-rural divisions are both significant in China (Liu, 2010). When overweight/obesity is spreading among the wealthy and urban

residents to less affluent and rural areas, undernutrition still exists (Des-Wesley et al., 2011). Although the Engel's Coefficient decreased from 57.5% in 1978 to 37.9% in 2008 for urban residents and from 67.7% in 1978 to 43.7% in 2008 for rural residents (China National Statistics Bureau, 2009), the poverty rate in 2011 was still as high as 13.4%, representing 128 million people (CIA World Fact Book, 2012). For the girls living at or near poverty level, having a younger sibling could significantly impact their food insecurity.

## **Chapter 6: Co-residence with grandparent(s) benefits child nutrition status in China**

### **6.1 Introduction**

Worldwide, the type of childcare has been identified as an important predictor of obesity or its prevention (Gardner et al., 2009; Pearce et al., 2010). For example, studies based in the United States and the United Kingdom found that informal alternatives to maternal child care are associated with higher risk of child obesity (Pearce et al., 2010; Kim et al., 2008; Benjamin et al., 2009). In China, market-provided alternatives to maternal childcare were scarce throughout the 1990s, particularly in rural areas (Wolf, 1985; Jacka, 1997), while the labor participation of women ages 25-44 was as high as 95% in urban areas and even higher in rural areas (Bauer et al., 1992). Coincident with the acute conflict between work and childcare faced by mothers is the traditional practice of grandparent's involvement in childcare, an expression of the importance of intergenerational tie that takes precedence to the tie between husband and wife (Cornwell et al., 1990; Hermalin et al., 1998; Chen et al., 2000). Since childcare provided by grandparents is a well-adopted substitute for maternal childcare, it is important to identify the impact of such care on child nutrition status, particularly in countries heavily influenced by Confucianism such as the Great China Area, Korean, Singapore and Malaysia.

A U.K. cohort study found that children cared for by grandparents either part-time or fulltime are subjected to considerably higher risk of overweight/obesity (Pearce et al., 2010). A cross-sectional study based in Greece found that obese children are much

more likely to report that food preparation was carried out by their grandmothers (Hassapidou, 2009). In China, however, only few studies have touched upon this issue. Jiang et al. (2006) conducted semi-structured in-depth interviews with 12 parents and 11 grandparents in Beijing, China and found some evidence to support the view that the presence of grandparents in households could increase the risk of child overweight/obesity. Brauw and Mu (2011) found the presence of grandparents is associated with a higher rate of overweight for children ages 2-6 and lower rate of underweight for children ages 2-12 in rural parts of eight provinces in China but did not identify the causal inference or discuss any mechanisms.

Grandparents' involvement in childcare in China is highly conditioned by residential proximity to their grandchildren (Chen et al., 2002). This chapter aims to develop a conceptual framework to understand the impact of the presence and proximity of grandparents on child overweight (including obesity) and child underweight, and also attempts to empirically identify this impact. Extensive discussion on the validity of the estimator would contribute to the methodology in identifying the impact of family structure on family members' wellbeing. Given the importance of identifying the consequences of three generations living together or proximately, obtaining a valid estimator of this living arrangement is of great importance. Using the China Health and Nutrition Survey 1991, 1993, 1997, 2000, 2004 and 2006, I exploit the randomness of the gender composition of children's paternal siblings as the instrument, and employ maximum likelihood bivariate probit models and two-stage linear models

to identify the impact of the presence and proximity of grandparents on child nutrition status.

## **6.2 Background**

Childcare arrangements have profound implications on children's developmental outcomes including nutrition status (Clarke-Stewart and Allhusen 2005; Lamontagne, et al., 1998; Short et al., 2002). In contrast to Western society, the major alternative to maternal care in developing countries is more likely to be care provided by extended family members such as grandparents or elder children (Leslie, 1988; Lamontagne et al., 1998).

Women in developing countries assume dual responsibility as generators of household income and as primary caregivers (Leslie, 1988; Glick and Sahn, 1998). In China, the majority of women in urban areas participated in full-time work that usually did not accommodate childcare, particularly before the public sectors and state-owned companies began to lay off employees on a large scale (Connelly, 1992; Klerman and Leibowitz 1999). Rural women carried a heavy load (Entwisle and Chen, 1998), and their increasing participation in the migration work forces to urban markets (Zhao, 1999; Rozelle et al., 1999) makes childcare even more difficult. Childcare services provided by the public sector usually fall short of demand, while market-provided childcare only began to emerge in the late 1990s and suffers from serious quality issues (Parish and Whyte, 1978; Chen et al., 2000; Zhao and Wang, 2008). As a consequence, the level of institutional care utilization was low (e.g., Kilburn and Datar, 2002.)

The role conflicts of mothers are, to some extent, eased by the traditional family living arrangements. Family living arrangements in China are undergoing changes but the pattern of three generations living together still characterizes a significant portion of households. Whereas the typical living arrangement for adults is a nuclear family, the typical living arrangement for the elderly with adult children is to co-reside with their children to form a three-generation household (Zeng and George, 2002). Zeng and George found that for the elderly ages 65 to 79, among males, 68.1% in 1982, 67.6% in 1990, and 59.0% in 2000 lived with their children. For females, 73.2% in 1982, 73.1% in 1990 and 66.7% in 2000 lived with their children. Among all the household types, three-generation households constituted 19.5% of all households in 1982, 18.97% in 1990 and 20.89% in 2000, a stable pattern reinforced by traditional values and the housing shortage (Zeng and George, 2002). Grandparents living in the same neighborhood make up an even larger portion of the population (Chen et al., 2000). When grandparents live in the same household or nearby, they take up household chores and/or even play a central role in family meal preparation (Jiang, 2006). Chen (2002) found that the close proximity of grandparents reduces the time mothers spent on childcare by a considerable amount.

### **6.3 Potential pathways**

Grandparents affect children's food preferences and physiologic regulation of energy intake through shaping family food environments and practicing certain parenting styles. The family food environment during early childhood has life-long effects on children's eating styles and food preferences (Birch and Fisher, 1998). Whether

families socialize children in ways that support healthy growth is an important predictor of obesity (Gable and Lutz, 2000). Studies conducted in the United States (e.g., Anderson et al., 2003) suggest that caregivers have enormous influence on children's physiologic regulation of energy intake, evident as early as the preschool years. For example, unresponsive overfeeding could gradually make a child fail to respond to the sense of satiety which is critical for his or her ability to regulate food intake (DiSantis et al., 2011). Early post-natal over-feeding predisposes the child to later obesity through food-mediated hormonal change across different windows of development (Prentice, 2005).

In three-generation residential settings, grandparents play a central role in forming the family diet (Jiang, 2006). Compared to the younger generations, grandparents, who are more likely to have experienced the Great Famine and long-term poverty, tend to conceive being overweight as a sign of abundance and health, which leads them to overfeed children in their care (Jiang, 2006). Their determination and effort to ensure that their grandchildren be "well-fed" would be admirable in times of lack, but as overweight/obesity began to be a concern, this tendency could be counterproductive.

Grandparents in charge of family meals may contribute to greater variety of family foods and reduce the incidence of eating out and missing breakfast. Restaurant meals, especially those in fast food restaurants, are generally denser in calories and less nutritious than meals prepared at home (Lin et al., 1999; Rolls et al., 2004). Missing breakfast might lead to a higher risk of overweight/obesity when hunger later results in a higher daily caloric intake (Siega-Riz et al., 1998; Morgan et al., 1986). Grandparents

might also attempt to earn affection from children by buying them popular Western fast food or other energy-dense snacks (Yang, 2006).

Regarding physical activity, grandparents living in the same household or neighborhood might be in a better position than working mothers to facilitate child's physical activity. They may be more likely to give children opportunities to play on the street or playground. Children without supervision tend to spend more time indoors on sedentary activities like watching TV (Anderson et al., 2003). Grandparents have fewer time constraints in facilitating social efficacy of physical activity in the neighborhood: they may have more in-depth social interactions with the other caregivers which might help facilitate organized physical activity in the neighborhood.

Overall, children cared by grandparents might have more energy intake and also more opportunity for physical activities in China. The implication of grandparents' involvement in childcare is that it could reduce child underweight but not necessarily elevate child overweight, especially because the effect of physical activity on weight gain is more relevant than food intake for children and adolescents (Hassapidou et al., 2006).

More importantly, the effect could be conditioned by a country's contextual factors. In U.K. or U.S. settings with highly penetrating obesogenic environments, caregivers would need to work especially hard to combat children's obesity. It takes time, energy and planning to keep children in these environments from consuming readily available and cheap calorie-dense foods. Caregivers, who lack time and energy or are more likely to indulge children than their mothers or center-based caregivers, might simply do what's easiest. In contrast, overweight/obesity in China is concentrated

in the higher socioeconomic groups (Wang, 2002, 2006; Li et al., 2007; Hsu et al., 2011) because energy-dense foods are more expensive (Ge et al., 1999; Lu and Goldman, 2010) and access to cars were far from universal, particularly one or two decades ago. Much less extra work besides the economic constraints in a household may be needed to control the child's risky eating behavior of obesity in China.

One additional important reason to suspect that grandparents in China have a different impact than grandparents in the Western world is that, given the much closer intergenerational relationship (Thornton and Lin, 1994) and closer living arrangements, effective communication might more likely to be conveyed and as a result, parents are better able to modify grandparents' over-indulgent tendencies.

Although the impact of grandparents is theoretically undetermined, it might be particularly pronounced for children under age 7 since they spend more time at home and adult's supervision in physical activities is necessary. Older children's eating behavior and physical activity are presumably less controlled by their grandparents. Grandparents living in the neighborhood contribute to childcare as noted, but not as intensively as grandparents in the household (Chen et al., 2000). It is also less likely that grandparents who don't live in the same house dominate the child's family food environment. The effect might also vary by paternal/maternal grandparents. Traditional Confucian ideals prescribe a strong parent-son relationship and a weak parent-daughter relationship. Therefore, only a small portion of households have maternal grandparents in the household or neighborhood (Chen et al., 2000). In addition, the reduction in a mother's childcare brought by proximity of grandparents is mainly driven by paternal

grandparents (Chen et al., 2000). Gender of the child could also play a role to moderate the effect if the grandparents practice a gendered ideal that imposes more pressure on females to be thin (Luo et al., 2005).

The only study based on a representative sample that touched upon this topic found association between the presence of grandparents and child overweight and underweight among rural residents in China using fixed-effects models (Brauw and Mu, 2011). However, the research fails to identify the mechanisms. Equally importantly, because the impact is theoretically undetermined, we rely on the specification of empirical strategy to learn about the direction and the magnitude of the effect. Therefore fixed-effects models used in this study are not satisfactory because they are subject to bias from time-varying heterogeneity. For example, higher working intensity or more working hours are risk factors for having grandparents move in. Therefore, the simple correlation between grandparents' presence and child weight status could be confounded by the effect of the characteristics of maternal employment. It is also difficult to disentangle the effect of grandparents from institutional care. For example, grandparents' co-residence might be a response to the absence of affordable institutional care. Although relevant studies are sparse in China, evidence in the Western literature shows that maternal employment and institutional care are both related to child overweight/obesity (Anderson et al., 2003; Lumeng, 2006). To address these problems, I exploit the randomness of gender composition of child's father's siblings to instrument the presence and proximity of grandparents using China Health and Nutrition Survey. The basic idea of this strategy is that under the patrilineal tradition, the elderly live with

one of their sons (Zeng and George, 2002). If the elderly have multiple sons, then the chance to live with a particular son is lower. Conditioning on the total number of children, number of sons are randomly distributed, which serves as a good candidate for instrument variable. To verify this claim, I also conducted extensive analysis in the method section.

