

Multilevel Effects of Socioeconomic Status and Income Inequality on Obesity among Chinese Adults

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Abstract

Although the obesity epidemic has been consistently observed in both developed and developing countries, social determinants of obesity in developing countries remain poorly understood. This study examines multilevel social determinants of obesity among Chinese adults. By bringing together the literature on the SES gradients in health and the income inequality effects on health, we analyze the 2006 China Health and Nutrition Survey data to understand the effects of individual- and area-level socioeconomic status and income inequality on obesity. We find that at the individual-level, adjusting for demographic characteristics, income and wealth are positively associated with obesity, whereas education and manual occupation are negatively associated with obesity, while relative income has no effect on obesity. At the area-level, adjusting for community characteristics, income inequality is inversely associated with obesity. Therefore, patterns of how SES and inequality affect obesity risks in a developing country can be uniquely different from that in developed societies.

Introduction

The obesity epidemic has been observed in many regions in the world. In 2010, the World Health Organization (WHO) estimated that 475 million people were clinically obese (WHO 2000). In the U.S., Western Europe, Canada and Australia, burgeoning social studies of obesity generally support an inverse SES-obesity association that higher risk of obesity exists in low income, less educated and minority population. An extensive review of studies on obesity in America published between 1990 and 2006 concluded that low-SES groups in the U.S. were at increased risk of obesity (Wang and Beydoun 2007). Roskam et al (2010) studied 127,018 adults aging from 25-44 years from 19 European countries, and found inverse educational gradients in overweight and obesity in most of these countries. They further reported cross-national differences in the strength and direction of this relationship in respect of different levels of socio-economic development (Roskam et al. 2010). Not only the individual SES, but also the societal social-economic development affects one's weight in an inverse way. In a study of 16,695 adults in 10 European countries participating in the Health, Aging and Retirement Study, a higher mean BMI was associated with lower GDP (Peytremann-Bridevaux et al. 2007). The SES-obesity association varies in subgroups and over time. It is less consistent among men than among women (Chang and Christakis 2005; McLaren 2007; Mokdad et al. 2001; Robert and Reither 2004; Schoenborn et al. 2004; Sobal and Stunkard 1989). Over time, studies found the latest trend for this inverse SES-obesity association was weakened among the high-SES individuals between 1971 and 2000 (Zhang and Wang 2004), especially in the most recent decade i.e. 1999-2008 (Flegal, Carroll, Ogden, and Curtin 2010).

By contrast, studies from non-Western developing countries generally reported higher BMIs clustered among people of higher SES (McLaren 2007; Sobal and Stunkard 1989). However, studies reveal that obesity was not solely found in higher SES groups. In the cross-national comparative setting, as one examined from less economically developed to more economically developed countries, an inverse SES-obesity association began to show (McLaren 2007; Mokdad et al. 2003a; Sobal and Stunkard 1989). Monteiro et al (2004) reviewed studies conducted in adult populations from developing countries published between 1989 and 2003; they agreed that the burden of obesity in each developing country tended to shift towards lower SES population as the country's gross national product (GNP) increased. In addition, a shift towards obesity in women with low SES occurred at an earlier stage of economic development than that with men (Monteiro, Moura, Conde, and Popkin 2004b).

Evidence supporting the income inequality hypothesis of obesity varied in different social environment. Two studies are based on cross-national comparisons. In Europe, an ecological study of 21 developed countries (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the UK, and the USA) reported "wider income gaps are related to wider waistbands," namely a positive correlation between income inequality for both males and females. Further, the effect of income inequality on female obesity was independent of average calorie intake (Pickett et al. 2005). Recently, a study assesses the relation between income inequality and obesity prevalence among 31 OECD countries through a series of bivariate and multivariate linear regressions. The authors found a consistent and positive correlation between

income inequality and obesity prevalence overall. However, this is based on inclusion of two extreme cases: the United States and Mexico, which well lead OECD countries in both obesity prevalence and income inequality. When both cases are excluded, the associations virtually disappeared (Su et al. 2012). Within-country comparisons revealed similar results as the Wilkinson's thesis. Robert and Reither (2004) showed that community income inequality as measured by Gini coefficients had an independent positive association with BMI based on the U.S. sample. Other studies found the effect of income inequality on BMI was quite small. For example, the HUNT study in Norway reported only 1% of the unexplained variance was located on the neighborhood and municipality levels (Sund et al. 2010).