## **6.4 Data**

I draw data from waves 1991, 1993, 1997, 2000, 2002, 2004 and 2006 of the China Health and Nutrition Survey (CHNS). For data description, please refer to Section 3.1 in Chapter 3. Like many longitudinal data, CHNS data is subjected to attrition. A close check shows that the respondent's overweight status in the previous wave is not related to the attrition status conditional on the set of observables, suggesting that the attrition is conditionally at random (See Appendix 6.1). There are 6,182 observations of children ages 2-12 with non-missing values for the variables included in the analysis. I conducted a sensitive check to see if missing values were related to mother's BMI, and the results suggest that missing values are random (See Appendix 6.2). I dropped 12 observations with BMI value greater than 50 or less than 10 and obtained a sample size of 6170 children. I also obtained 18,434 observations of adults ages 25 and older in 2004 and 2006 with no missing values in questions about obesity-related health knowledge.

## **6.5 Measurement**

Overweight/obesity is measured using a composite scale based on The Working Group of Obesity in China (WGO) reference and the International Obesity Task Force (IOTF) reference. Underweight is defined by IOTF 2007 reference of thinness. For more

detailed information for the definition of overweight/obesity and underweight, please refer to Section 3.2.1.1 and 3. 2.1.2 in Chapter 3. Measures of energy intake are constructed by three-day average values (See Appendix 4.4 for the method of collecting these data). Obesity-related health knowledge was measured by the questions listed in Section 3.2.2.3 in Chapter 3. For the measurement of other covariates, please see Section 3.2 in Chapter 3.

## **6.6 Methods**

I exploit the randomness of having a son in the birth events by the child's paternal grandparents to instrument the presence of grandparents in the household. In the absence of manipulation, the sex ratio at birth is consistent across human populations: with 1.05–1.07 male births versus female births (Campbell, 2001). For a parsimonious model, I assume in a sequence of  $n$  births, the number of male births follows a binomial distribution  $S = B(n, 0.5)$ , assuming the probability of having a son is strictly 0.5 at each event. Therefore the proportion of male siblings among all the siblings follows a distribution with a mean of 0.5. One technical obstacle is that the questions in the survey that ask for information about the child's paternal grandparents' number of sons and siblings are not clear about whether they are asking for birth events or living births that survived to adulthood. One threat to the randomness of the instrument variable is that prenatal and postnatal discrimination on girls has been traditionally practiced, especially for higher-order girls (Li, 2004). The unobserved preference for sons could be related to the treatment of girls in the household and bias the estimate for girls upward. How severe could this threat be? The gender ratio at birth has declined since

1949 and hovered around 1.06 to 1.08 from the 1950s to 1980 (Das Gupta and Li, 1999). It has markedly increased since 1980 when the One Child Policy was initiated in concurrence with easier access to ultrasound technology (Hesketh, 2005). The children under study are ages 2-18 in years 1991 to 2006, and the majority of their parents were born before 1980 when the gender ratio at birth was much less a concern. I further examined the gender ratio for the surviving adults using U.S. Census Bureau data (U.S. Census Bureau international database, 2012) and found that in 2000, the male/female gender ratio ranged from 1.02 to 1.08 for adults in China ages 20 to 60, close to the ratio at birth in the absence of manipulation.

To assess if there is any evidence of unbalanced gender ratio in the sample, resulting from a preference for sons, I examined the distribution of proportion of father's male siblings among all siblings by the total number of siblings and father's birth cohort, using data drawn from CHNS 2000, 2004 and 2006 surveys and conducted T test to assess if the proportion of male is significantly larger than .5. The results (See Appendix 6.3) show that the youngest fathers were born in 1978 in the 2000 survey and 2004 survey, and 1981 in the 2006 survey. When the total number of siblings is no more than five, the proportion obtained from the sample is generally close to 0.5 across all the birth cohorts. However, there are two exceptions when the total number of siblings is one and fathers were born after 1971 in the 2000 and 2006 surveys. These exceptions could be evidence of son preference, consistent with the "intensification argument" (Gupta, 1997) that son preference is intensified when total fertility is reduced. Whether this issue could bias the estimate remains to be seen. I compare the results of the instrument variable

models using the whole effective sample with the results using the restricted sample of children whose fathers were born after 1971.

Maximum likelihood bivariate probit (BP) models (Heckman, 1978; Greene, 1998) correcting for clustering at the individual level are used to identify the impact of the presence of grandparents in the household and neighborhood on children's risk of being overweight and underweight. Linear instrument variable models are not chosen because overweight and underweight are both binary variables. In the case that the outcome variable and the endogenous predictor of interest are both binary variables, maximum likelihood bivariate probit models tend to perform better than linear IV models for smaller sample sizes (below 5000), especially when the model specification includes additional covariates (Chiburis, Das and Lokshin, 2011). In addition, when the instrument is weak, two-stage IV model could be seriously biased (Bound et al., 1995).

The equations for BP models are set up as below, where Y denotes outcome variable overweight/obesity or underweight; P denotes whether any grandparent is present in the household; Z denotes the number of male siblings of the child's father; and X is a vector of exogenous covariates including total number of siblings of the child's father, the child's age, gender, family income adjusted by 2006 Consumer Price Index, urban/rural residency, parental education, year and province fixed effects. One concern of this model is there might be reasons to suspect that the total number of siblings not be completely exogenous to the health endowment of the family. For example, those families that end up having a lot of children might enjoy better health endowment. To address this concern, I examine whether the number of a child's

paternal uncles and the total number of siblings is related to child's father's height. The result shows that father's height is not related to any of these two variables after controlling other covariates.

$$P_i = 1[\alpha_{10} + \beta_{11}Z_i + \beta_{12}X_i > \xi_{1i}] \quad 1)$$

$$Y_i = 1[\alpha_{20} + \beta_{21}P_i + \beta_{22}X_i > \xi_{2i}] \quad 2)$$

Error terms  $\xi_{1i}$  and  $\xi_{2i}$  jointly distributed as standard bivariate normal with correlation  $\rho$  (rho). The joint probability of  $(P_i = 1, Y_i = 1)$  follows bivariate cumulative distribution, and bivariate probit models estimate the parameters by maximizing the joint likelihood of the two jointly determined variables.

$\xi_{1i}$  and  $\xi_{2i}$  contain common components such as preference/taste, informal social connections or unobserved wealth and health endowment that affect both co-residence with grandparents and child nutrition status. If  $\rho=0$ , then  $P_i$  is exogenous after taking into account the influence of the set of covariates. In such case the results from univariate probit models and bivariate probit models should be qualitatively the same, and the model can be simplified to a univariate probit model. If  $\rho$  is different than 0, a univariate probit model is subject to omitted variable bias. To test this exogeneity hypothesis, likelihood ratio test (Greene, 1998, 2000) will be conducted. The ratio of the log likelihood for the bivariate probit model versus the sum of the log likelihood of the two univariate probit models, follows chi-square distribution with one degree of freedom under the null hypothesis  $\rho=0$ . However, when  $\rho=0$  could not be rejected, and we do not have much power to say that  $\rho=0$ , the results from the Bivariate Probit models will still be preferred.

Lastly, linear IV strategy using the same instrument and controlling the same set of variables is employed to identify the impact of the presence/proximity of grandparents on child's daily energy intake to help understand the links.

## **6.7 Results**

### **6.7.1 Descriptive analysis**

Variable means for children ages 2-12 from 1991 to 2006 are reported in Table 6.1. Over the years, the unbalanced gender ratio in the sample went up. Average age, prevalence of grandparents' co-residence, percentage of respondents holding urban residency, average family real income, percentage of parents holding a high school diploma also increased. The prevalence of grandparents living in the same neighborhood or household stayed at 61% and declined slightly in 2004 and 2006. BMI increased, along with prevalence of overweight rising rapidly, and underweight decreasing slightly. The daily energy intake and protein intake slightly decreased, while fat intake increased, consistent with the findings by Du et al. (2002).

The analysis of the age difference in obesity-related health knowledge in 2004 and 2006 shows (See Table 6.2) that except for the response to the question "more fruit-vegetables good", the health knowledge conceived by the group ages 25-49, who normally have children under 19, is better than the older group. The only question regarding ideal body shape also reveals that the older group is less likely to disagree that being heavier is better. These results support the argument that the older cohorts born before 1954/1956, who had experienced more episodes of poverty and famine, are less concerned about the negative consequence of obesity.

**Table 6.1: Variable means by year for children aged 2-12, CHNS 1991-2006**

	1991	1993	1997	2000	2004	2006	Overall
Boy	.55	.54	.57	.55	.57	.58	.55
Age	6.89	7.34	8.35	8.36	8.12	8.14	7.50
Presence of grandparent(s)	.24	.25	.28	.30	.32	.34	.27
Grandparent(s) present or as neighbor	.61	.61	.61	.63	.60	.57	.61
Urban residency	.23	.20	.29	.27	.28	.31	.25
Father high school diploma	.23	.25	.26	.27	.31	.36	.26
Mother high school diploma	.15	.16	.18	.21	.20	.24	.18
Family real income (Yuan)	8747	9980	13562	16900	21071	25477	13515
BMI	15.73	15.88	16.00	16.36	17.38	17.70	16.20
Overweight/obese	.096	.097	.113	.134	.156	.170	.131
Underweight	.055	.062	.050	.059	.043	.058	.054
Daily energy intake	1698	1689	1604	1627	1534	1458	1634
Daily protein intake	48.9	49.3	47.9	49.3	46.33	45.0	48.4
Daily fat intake	41.4	41.6	46.1	55.0	51.7	49.8	46.0
Daily carbohydrates intake	281	278	250	233	216	208	256
Observations	1587	1399	1251	969	535	429	6170

**Table 6.2: Difference in percent of respondents who disagree on obesity related health statements between groups aged 25-49 and groups aged 50 or above in 2004 and 2006, CHNS 2004 and 2006, gender and household fixed effects controlled**

Age group/ Birth year	2004			2006		
	Mean difference	R <sup>2</sup> Within household	R <sup>2</sup> between household	Mean difference	R <sup>2</sup> Within household	R <sup>2</sup> between household
More High fat good	-0.09***	0.016	0.003	-0.09***	0.012	0.005
More sugar good	-0.08***	0.015	0.013	-0.10***	0.016	0.009
More fruit-veg good	-0.01	0.003	0.003	-0.001	0.002	0.003
More rice good	-0.07***	0.007	0.001	-0.03**	0.001	0.001
Heavier better	-0.06***	0.013	0.007	-0.06***	0.011	0.008
Number of Obs	9189			9245		

P<0.01:\*\*\*, P<0.05:\*\*, P<0.1:\*; Mean difference controlling for household fixed effects and gender.

**Table 6.3: Results of multivariate regressions on child nutrition status, children aged 2-12; correcting clustering at individual level**

Panel A: Overweight/Obesity	Age groups		
	2-12	2-6	7-12
<b>Grandparent(s) present</b>	<b>-.008 (.010)</b>	<b>-.020(.015)</b>	<b>-.001(.012)</b>
Urban residency	.283 (.010)***	.016(.017)	.037(.013)***
Boy	.026 (.009)***	.031 (.015)**	.023(.010)**
Age	-.012 (.002)***	-.021(.006)***	-.008(.003)**
Number of father's siblings	-.005(.003)	-.006(.004)	-.005(.003)
Per capita family real income logged	-.003(.005)	-.002(.010)	-.003(.006)
Father high school diploma	.015 (.011)	-.006(.010)	.029(.013)**
Mother high school diploma	.020(.013)	.011(.011)	.019(.015)
Observations	6097	2362	3735
R <sup>2</sup>	.088	.074	.102
<b>Panel B: Underweight</b>	<b>2-12</b>	<b>2-6</b>	<b>7-12</b>
<b>Grandparent(s) present</b>	<b>-.014(.010)</b>	<b>-.026(.013)**</b>	<b>-.004(.014)</b>
Urban residency	-.032(.011)***	.002(.016)	-.054(.014)***
Boy	-.019(.009)**	-.011(.012)	-.024 (.012)**
Age	.012(.002)***	.017 (.004)***	.013 (.004)***
Number of father's siblings	-0.004(.003)	.001(.003)	-.006(.004)
Per capita family real income logged	.005(.005)	.008(.007)	.003(.0007)
Father high school diploma	.004(.012)	-.006(.014)	.012(.016)
Mother high school diploma	-.022 (.013)*	-.011(.016)	-.029 (.018)
Observations	6097	2362	3735
R <sup>2</sup>	.034	.028	.037

Note: Robust standard errors in parentheses; Survey year and province fixed effects are controlled; \*:  $p \leq 0.10$ , \*\*  $p \leq 0.05$ , \*\*\*:  $p \leq 0.01$ .

For descriptive purpose, I estimated multivariate models adjusting clustering at the individual level to obtain conditional correlations. The results show (Table 6.3) that after controlling gender, age, urban/rural residency, number of father's siblings, parental education, family income, province fixed effects and year fixed effects, the presence of grandparents is not related to children's overweight/obesity. Children under 7 are 2.6% less likely to be underweight at the presence of their grandparents ( $P < 0.05$ ). Neither overweight nor underweight status of children ages 7 and up is related to this living arrangement.

## 6.7.2 Causal inference analysis

To identify potential causal pathways, I estimated bivariate models and univariate models by outcome and age groups, and the results tell consistent stories (See Table 6.4). The presence of grandparents does not predict if a child will be overweight/obese, but reduces the risk of underweight for children under 7. First-stage estimate of the instrument variable's impact on the presence of grandparents in the household shows that the number of father's brothers, adjusting for number of father's siblings, is a strong instrument for each age group (for children under 7,  $t=6.68$ ; for children 7-12,  $t=8.25$ ). Wald likelihood ratio test for the exogeneity of the presence of grandparents for the four models all suggest that after taking into account the influences of the aforementioned set of covariates, the null hypothesis " $\rho=0$ , no correlation between the error term of the two equations" could not be rejected. Therefore, the probit model and bivariate models produce qualitatively same results, suggesting that after controlling for the influence of number of paternal siblings, parental education, family income, child's gender and age, year and province effects, the presence of grandparents is not related to uncontrolled variables such as maternal employment or use of a childcare center. In other words, child nutrition status does not vary by maternal employment or use of a childcare center in China, an understudied area so far. There are plenty of reasons to suspect a different relationship between these variables and child nutrition status in China as opposed to Western countries. Mothers who do not work in China might spend most of their spare time seeking a job instead of caring for a child, given the extreme high labor force participation rate in China. Childcare centers might restrain

**Table 6.4: Results of Univariate Probit models and Bivariate Probit models on child nutrition status, children aged 2-12; correcting clustering at individual level**

Panel A: Overweight/Obesity	Children aged 2-6		Children aged 7-12	
	Uni-Probit	Bi-Probit	Uni-Probit	Bi-Probit
<b>Grandparent(s) present</b>	<b>-.103 (.073)</b>	<b>.366 (.415)</b>	<b>-.019(.072)</b>	<b>.185(.297)</b>
Urban residency	.071 (.081)	.032 (.083)	.205(.073)***	.197(.073)***
Boy	.15 (.068)**	-.006 (.027)	.132(.062)**	.129(.063)**
Age	-.099 (.024)***	-.086(.027)***	-.048(.020)**	-.046(.020)**
Number of father's siblings	-.027(.020)	-.006(.027)	-.028(.017)	-.022(.019)
Per capita family real income logged	-.010 (.041)	-.001(.042)	-.014(.035)	-.008(.036)
Father high school diploma	-.069 (.084)	-.074(.083)	.160(.072)**	.153(.074)**
Mother high school diploma	.102 (.095)	.081(.098)	.090(.083)	.086(.083)
Marginal effect of IV		-.090(.013)***		-.074(.009)***
Rho		296 (.239)		-.121(.170)
P value of Wald LR test		0.243		.479
<b>Marginal effect of the presence of grandparents</b>	<b>-.033(.020)</b>	<b>.020(.018)</b>	<b>-.003(.011)</b>	<b>.007(.009)</b>
<b>Marginal effect after adjusting energy intake</b>	<b>-.030(.020)</b>	<b>.016(.019)</b>	<b>-.003(.010)</b>	<b>.006(.008)</b>
Prevalence of overweight	.165	.165	.117	.117
<b>Panel B: Underweight</b>				
Grandparent(s) present	-.173(.085)**	-.593(.320)*	-.042(.067)	.022(.352)
Urban residency	.003(.090)	.023(.095)	-.251(.071)***	-.254(.072)***
Boy	-.068(.073)	-.052(.075)	-.106(.055)*	-.107(.055)*
Age	.101(.029)**	.088(.032)	.063(.017)***	.063(.017)***
Number of father's siblings	.008(.020)	-.012(.029)	-.030(.016)*	-.028(.019)
Per capita family real income logged	.049(.044)	.039(.045)	.022(.031)	.023(.032)
Father high school diploma	-.027(.089)	-.017(.089)	.043(.070)	.036(.072)
Mother high school diploma	-.059(.102)	-.039(.103)	-.139(.086)	-.142(.087)
Marginal effect of IV		-.090(.013)***		-.074(.009)***
Rho		.264(.267)		-.038(.025)
P value of Wald LR test		.349		.853
<b>Marginal effect of the presence of grandparents</b>	<b>-.028(.014)**</b>	<b>-.035(.019)*</b>	<b>-.011(.016)</b>	<b>.001(.021)</b>
<b>Marginal effect after adjusting energy intake</b>	<b>-.021(.014)</b>	<b>-.032(.025)</b>	<b>-.006(.015)</b>	<b>.000(.020)</b>
Prevalence of underweight	.047	.047	.057	.057
Observations	2362	2362	3735	3735

Note: Robust standard errors in parentheses; Survey year and province fixed effects are controlled; \*:  $p \leq 0.10$ ; \*\*  $p \leq 0.05$ ; \*\*\*:  $p \leq 0.01$ .

**Table 6.5: Results of Univariate Probit models and Bivariate Probit models on child nutrition status, children aged 2-12 whose father was born before 1971, correcting clustering at individual level**

	Children aged 2-6		Children aged 7-12	
	Uni-Probit	Bi-Probit	Uni-Probit	Bi-Probit
<b>Panel A: Overweight/Obesity</b>				
<b>Grandparent(s) present</b>	<b>-.102(.079)</b>	<b>.323(.344)</b>	<b>-.017(.078)</b>	<b>.198(.315)</b>
Urban residency	.065(.084)	.033(.085)	.190(.078)**	.190(.077)**
Boy	.160(.072)**	.151(.073)**	.137(.064)**	.130(.067)*
Age	-.092(.025)***	-.076(.026)***	-.041(.020)**	-.049(.020)**
Number of father's siblings	-.038(.026)	-.016(.035)	-.022(.014)	-.048(.029)
Per capita family real income logged	.023(.043)	.022(.043)	.057(.038)	.061(.039)
Father high school diploma	.020(.051)	.026(.052)	.146(.078)*	.150(.076)*
Mother high school diploma	.039(.054)	.035(.054)	.085(.058)	.084(.047)*
Marginal effect of IV		-.112(.012)***		-.086(.008)***
Rho		-.188(.223)		-.190(.188)
P value of Wald LR test		.406		.328
<b>Marginal effect of the presence of grandparents</b>	<b>-.032(.019)</b>	<b>.022(.017)</b>	<b>-.002(.005)</b>	<b>.006(.006)</b>
<b>Marginal effect after adjusting energy intake</b>	<b>-.020(.016)</b>	<b>.015(.015)</b>	<b>.000(.006)</b>	<b>.005(.004)</b>
Prevalence of overweight	.154	.154	.105	.105
<b>Panel B: Underweight</b>				
<b>Grandparent(s) present</b>	<b>-.178(.090)**</b>	<b>-.505(.264)*</b>	<b>-.046(.071)</b>	<b>.028(.320)</b>
Urban residency	-.032(.095)	-.016(.097)	-.257(.075)**	-.257(.075)**
Boy	-.069(.078)	-.051(.079)	-.126(.060)**	-.121(.060)**
Age	.101(.030)***	.090(.031)***	.057(.018)***	.057(.018)
Number of father's siblings	.004(.031)	.030(.040)	-.040(.022)*	-.038(.027)
Per capita family real income logged	.035(.044)	.035(.044)	.031(.034)	.032(.034)
Father high school diploma	.002(.055)	.019(.054)	.014(.043)	.011(.045)
Mother high school diploma	.007(.056)	.014(.056)	-.011(.045)	-.011(.045)
Marginal effect of IV		-.110(.011)***		-.085(.008)***
Rho		.275(.201)		-.025(.018)
P value of Wald LR test		.199		.900
<b>Marginal effect of the presence of grandparents</b>	<b>-.029(.014)**</b>	<b>-.031(.016)*</b>	<b>-.014(.028)</b>	<b>.002(.026)</b>
<b>Marginal effect after adjusting energy intake</b>	<b>-.022(.017)</b>	<b>-.035(.036)</b>	<b>-.003(.018)</b>	<b>-.000(.024)</b>
Prevalence of underweight	.049	.049	.059	.059
Observations	2202	2202	3579	3579

Note: Robust standard errors in parentheses; Survey year and province fixed effects are controlled; \*:  $p \leq 0.10$ ; \*\*  $p \leq 0.05$ ; \*\*\*:  $p \leq 0.01$ .

high-energy-dense food consumption because of budget issues, but would be very cautious about the issue of child undernutrition, etc. The marginal effect of the presence of grandparents on child underweight for children under age 7 is -2.8% ( $P < 0.05$ ) in univariate probit model, and -3.5% ( $P < 0.1$ ) in bivariate probit model. A sensitivity check is conducted by restricting the sample to those whose fathers were born before 1971. The results are essentially the same (See Table 6.5). Again, no discernible impact is found for children ages 7-12. To understand the link between underweight and the presence of grandparents, I first estimated linear IV models to identify the impact of the presence of grandparents on children's daily energy intake. The results (See Table 6.6) indicate that the presence of grandparents increased daily total energy intake by 266 K calorie ( $P < 0.05$ ), including daily protein intake by 8.32 gram ( $P < 0.05$ ) and daily carbohydrate by 59.8 grams. The presence of grandparents does not seem to affect the child's daily fat intake. I further break the sample by per capita family income and the results suggest that grandparents' presence has similar effects on child nutrition intake across the median line of income. It is intriguing that children's intake of protein does not match their intake of fat. This might be due to the fact that Chinese cooks use a considerable amount of animal/plant oil as cooking oil. Snacks and processed food made of starch might also contain fat. The survey team collected detailed household food consumption data and individual-level data which allowed them to check the quality of data collection by comparing the two. Where significant discrepancies were found, the household and the individual in question were revisited and asked about their food consumption to resolve these discrepancies. The household consumption data are

collected by calculating the difference between all the foods (including edible oils and salt) remaining after the last meal before initiation of the survey and all the remaining foods. The number of household members and visitors was recorded at each meal. Information about individual food intake was collected by a survey asking for the names of foods, the location where food was consumed and the method of preparation. Based on the method of preparation, it is feasible to calculate the amount of fat intake independent of meat intake. For details, please see Appendix 4.4.

I then re-estimated the univariate probit models and bivariate probit models by adding controls on the daily total energy intake. The effect on underweight status for children under 7 is reduced to insignificance (See the bottom rows in Table 6.4 and Table 6.5), suggesting that energy intake explains away this effect.

To understand which aspects of grandparents' presence contribute more to the reduction in underweight, I examine the impact on children's daily energy intake and underweight status for children of maternal grandparents' co-residence and paternal grandparents' co-residence respectively, as compare to no grandparent(s) living in the house. The results (See Table 6.7) suggest that the effect of maternal grandparents' presence might have a larger impact on the underweight reduction, but the standard error is also large probably because of the very small sample size (the prevalence of maternal grandparents is only 2.55%). Therefore, we cannot say there is any difference in the effect between paternal grandparents and maternal grandparents. Both bi-variate models failed to produce a significant estimate of grandparents' impact. Likelihood ratio

**Table 6.6: Results of linear instrument variable models on child daily nutrition intake, children aged 2-12; correcting clustering at individual level**

	Kcal	Protein	Carbohydrates	Fat
Panel A: all children aged 2-12				
<b>Grandparent(s) present</b>	<b>266(125)**</b>	<b>8.32(3.52)**</b>	<b>59.8(17.7)**</b>	<b>6.16(5.38)</b>
Urban residency	16.54(19.57)	2.51(.671)***	-21.6(3.20)***	10.77(1.04)***
Boy	87.06(15.68)**	2.83(.518)***	14.4 (2.62)***	2.05(.790)***
Age	110.42(3.24)***	3.14(.105)***	18.9(.540)***	2.51(.158)
Number of father's siblings	9.79(6.00)	.402(.195)**	1.17(1.00)	.333(.295)
Per capita family real income logged	26.33(9.39)**	2.01(.319)***	-5.38(1.57)**	5.12(.450)***
Father high school diploma	21.13(19.77)	2.15(.683)***	-5.12(1.98)**	3.18(1.04)***
Mother high school diploma	-31.15(24.38)	.965(.787)	-9.51(2.01)**	2.92(1.24)**
Wald F stats for weak instrument	160	160	160	160
Observations	6097	6097	6097	6097
Panel B: Income higher than median				
<b>Grandparent(s) present</b>	<b>264 (144)*</b>	<b>8.98(4.72)**</b>	<b>47.6.7(23.4)</b>	<b>5.69(8.22)</b>
Boy	88.81(18.35)***	2.93(.588)***	14.54(3.25)***	2.13(.858)**
Number of father's siblings	7.60(8.04)	.332(.260)	2.08(1.47)	-.135(.366)
Per capita family real income logged	-25.5(10.26)**	.386(.334)	-17.43(1.83)***	5.03(.46)***
Wald F stats for weak instrument	96.4	96.4	96.4	96.4
Observations	3048	3048	3048	3048
Panel C: Income not higher than median				
<b>Grandparent(s) present</b>	<b>286(151)*</b>	<b>4.94(5.77)*</b>	<b>273.90(34.9)***</b>	<b>7.1(11.4)</b>
Boy	68.03(34.4)**	2.77(1.13)**	10.43(5.31)**	2.35(1.86)
Number of father's siblings	29.5(11.8)**	.818(.358)**	2.26(1.67)	1.44(.583)
Per capita family real income logged	30.08(20.02)	2.47(.664)***	-9.13(3.09)***	6.15(1.06)***
Wald F stats for weak instrument	54.4	54.4	54.4	54.4
Observations	3049	3049	3049	3049

Note: Robust standard errors in parentheses; Survey year and province fixed effects are controlled; \*: p <= 0.10; \*\* p <= 0.05; \*\*\*: p <= 0.01.

**Table 6.7: Results of Linear Instrument Variable models on child nutrition intake and Probit models on child underweight for children aged 2-6; correcting clustering at individual level**

	Daily energy intake	Underweight (Bi-probit)	Underweight (Uni-probit)
<b>Paternal grandparent(s) present</b>	<b>247(100)**</b>	<b>-.518(.402)</b>	<b>-.167(.082)**</b>
Urban residency	16.9(19.4)	.028(.093)	.011(.089)
Boy	89.1(15.6)***	-.052(.075)	-.066(.073)
Age	111(3.23)***	.091(.032)***	.102(.029)***
Number of father's siblings	10.6(6.10)*	-.011(.029)	.007(.019)
Per capita family real income logged	25.7(9.27)**	.051(.043)	.057(.043)
Father high school diploma	21.8(19.6)	-.019(.088)	-.027(.089)
Mother high school diploma	-24.9(23.8)	-.056(.102)	-.066(.102)
Effect of instrument on the presence of grandparent(s)		-.321(.042)***	
Wald F stats for weak instrument	81.5		
P value: Wald test of rho=0		.393	
Marginal effect of the presence of grandparent(s)		-.026(.030)	-.028(.013)**
Observations	2016	2016	2016
<b>Maternal grandparent(s) present</b>	<b>639(899)</b>	<b>-.641(.847)</b>	<b>-.615(.442)</b>
Urban residency	51.2(34.3)	-.045(.113)	-.046(.114)
Boy	49.2(29.6)*	-.077(.091)	-.077(.091)
Age	119(11.0)***	.090(.036)**	.090(.036)**
Number of father's siblings	25.0(15.9)	.044(.030)	.045(.028)
Per capita family real income logged	23.6(15.6)	.033(.052)	.033(.052)
Father high school diploma	3.85(19.4)	.053(.061)	.053(.061)
Mother high school diploma	1.64(24.7)	-.025(.067)	-.026(.066)
Effect of instrument on the presence of grandparent(s)		-.580(.173)***	
Marginal effect of IV		-.003(.001)***	
Wald F stats for weak instrument	17.2		
P value: Wald test of rho=0		.97	
Marginal effect of the presence of grandparent(s)		-.0001(.0003)	-.073(.041)
Observations	1420	1420	1420

Note: Reference group of paternal grandparents is no grandparent living in household; Reference group of maternal grandparents is no grandparent living in household; Robust standard errors in parentheses; Survey year and province fixed effects are controlled; \*: p <= 0.10; \*\* p <= 0.05; \*\*\*: p <= 0.01.

test failed to reject that  $\rho=0$ . For the maternal grandparents, the power of accepting  $\rho=0$  is 97%. The presence of paternal grandparents increases the daily energy intake by 247 K calorie ( $P<0.05$ ), and reduces the risk of underweight by 2.8% ( $P<0.05$ ).

I further analyzed the effect by children's gender. The results do not suggest that the presence of grandparents on children's overweight or underweight varies by gender. However, linear two-stage models suggest that the effect on daily total energy intake is driven by boys for whom the magnitude of effect is 294 (standard error= 131,  $P<0.05$ ). For girls, the estimate is 217 with a standard error 164, short of significance. Interestingly, the effect on daily protein intake is driven by girls with a magnitude of 12.4 ( $P<0.05$ ), while for boys the estimate is 5.67 with a standard error of 4.64, not statistically significant.

Finally, the same set of analyses was conducted to identify the impact of the proximity of grandparents on children's nutrition status, and none of the results suggest any relation between these two variables (Note: the t value for the instrument variable on the first stage is 5.08 for the whole sample, 4.14 for children ages 2-6 and 3.85 for children ages 7 to 12).

## ***6.8 Discussions and conclusion***

Whereas most Western social science literature on alternatives to maternal care focuses on center-based care, informal child care by grandparents in China is crucial for mothers to accommodate their work responsibilities. Using the China Health and Nutrition Survey 1991, 1993, 1997, 2000, 2004 and 2006, I estimated bivariate probit

models and linear instrument variable models, and found that the presence of grandparents in the household increases the total energy intake and protein intake for children ages 2-12, reduces the risk of underweight for children ages 2-6. Gender difference in the effect of the presence of grandparents on nutrition intake is also found but does not lead to a difference in overweight or underweight. Child nutrition status does not vary by the proximity of grandparents.

Children living with grandparents generally eat more but are not at higher risk of overweight/obesity. This is probably because grandparents organize more physical activity for them. Unfortunately the measure of expenditure on physical activity is not available for most of the sample; therefore we could not examine the contribution of physical activity to the overall effect. Another explanation is that the difference in nutrition intake that grandparents determine is just the right amount to reduce the risk of underweight, as observed among children ages 2-6. The impact on nutrition status is limited to children 2-6, probably due to the fact that older kids' eating behavior and physical activity are less influenced by caregivers. It is interesting that boys consumed more total energy but girls consumed more protein when grandparents were present. This could be a reflection of gendered body ideals (Luo et al., 2006).

A major limitation of this study is that I had to extract the value of the instrument variable and the information about grandparents from mothers' surveys, therefore this study does not cover children whose mothers are absent. Given the increasing migratory labor flows from rural to urban areas (Fan, 2007), it will be interesting to see if the impact of grandparents is different in families where maternal

care is present. However, among the children whose mothers are absent, the reference group to grandparents' care would be other informal care, a much more diverse group as opposed to maternal care, which makes the interpretation more difficult. Further study needs to be done for this particular group.

In contrast to U.K. findings, where informal care by grandparents was associated with a much higher risk of obesity (Pearce et al., 2010), care provided by grandparents in China does not appear to put children at higher risk of obesity. In conclusion, this chapter identifies the impact of grandparents' presence in the household on the nutrition status of children in China and finds this living arrangement is beneficial to children's nutrition status so far, particularly for children under 7. This finding eases public concern that grandparents as childcare givers increase the risk of child obesity. This chapter also contributes to the literature of family structure and family members' wellbeing. The Western social science literature on family structure focuses on marriage disruption or single parenthood, whereas countries nurtured by the Confucian tradition are more interested in the difference in family functions between extended families and nuclear families. Methodologically, the instrument variable models developed in this chapter could be used to identify the multiple consequences of three generations living together, an important institutional setting still prevalent in countries nurtured by the Confucian tradition.

## **Chapter 7: Discussions and implications**

### **7.1 Introduction**

Over the past three decades, the double burden of overweight and underweight has been observed among children and adolescents in China. On one hand, given the tremendous economic growth in China over the past three decades, the prevalence of overweight/obesity has increased rapidly, especially for young and urban children and adolescents (Wang et al., 2002). On the other hand, underweight remains high in rural areas despite a considerable decrease in the overall prevalence (Svedberg, 2006; Dearth-Wesley et al., 2008). Previous research has suggested that children's overweight and underweight have profound influences on individual's health, even in the later stages of their life courses (Freedman et al., 1999; Ebbeling et al., 2002). Scholars have also suggested that children's overweight and underweight invoke substantial economic costs for the medical care system (e.g., Popkin et al, 2008). Thus, a more-developed understanding of child overweight and underweight offers important implications for research and public policy.

In this dissertation, I focus on the role of family socioeconomic status (SES) and two important family structural elements in child malnutrition. By advancing a framework that addresses the contextual factors that shape the heterogeneity of SES gradients of child overweight/obesity, this dissertation has sought to identify the mechanisms by which an individual's access to family resources influences his/her risk of overweight/obesity. I also sought to identify the impact of two important family structural elements on child overweight/obesity and underweight in China, namely,

having any younger siblings and three generations living in the same household/neighborhood.

In China, the percentage of only children has been increasing in the years since the One Child Policy was implemented in late 1970s (Hesketh et al., 2005). The policy resulted in a family structure different from that of previous generations and may have spawned multiple consequences in different domains, including child nutrition status. Meanwhile, three-generation co-residence still characterizes 20% of Chinese households, a stable pattern reinforced by traditional values and a housing shortage (Zeng and George, 2002). Studies have shown that childcare provided by grandparents living in the same household or neighborhood helps to alleviate pressures on mothers in the workforce (Chen et al., 2002), but its impact on child nutrition is not as well documented.

My dissertation's final chapter is structured around the aforementioned three questions, the answers to which shed light on the general role that family plays in child malnutrition in China and suggest policy interventions. The following sections discuss the findings relevant to each research question, highlighting the contributions this dissertation makes to a broader social scientific literature on child malnutrition and related policy implications.

## ***7.2 Increasing socioeconomic gap in child overweight/obesity***

Chapter 4 began with a review of how the signs and strength of SES gradients of overweight/obesity vary by a country's stage of economic development and addressed these questions: what contextual factors connect the stage of economic development with the signs and strength of the association between socioeconomic status (SES) and

child overweight/obesity; what is the relative importance of these factors; what happens when these contextual factors exert contradictory influences on the SES profile of overweight/obesity as a country undergoes rapid socioeconomic changes? A new conceptual framework was then developed, derived from tenets in health economics and public health. This framework highlights the effect of the price of obesogenic foods, the penetration of obesogenic inactivity environments (environments that promote physical inactivity), and the awareness of and incentives to prevent overweight/obesity. The interaction of these factors with the income gap between higher and lower socioeconomic groups was also explored. In the case of China, previous studies have documented a decline in the price of obesogenic foods, but the amount of decline has not yet reversed the sign of the relative price of energy-dense foods compared to energy-light substitutes. Meanwhile, access to labor saving devices, including automobiles, is still largely limited to individuals in higher socioeconomic groups. These two contextual factors—combined with China’s dramatic increase in income inequality after the mid1990s—suggest an increasing gap in access to energy-dense foods and exposure to obesogenic environments. At the same time, the Western ideal body shape that favors being thin and information about the negative consequences of overweight/obesity has begun to spread, first penetrating the higher SES groups. According to the Ecological System framework, the environment has a much stronger effect than willpower based on knowledge on obesity-related risk behavior, therefore, I predicted that the positive SES gradients of child overweight/obesity would increase after 1997 when the income inequality began to increase at a faster pace.

Results showed increasing prevalence of overweight/obesity among children and adolescents across all socioeconomic groups, with higher SES groups showing a faster rate of increase; this, in turn, led to an increasing SES gap in child overweight/obesity, especially after 1997. Correspondently, analyses also produced a finding that showed a widening of the gap in per capita family income after 1997 when the Fifteenth National Congress of the Communist Party launched an intensification of market reforms which resulted in a dramatic increase in the income gap between higher and lower SES groups in subsequent years. While this pattern held for both boys and girls, it was weaker for girls. The reason might be that society encourages a super slim body for girls and that girls are more attuned to information about healthy diets and lifestyles. These findings also suggest that for children and adolescents, educational efforts about healthy behaviors and how to avoid overweight/obesity produce weak results, as found in some previous studies in Western literature (Bandura, 2004).

The findings in this chapter strongly point to the policy urgency to limit the availability of obesogenic foods and alter obesogenic environments to protect China's youth from becoming overweight/obese. For example, policy could limit the amount of MSG (clinically proven to induce obesity) used in processed foods. The Department of Education could take action to reduce the pressure on students to excel academically and facilitate more physical activity. A comprehensive program that addresses permissive parenting styles in order to create a healthier family food environment might be able to have tremendous impact. In addition, the government could assist consumers in making wiser food choices by strengthening regulations on nutrition content labeling.

The nutrition content labeling in China is generally poor which handicaps the consumer. A study (Tao et al., 2010) investigated food labeling in a sample of 900 pre-packaged foods sold in Wal-Mart stores in Shanghai and Beijing. They found that less than 30 percent of the processed foods were labeled with total calories, fat, protein, trans fat acid, sodium, etc. And among salty snacks that should be categorized as high fat foods, only 11% were labeled.

Overall, the results suggested that the increasing SES gap in purchasing power on obesogenic foods (environment) caused by rising income inequality played a prominent role, outperforming the advantage that higher SES groups have in obesity-related knowledge and ideology. It confirmed the position of the Ecological System of Obesity framework (Egger and Swinburn, 1997) that willpower based on knowledge and ideology only has minor effect compared to environment in obesity prevention, at least for a short period of time. Child overweight/obesity is an emerging problem in China, therefore in a short period of time, this framework serves best to explain the observed trends.

What about in the long run? Although the results in this dissertation runs counter to the predictions from Fundamental Social Cause of Diseases (FSCD) perspective (Link and Phelan, 1995), a few more decades might reveal that the FSCD argument will hold in China, as the power of knowledge changes the environment. The findings in this dissertation raised questions on the universality of FSCD because it challenged a key assumption of this theory: that taking action to prevent elevated disease risks always requires resource marshaling at a considerable cost. In China's case,

only 45 years ago, it experienced massive famine. When obesity began to strike the society, access to obesogenic foods, cars and other labor saving devices were still a luxury enjoyed only by higher SES groups; those with fewer resources remained “protected” and thin without extra work on resource marshaling.

The lack of power of FSCD in explaining the results in this dissertation might also be a consequence of data limitation. The data covers nine provinces in China that are at a median level of development or underdeveloped, as compared to places at the highest stage of economic development such as Beijing, Shanghai, Guangdong, Hongkong, etc. The sample represents the majority of China, but the absence of cities or regions at advanced stages of development hinders analysis of the relationship between the stage of development and the SES gradients of child overweight/obesity. It could be that the power of knowledge has changed parts of the environment in such places and shaped a different SES profile from what we observed in the majority of China, a profile that FSCD might be more powerful in explaining. This dissertation does not attempt to make policy recommendation for overweight/obesity disparity reduction in China for now, largely because as knowledge and technology change the political, social and economic environment of food and physical activity, the advantage that higher SES groups hold in access to resources will eventually translate into advantage in healthy life style and body shape.

Another limitation is sample attrition and non-response items. Although sensitive analysis suggests missing at random, it does not rule out the possibility of missing at unobserved factors, which might bias the estimates.

Despite these limitations, the framework developed in this chapter could be useful in understanding the heterogeneity of SES profile of child overweight/obesity, particularly in rapidly developing countries that might have different configurations of the contextual factors than developed countries. Future studies could test and enrich this framework by examining these key factors and the heterogeneity of SES profile of child overweight/obesity in multiple countries cross-sectionally. Application of this framework on the temporal change of SES profile in a particular country other than China would also be informative. Moreover, in this dissertation, there are no direct measures on the contextual factors. Future studies should directly test the effects of these contextual factors by using more comprehensive datasets.

### ***7.3 Does having younger siblings matter for nutrition status?***

Previous studies on fertility level and child nutrition status focused on comparing the impact of having multiple children as opposed to one or two (e.g., Hatton and Martin, 2010). Little is known about the effects of increasing the number of children from one to two or three. Chapter 5 identifies the impact of having any younger siblings on child nutrition status in China under the One Child Policy regime.

Resource dilution model suggests that reduction in sibsize reduces resource competition (Becker and Lewis, 1973; Becker and Tomes, 1976; Blake 1981; Steelman et al., 2002) so children with fewer siblings receive more resources. Under China's context, more resources mean a higher likelihood in developing overweight/obesity and lower likelihood in underweight. Furthermore, having no siblings might grant the child more access to resources than resource dilution hypothesis alone would predict because

having only one child gives the child too much power in family spending decisions (McNeal and Wu, 1995; Ng, 2005). On the other hand, economies of scale in raising children (Qian, 2009) might exist. Meanwhile, parents might be able to maintain the level of investment in child nutrition regardless the number of children when the fertility level is generally low and the expenditure in food only makes up a small portion of a family's disposable income. Whether having younger siblings affects resource allocation within families may vary by gender of the child, since girls are documented as suffering from discriminatory treatment especially in rural areas and poorer populations (Li et al., 2007; Li, 2004; Li and Cooney, 1993).

Although association between number of siblings and overweight/underweight in China and across many other countries has been found in previous studies (Hesketh et al., 2003; Yang, 2006; Bredenkamp, 2008), no study has attempted to establish causality. One important contribution of this chapter is that it found a valid instrument variable to establish causality by exploiting the variation of monetary fines levied over time and location for unsanctioned births.

The results showed that from 1991 to 2006, having more than one child still has resource dilution effects on the first-born children's nutrition status. This effect is less pronounced for boys but is evident in girls' underweight status, implying girls' lower parity hasn't eliminated the discriminatory treatment. The results also suggest increase in income protects girls from underweight but does not affect boys' risk of underweight, implying that boys are protected from underweight regardless. One explanation is that when the first-born boys are faced with potential risk of underweight due to financial

constraints, the cost is absorbed by other family members. Money transfers from extended family members such as grandparents and uncles/aunts might partially depend on the child's gender, and should be explored. Further inquiries on how having multiple children affects the parents' nutrition status, younger siblings' risk of underweight by gender, and other expenditures based on children's gender would also be revealing.

Overall, gendered practice in resource allocation could be embedded in every aspect of family life, shaped by structural factors such as the patrilineal family system and the related traditional expectations and family living arrangements. For example, adult sons are expected to stay with their parents to care for them and carry on the family surname while daughters are to marry into their husbands' households. As dramatic demographic, economic, and cultural changes have occurred over the past several decades in China, especially in urban areas where a pension system exists, studies have found that daughters have contributed more and more to their elder parents' financial wellbeing (e.g., Xie and Zhu, 2006). However, in rural areas and under conditions of poverty, where a pension system is absent, traditional gendered expectations and practices are still pronounced (Murphy et al., 2011), or even intensified because of the One Child Policy (Banister, 2004; Chu, 2001; Das Gupta, Chung, and Li, 2009). Especially in conditions of extreme poverty, excess mortality of female ages 0–4 years was found (Attané, 2009).

Although rapid economic growth has made food availability no longer a problem for most Chinese (Smil, 1995), 13.4% of the Chinese population was still living

in poverty in 2011 (CIA World Fact Book, 2012). And the findings in this chapter highlight the urgency of eliminating discrimination for girls especially in their nutrition intake, in order to improve their health, especially in poorer, rural areas where families may have more than one child. In addition to establishing a pension system, the government might also designate financial aid for girls living in poverty to interrupt the vicious cycle in which girls are given less food and fewer educational opportunities, leaving them less able as adults to contribute financially to their families, reinforcing their traditional lack of value, and continuing discriminatory treatment of their own daughters.

#### ***7.4 The presence of grandparents in households or neighborhood and child nutrition status***

Chapter 6 began with findings in some Western countries (the United Kingdom and Greece) that showed children cared for by grandparents are at a much higher risk of overweight/obesity (Pearce et al., 2010, Hassapidou et al., 2006; Hassapidou et al., 2009). It is surprising that little is known about the impact of grandparents' care on child nutrition status in China, a society nurtured by the Confucian tradition which prescribes strong intergenerational ties and often sees grandparents' caring for children as a common substitute for maternal childcare. This chapter contributed to identifying the impact and mechanisms of the traditional family living arrangement, namely, the presence of grandparents in households/neighborhoods, on child nutrition status. This chapter also found a valid estimator on the impact of this traditional family living

arrangement and provided a useful tool to identify the multiple consequences of this arrangement that still characterizes a significant portion of Chinese households.

By shaping family food environments and practicing certain parenting styles, grandparents could shape children's food preferences and physiologic regulation of energy intake. Compared to younger generations, grandparents who experienced more episodes of famine and poverty tend to overfeed (Jiang et al., 2006) which might potentially reduce underweight but promote overweight/obesity. On the other hand, grandparents may contribute to a greater variety of family foods and reduce the incidence of eating out and missing breakfast—both widely recognized as risk factors for overweight/obesity (Lin et al., 1999; Rolls et al., 2004; Siega-Riz et al., 1998; Morgan et al., 1986). Moreover, grandparents could be in a better position than working mothers to facilitate children's physical activity by devoting more time to watching children play on the street or playground, which might reduce TV watching and other sedentary activities.

Chapter 6 provided a careful and extensive analysis on the validity of the instrument variable strategy. The findings suggest that the presence of grandparents in households does not produce overweight/obese children as suggested by the public media, but reduces the risk of underweight for children ages 2-6. This finding highlights the difference in the contextual factors between China and the United Kingdom. In developed countries, general access to obesogenic foods and the penetration of obesogenic environments are high. In such settings, extra work is required to prevent children from consuming too much readily-available fast food and to encourage

activities such as walking or biking to a destination instead of riding in a car or taxi. Limited by energy and concentration, grandparents might not strictly practice or monitor the children's risk behavior as mothers or center-based caregivers do. Whereas in China, access to energy-dense foods and labor-saving devices including cars is less of a given, so the relatively high cost of fast food and the need to walk or bike might be sufficient help the children stay away from the risks. Another explanation is that with much closer intergenerational relationships and close living arrangements (Thornton and Lin, 1994), communication between parents and grandparents is easier and may result in a consensus that enforces better diet and exercise norms.

Future studies on how family members interact with each other on the issues of childrearing across different types of households might provide a better explanation for these observed differences between China and the United Kingdom. A comparison between the wealthier households and low-income households in China could also be revealing; wealthier families that have good regular access to energy dense foods and cars may need to do more to countermand the risk of overweight/obesity that their lifestyle poses for their children. Due to data limitation, this dissertation could not explore the pattern in more developed regions such as Beijing and Hong Kong where the obesogenic foods and physical activity environment are within close reach.

Also because of data limitations, this chapter does not identify the impact of the skipped generation household which is composed of grandparents and children only, while the parents are absent. However, this skipped generation household has become

more prevalent with increasing migratory labor flows from rural to urban areas (Fan, 2007).

A direct policy implication of the finding of Chapter 6 is that it eased public concern that grandparents tend to produce obese grandchildren. However, any policy implication on this living arrangement should also take into account its impact on the wellbeing of the grandparents and parents. Assuming the involvement of the grandparents alleviates work-family conflicts for working parents, then what is the impact of grandparenting on the grandparents' health outcomes and life satisfaction? Taking care of children requires extensive work, especially when the children are young. Does the extensive work carried by grandparents induce early onset of chronic disease? Minkler and Thomson (1999) found that in the United States, custodial grandparents were significantly more likely to have limitations in four of the five activities of daily living (ADLs) examined, and more likely to report lower satisfaction with health. Although in China, most grandparents who take care of children do not have to assume custody, the negative impact on their health is still possible. If, in the short term, grandparents suffer more health problems, what is the long-term effect of living together? One study found that for China's elderly, living with grandchildren is associated with a much higher degree of happiness than their counterparts (Chyi and Mao, 2011). However, as the modern value of independence and privacy begins to erode traditional values, the choice made by this current generation of elderly showed some transitional characteristics. For example, one study based on recent data shows that

elderly with higher education tend to live separately, implying an increasing desire for independence and privacy (Lei et al., 2011).

In summary, although it is clear that the presence of grandparents benefits children's nutrition status, more studies about this arrangement's impact on grandparents' wellbeing are needed, particularly as China continues to experience rapid economic, demographic and cultural changes.

## **7.5 Conclusion**

Seeking to better understand the influence of family-level factors on child overweight/obesity and underweight in China, this dissertation first developed a conceptual framework to address contextual factors that shape the SES profile of child overweight/obesity, and analyzed the central role of access to obesogenic foods and obesogenic inactivity environments. Then this dissertation examined the impact of having younger siblings on the eldest child's nutrition status and the impact of presence of grandparents on child nutrition status.

As the primary institution for a child, family is an opportune place for intervention in child malnutrition. Although China shares with the Western world many aspects of family life and structure, this dissertation found remarkable differences in multiple levels of contextual factors that shape a child's risk of overweight/obesity and underweight. China's stage of economic development together with the drastically increasing income inequality has created an ever-increasing SES gap in child overweight/obesity. Despite the low fertility level and tremendous economic growth, resource dilution effect on nutrition status still existed among girls. Children in the care

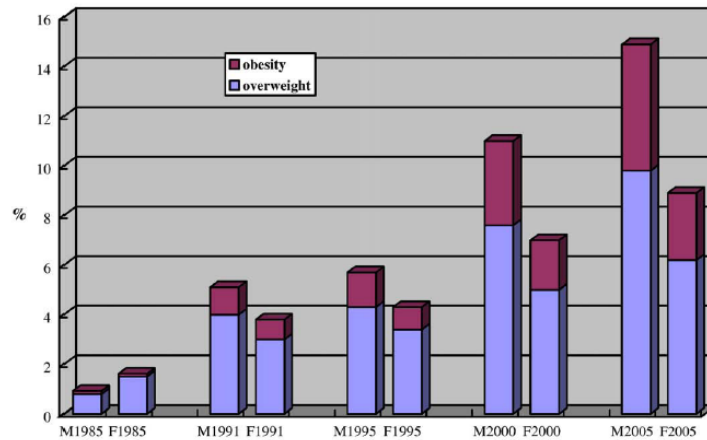
of grandparents are healthier, probably due to the low degree of general access to obesogenic environment and a closer intergenerational relationship that facilitates communication and promotes healthy life style formation.

By comparing differences between China and more developed countries, the framework addressing contextual factors that shape the heterogeneity of SES profile of child overweight/obesity could be used to analyze the experiences of other developing countries in Asia, Latin America and Africa. The findings on family structural elements in China might also be extrapolated to other countries experiencing low fertility or sharing the traditional Confucian values, such as Korea, Japan, Singapore, the Greater China area, and Malaysia.

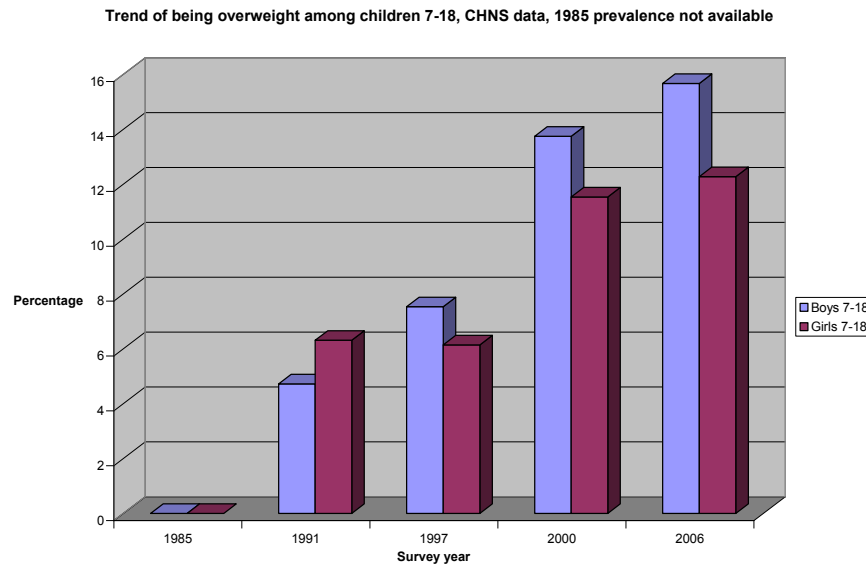
# Appendix

## Appendix 3.1: Temporary change in prevalence of obesity in China

*C.Y. Ji, T.O. Cheng / International Journal of Cardiology 132 (2009) 1–10*



**A: temporary change in prevalence of obesity plus overweight among school age (7-18) children in China, from a national representative sample drawn from CNSSCH (Chinese National Survey on Students Constitution and Health), overweight measurement using Working Group on Obesity in China (WGOC) references 2004**



**B: Temporary change in prevalence of being overweight among children aged 7-18 in 9 provinces in China, CHNS. Overweight measurement using Working Group on Obesity in China (WGOC) references 2004**

**Appendix 4.1: Logistic regression on attrition status by characteristics at the previous wave, CHNS 1991- 2006 (robust standard error adjusted at personal ID level).**

	Model 3
Gender	-0.05
Age	0.05***
Being Overweight/Obese last wave	0.10
Log per capita family income	0.02
Liaoning	1.58***
Heilongjiang	-0.59***
Jiangsu	-0.20
Shandong	-0.17
Henan	-0.14
Hubei	-0.32***
Hunan	-0.32**
Guangxi	-0.33***
Urban residence	-0.013**
Father high school or higher	0.07***
Mother high school or higher	0.17***
Period	0.15***
Father political elite	-0.15
Mother political elite	0.09***
Father's height	0.00
Mother's height	0.01**
Pseudo R2	0.1415
N	11041

\*: P<0.1, \*\*: P<0.05, \*\*\* P<0.01

**Appendix 4.2: Regress mother's BMI on Missing status for children aged 2-18, CHNS 1991 to 2006, correcting clustering at individual level**

Mother's BMI	Coefficient	Standard Error
Missing	-.825	.600
N	21105	

P<0.01:\*\*\*, P<0.05:\*\*, P<0.1:\*,

**Appendix 4.3: Descriptive statistics for children aged 2-18 with no missing values in the major variables, China Health and Nutrition Survey 1991-2006**

	1991	1993	1997	2000	2004	2006
Male	0.521	0.526	0.536	0.524	0.550	0.585
Age (years)	9.74	10.01	10.77	11.55	11.62	11.56
Overweight/Obese	8.20	9.95	9.65	8.97	14.89	18.30
Family real income (in thousand Yuan)	9.62	10.99	13.60	16.52	22.06	25.72
Urban resident	.262	.250	.303	.282	.285	.278
Father high school	.191	.218	.255	.295	.329	.349
Mother high school	.121	.140	.173	.218	.246	.228
Father political elite	.055	.045	.058	.045	.034	.034
Mother political elite	.0143	.010	.013	.019	.018	.017
Father's height (cm)	165	166	166	166	167	167
Mother's height (cm)	155	155	155	156	156	157
Kcal (1000 cal)	1999	1932	1824	1906	1799	1732
Fat (gram)	48.5	48.3	50.3	59.9	57.9	57.1
Protein (gram)	57.3	57.1	54.0	56.0	55.0	54.6
Number of obs.	2733	2391	1845	1527	895	795

## Appendix 4.4: How nutrition intake data is collected

Source: <http://www.cpc.unc.edu/projects/china/design/datacoll>

The three consecutive days during which detailed household food consumption data have been collected were randomly allocated from Monday to Sunday and are almost equally balanced across the seven days of the week for each sampling unit. Household food consumption has determined by examining changes in inventory from the beginning to the end of each day, in combination with a weighing and measuring technique. Chinese balances with a maximum limit of 15 kilograms and a minimum of 20 grams have been used. All processed foods (including edible oils and salt) remaining after the last meal before initiation of the survey have been weighed and recorded. All purchases, home production, and processed snack foods have been recorded. Whenever foods have been brought into the household unit, they have been weighed, and preparation waste (e.g., spoiled rice, discarded cooked meals fed to pets or animals) has been estimated when weighing was not possible. At the end of the survey, all remaining foods have been again weighed and recorded. The number of household members and visitors has been recorded at each meal.

Individual dietary intake for the same three consecutive days has been surveyed for all children age 1 to 6 and all adults age 20 to 45 in 1989 and for all individuals in later years. This step has been achieved by asking individuals each day to report all food consumed away from home on a 24-hour recall basis, and the same daily interview has been used to collect at-home individual consumption. In a few cases, subjects have missed one day because of absence, but over 99 percent of the sample has been available for the full three days of data.

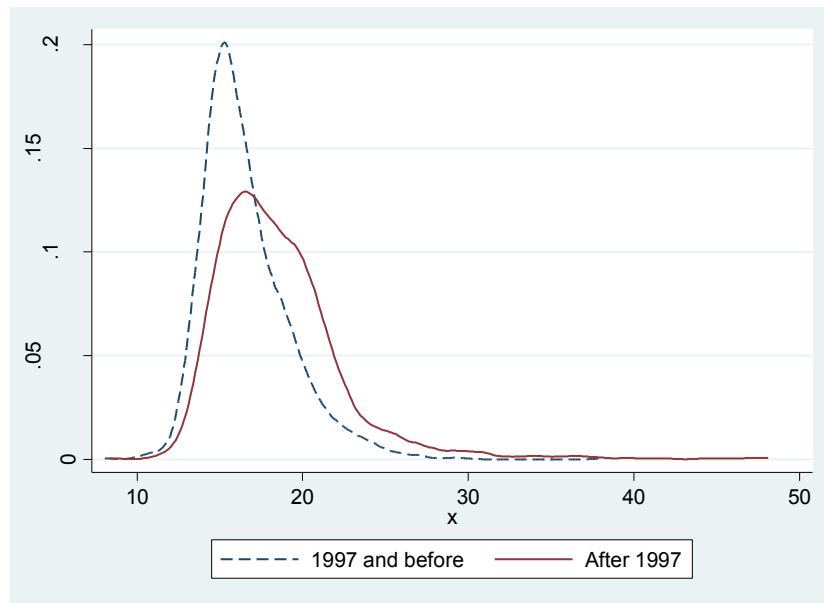
The collection of both household and individual dietary intake allowed us to check the quality of data collection by comparing the two. Thus, each individual's average daily dietary

intake, calculated from the household survey, has been compared with his or her dietary intake based on 24-hour recall data. Where significant discrepancies were found, the household and the individual in question were revisited and asked about their food consumption to resolve these discrepancies.

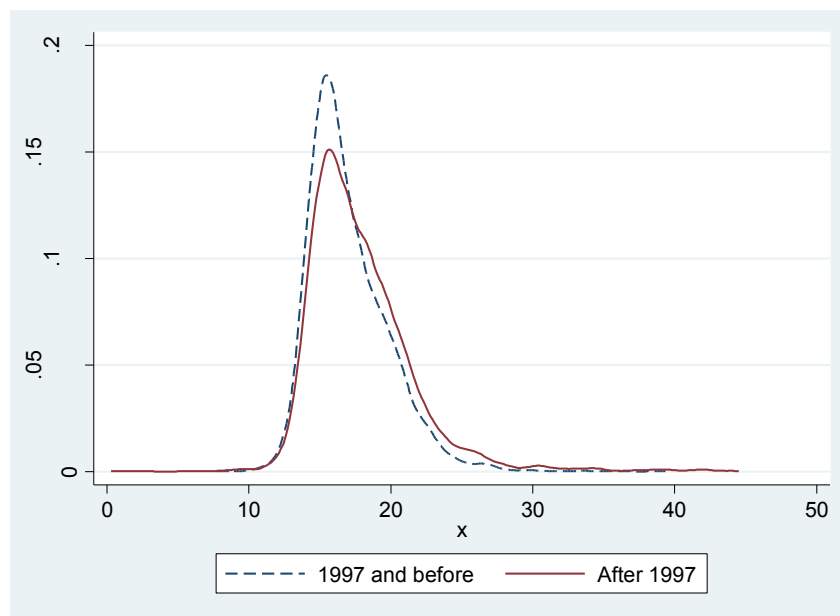
All field workers have been trained nutritionists who are otherwise professionally engaged in nutrition work in their own counties and who have participated in other national surveys. Almost all interviewers have been graduates of post-secondary schools; many have had four-year degrees. In addition, three days of specific training in the collection of dietary data have been provided for this survey.

The 1991 Food Composition Table (FCT) for China was utilized to calculate nutrient values for the dietary data of 2000 and previous years. This FCT represents a significant advance over the earlier China FCT both for higher quality chemical analyses and for improved techniques of developing average nutrient values for foods whose nutrient value varies over the country in a geographic context. The UNC-CH group has worked with the National Institute of Nutrition and Food Safety to update and improve this FCT. A newer version of FCT (2002) was used for the 2004 survey and the latest version (2004) was used for the 2006 survey.

### Appendix 4.5: Distribution of BMI for children age 2-18 by father's education attainment and period

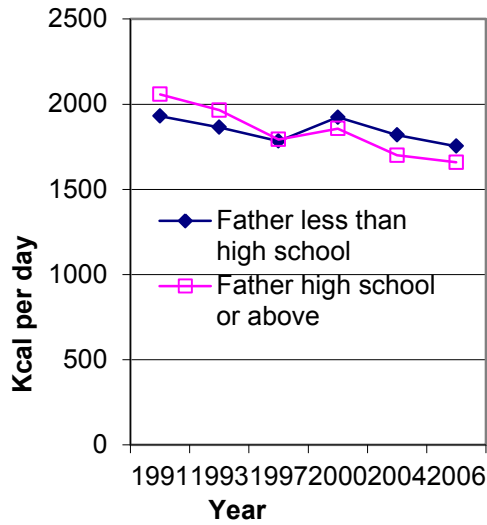


a. Distribution of BMI by period for children whose father has high school degree or above, CHNS 1991-2006, children aged 2-18

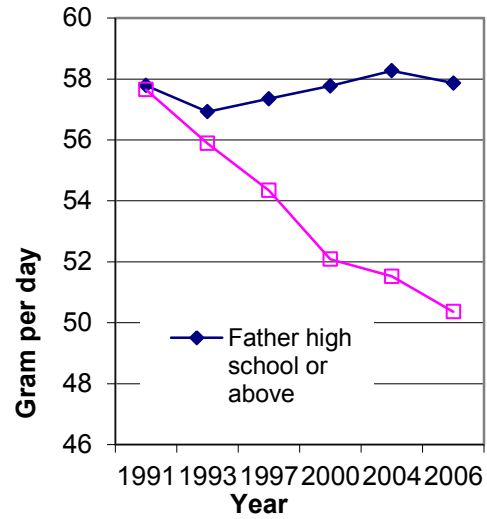


b. Distribution of BMI by period for children whose father does not have a high school degree, CHNS 1991-2006, children aged 2-18

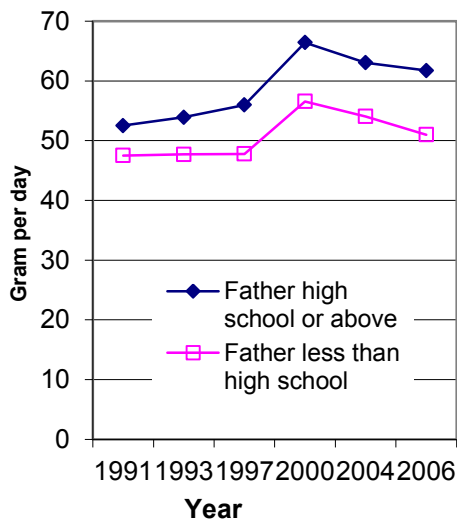
**Appendix 4.6: Trend of child (aged 2-18) daily energy intake, daily protein intake and daily fat intake by father's education attainment. CHNS 1991-2006**



**a: energy intake**



**b: protein intake**



**c: fat intake**

**Appendix 4.7: Overweight/obesity status and SES indicators by gender, CHNS 1991-2006, Results from GEE models**

	Boys (2-18)		Girls (2-18)	
	Model 1	Model 2	Model 3	Model 4
PC Family income logged	<b>.100*</b>	<b>.083*</b>	.054	.061
Father high school or above	.005	.045	-.201	-.303
Mother high school or above	.030	-.004	.128	.166
Urban residency	<b>.242*</b>	<b>.278**</b>	<b>.299**</b>	<b>.280**</b>
Father political elite	.236	.148	.057	.162
Mother political elite	.004	.049	.261	.424
After 1997	<b>.296**</b>	<b>.343**</b>	.082	.139
Father high school or above*after 1997	<b>.447**</b>	<b>.423*</b>	<b>.443*</b>	.420
Mother high school or above*after 1997	-.121	-.181	.082	.115
Urban *after 1997	.053	-.046	.174	.023
Father political elite* after 1997	-.285	-.132	.386	.140
Mother political elite* after 1997	-.763	-.810	-.104	-.364
Energy intake (kcal)		<b>0.0002***</b>		<b>.0002***</b>
N of observations	5415	5415	4771	4771
N of groups	2780	2780	2515	2515
Wald chi2	178.90	303.37	211.02	229.55

\*: P<0.1, \*\*: P<0.05, \*\*\* P<0.01;

Child's age, parental height, province fixed effects are controlled in all models.

**Appendix 4.8: Percentage who disagree on the listed statements by SES (aged 12 to 18), China Health and Nutrition Survey 2004 and 2006 (sample size in parentheses)**

		2004			2006		
	Percentage that Disagree	Heavier better	More high fat good	More sugar good	Heavier better	More high fat good	More sugar good
<b>Income</b>	Per capita income median or above	90.76** (540)	82.06** (540)	81.35*** (540)	93.73** (351)	76.19*** (351)	77.44*** (351)
	Per capita income below median	87.09** (542)	75.92** (5425)	78.42*** (542)	89.44** (351)	64.03*** (351)	67.03*** (351)
<b>Education</b>	Father High school degree or higher	93.66*** (268)	85.97*** (268)	83.21** (268)	94.15* (205)	79.02*** (205)	77.07*** (205)
	Father Middle school degree or lower	88.35*** (635)	77.64*** (635)	78.90** (635)	91.88* (357)	69.75*** (357)	71.99*** (357)
<b>Residency</b>	Urban residency	89.77 (352)	82.95*** (352)	80.97 (352)	94.21** (242)	78.51*** (242)	78.51*** (242)
	Rural residency	88.20 (746)	76.81*** (746)	78.82 (746)	90.57** (477)	66.88*** (477)	70.44*** (477)
<b>Gender</b>	Girl adolescents	90.51* (1051)	79.45 (1051)	82.41** (1051)	92.71 (1051)	74.24*** (1051)	77.27*** (1051)
	Boy adolescents	87.16* (1216)	78.21 (1216)	77.03** (1216)	91.00 (1216)	67.87*** (1216)	69.27*** (1216)

\*: P<0.1, \*\*: P<0.05, \*\*\* P<0.01; significance test is for the difference from higher SES groups and lower SES groups.

**Appendix 5.1: Logistic regression on attrition status by characteristics at the previous wave, for first-born children age 2-18, CHNS1991- 2006 (robust standard error adjusted at personal ID level)**

Gender	-0.059(.310)
Age	0.087(.007)***
BMI at previous wave	1.01(.091)
Log family income	.033(.032)
Urban residence	-0.012(.005)**
Father high school or higher	0.071(.027)**
Mother high school or higher	0.131(.005)**
After 1997	0.153(.020)**
Father's height	0.001(.203)
Mother's height	0.012(.004)**
Pseudo R2	0.139
N	4284

Notes: \*: P<0.1, \*\*: P<0.05, \*\*\* P<0.01; Province fixed effects are controlled.

**Appendix 5.2: Regress mother's BMI on Missing status for first born children aged 2-18, CHNS 1991 to 2006, correcting clustering at individual level**

Mother's BMI	Coefficient
Missing	1.34(1.15)
Age	.018(.117)
Gender	1.58(.98)
Urban residency	.663(.105)***
R squared	.002
N of observations	7910

Notes: P<0.01:\*\*\*, P<0.05:\*\*, P<0.1:\*, Province fixed effects are controlled.

### Appendix 5.3: Monetary punishments for excess fertility, China 1979-2000

Province	First report	Second report	Third report	Fourth report	Fifth report
Liaoning	1979:14Y,10%	1980: 14Y, 10%	1988: 14Y,10%	1992: 1Y, 500%	1997: 1Y, 500%
Heilongjiang	1982: 14Y, 10%	1983:1Y,120%	1989:14Y,10%		
Jiangsu	1982: 10Y,10%	1990:1Y,300%	1995:1Y,300%	1997:1Y, 300%	
Shandong	1996: 1Y,100%				
Henan	1982: 7Y,15%	1985: 7Y,15%	1990: 7Y,30%		
Hubei	1979: 14Y,10%	1987: 5Y,10%	1991: 5Y,60%	1997: 5Y,60%	
Hunan	1979: 14Y,5%	1982: 5Y,10%	1989: 1Y,200%		
Guangxi	1994: 1Y,500%				
Guizhou	1984: 14Y, 10%	1998: 1Y,500%			

Notes: Taken from Ebenstein (2011). Monetary punishment listed above as “Year of report: length of wage deduction, percent of annual salary”. Fines that are levied as one-time punishments are listed above as being collected in a single year.

### Appendix 5.4: Regress change of fine level from 1991 to 2000 on 1991 community level characteristics, correcting clustering at individual level

	Change of fine level from 1991 to 2000
Community level characteristics at 1991	
Average number of children per family	-.237(.209)
Average per capita family real income	4.68e-06(.0000106)
Percentage of boys among children	-5.38 (.467)***
Percentage of minority	2.70 (.157)***
Two-child zone	.591(.130)***
1.5-child zone	1.28(.094)***
Percentage of fathers holding high school diploma	-.457(.384)
Percentage of mothers holding high school diploma	1.31 (.441)***
Average father’s height	.136(.019)***
Average mother’s height	-.010(.004)
R-squared	0.4201
Number of observations	2152

Notes: \*: P<0.1, \*\*: P<0.05, \*\*\* P<0.01;

**Appendix 6.1: Logistic regression on attrition for children aged 2-12, CHNS 1991-2006, correcting clustering at individual level**

	Dropping out
Overweight at previous wave	.27 (.19)
Underweight at previous wave	-.14 (.11)
Presence of grandparents in the household	.23 (.08)***
Age	-.010(.014)
Gender	-.020(.071)
Urban residence	.21 (.08) **
Family income 2006 Yuan	6.57e-06 **
Father high school diploma	.02 (.05)
Mother high school diploma	.27 (.05)***
Observations	6170

Note: Robust standard errors in parentheses; Survey year and province fixed effects are controlled; \*:  $p \leq 0.10$ ; \*\*  $p \leq 0.05$ ; \*\*\*:  $p \leq 0.01$ .

**Appendix 6.2: Regress mother's BMI on Missing status for children aged 2-12, CHNS 1991 to 2006, correcting clustering at individual level**

Mother's BMI	Coefficient	Standard Error
Missing	1.21	.98
N	9420	

$P < 0.01$ :\*\*\*,  $P < 0.05$ :\*\*,  $P < 0.1$ :\*

**Appendix 6.31: Ratio of (number of male siblings)/(number of siblings) for the child's father, children 2-12, by fathers' birth year, CHNS 2000**

	All	1 sib	2sib	3 sib	4 sib	5 sib	6sib	7sib	8 sib
<i>Fathers' birth year range from 1941 to 1978</i>									
Proportion in sample	.50	.54	.45	.50	.51	.53	.46	.47	.58
P value of t test Ho: Ratio>.5	.65	.21	.97	.56	.33	.08	.94	.76	.8
Number of observations	940	98	208	202	189	133	66	27	.26
<i>Fathers' birth year range from 1941 to 1950</i>									
Proportion in sample	.65	1	1	.5	.375	.8	.17		
P value of t test Ho: Ratio>.5	.11			.50	.60	.18			
Number of observations	10	2	1	2	2	2	1	0	0
<i>Fathers' birth year range from 1951 to 1960</i>									
Proportion in sample	.53	.67	.44	.56	.58	.57	.41	.46	.69
P value of t test Ho: Ratio>.5	.09	.13	.85	.16	.06	.054	.90	.65	.25
Number of observations	162	12	33	32	35	23	17	8	2
<i>Fathers' birth year range from 1961 to 1970</i>									
Proportion in sample	.49	.46	.47	.49	.50	.51	.48	.46	.45
P value of t test Ho: Ratio>.5	.89	.73	.86	.67	.57	.34	.80	.75	.62
Number of observations	664	67	141	152	138	98	40	14	5
<i>Fathers' birth year range from 1971 to 1978</i>									
Proportion in sample	.49	.70	.38	.44	.46	.54	.48	.51	1
P value of t test Ho: Ratio>.5	.63	<b>.04</b>	.97	.80	.71	.32	.58	.35	
Number of observations	104	17	33	16	14	10	8	5	1

**Appendix 6.32: Ratio of (number of male siblings)/(number of siblings) for the child's father, children 2-12, by fathers' birth year, CHNS 2004**

	All	1 sib	2sib	3 sib	4 sib	5 sib	6sib	7sib	8 sib
<i>Fathers' birth year range from 1946 to 1978</i>									
Proportion in sample	.49	.52	.46	.46	.45	.53	.56	.62	.55
P value of t test Ho: Ratio>.5	.76	.33	.91	.93	.94	.12	<b>.04</b>	<b>.04</b>	.36
Number of observations	505	82	124	100	85	63	34	9	5
<i>Fathers' birth year range from 1946 to 1960</i>									
Proportion in sample	.40	.20	.38	.42	.5	.49	.33	.43	.25
P value of t test Ho: Ratio>.5	.97	.89	.68	.68		.79		.76	
Number of observations	31	5	4	4	6	7	1	4	.
<i>Fathers' birth year range from 1961 to 1970</i>									
Proportion in sample	.48	.47	.44	.48	.45	.54	.55	.76	.25
P value of t test Ho: Ratio>.5	.85	.63	.93	.67	.91	.13	.11	<b>.01</b>	
Number of observations	312	32	73	69	63	42	27	3	1
<i>Fathers' birth year range from 1971 to 1978</i>									
Proportion in sample	.52	.6	.48	.40	.44	.30	.67	.67	.75
P value of t test Ho: Ratio>.5	.22	.09	.59	.99	.79	.54	<b>.01</b>	<b>.04</b>	.09
Number of observations	163	45	47	27	16	13	6	3	3

**Appendix 6.33: Ratio of (number of male siblings)/(number of siblings) for the child's father, children 2-12, by fathers' birth year, CHNS 2006**

	All	1 sib	2sib	3 sib	4 sib	5 sib	6sib	7sib	8 sib
<i>Fathers' birth year range from 1948 to 1981</i>									
Proportion in sample	.49	.53	.49	.46	.45	.49	.49	.61	.25
P value of t test H <sub>0</sub> : Ratio>.5	.79	.31	.56	.87	.97	.58	.56	.18	
Number of observations	392	70	85	75	82	51	19	7	2
<i>Fathers' birth year range from 1948 to 1960</i>									
Proportion in sample	.51	.5	1	.67	.43	.33		.28	
P value of t test H <sub>0</sub> : Ratio>.5	.46	.5		.35	.91	.93			
Number of observations	17	2	2	2	7	3	0	1	0
<i>Fathers' birth year range from 1961 to 1970</i>									
Proportion in sample	.48	.32	.50	.50	.46	.49	.54	.43	.25
P value of t test H <sub>0</sub> : Ratio>.5	.95	.96	.50	.53	.89	.63	.22	.24	
Number of observations	219	25	42	47	53	32	15	2	2
<i>Fathers' birth year range from 1971 to 1981</i>									
Proportion in sample	.51	.78	.44	.35	.41	.54	.33	.71	
P value of t test H <sub>0</sub> : Ratio>.5	.33	<b>.0003</b>	.85	.98	.90	.26	.76		
Number of observations	156	32	31	16	20	10	3	1	0

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## Biography

I was born and grew up in Chongqing, China. I got B.A. in sociology from Renmin University of China (RUC) in 2002 and M.A. from RUC in 2004. I started pursuing Ph.D. at the School of Public Policy at Duke University since 2007 and became a James B. Duke fellow since then. My research interests pertain to the application of cross-disciplinary perspectives to study social, demographic, and policy influences on health outcomes. My current research projects concern the impact of family structure, family resource and family planning policies on the wellbeing of family members. My scholarship has appeared in a few books including *The Secret of Consumption* and *Performing and Labeling: In-depth Study on Female Sex Workers in China*.