Similar studies on association between income inequality and obesity in developing countries are quite limited, leaving more space for future investigation. A population-based multilevel study on income inequality and nutrition status in India reported a risk of being overweight by 9% on each standard deviation increase in state income inequality (Subramanian, Kawachi, and Smith 2007). In China, Ling (2009) found mixed associations between income inequality and overweight and obesity in her study of older adults. She found that income inequality was significantly and positively associated with waistline, but significantly and negatively associated with overweight status; the income inequality was not significantly associated with obesity. Meanwhile, Chen and Meltzer (2008) found a significant and positive association between the community income inequality and obesity in rural China. My study is based on the inconclusive association between income inequality and obesity.

Why Do We Study China?

There are multiple reasons suggesting China is a strategic case for a social determinants approach to the obesity study. First and foremost, the social determinants of obesity in China are not clear. Since the majority of the studies have been conducted in developed countries, limited research exists in developing countries, whose economic and social environments are very different from developed nations; hence obesity prevention strategies may vary. As such, obesity in the context of developing countries including China has only recently come to the attention of researchers. With the evolving obesity epidemic in developing countries including China, it has become increasingly intriguing and important to seek answers to social determinants of obesity in developing countries.

The second reason comes from the fact that China is facing a pressing concern of obesity which needs systematic research for prevention strategies. Although China is not the fattest nation in the world, obesity in China has been a public health concern for over one decade with millions of people suffering and billions of dollars in economic burdens involved (Zhao et al. 2008). There was an increase from 14.6 to 21.8% of the overall rate of overweight and obesity in China from 1992 and 2002. The increasing obesity prevalence is observed in all gender and age groups of all geographic areas. Central obesity was 19.5% in men and 38.2% in women (Wang et al. 2007b). In other words, there was an increase of nearly 50% in the overweight and obese population in China in only 10 years; the increase rate was similar to that of the U.S., the widely known “fattest country” in the world, from 1960 to 2000. Previous research mainly focused on proximate individual risk factors such as diet and activity level, but the social determinants of obesity in China remains unclear.

The third reason is that China's unique social context provides an intriguing case for studying the social determinants of obesity in a large developing country in transition with economic growth and deep income inequality. China is the largest developing country in the world, an economic power in transition, and an active player in global affairs with an average life expectancy of 73 years (The United Nations 2006), a per capita GDP of \$ 3,744 (World Bank 2009), and a Gini coefficient as high as over 4.0 (Human Development Report 2006). Between the foundation of the People's Republic of China (PRC) in 1949 and the mid-1970s, China had a strict, central-planned economy. Since the economic reform in the late 1970s, China has experienced profound social change and economic development. Major social changes have included the institutional transformation from the national level to the county level, the transformation from planned economy to the market economy (Bian and Logan 1996; Nee 1989), the migration of millions of farm laborers to the urban areas (Zhao 1999) and subsequent lifestyle changes. More recently, urbanization was witnessed across the whole country (Chen 2006; He and Pooler 2002; Kasarda and Crenshaw 1991; Shaoquan et al. 2004). In addition, the westernization in the lifestyle (high caloric intake dietary patterns and sedentary lifestyle) that were associated with health outcomes was observed (Cockram et al. 1993; Miao et al. 2008; Popkin 1999). The complex social context in China provides a fertile ground for studying the effects of SES disparities and social inequalities on obesity. However, there is very limited published research at the national-level on these topics.

In summary, China is a well-known developing country in major transitions, which include rapid economic growths, widening income gaps and dynamic changes in population health. The economic and political conditions at the macro level, the income and wealth conditions of individuals, the occupation structure, the education system, and income inequality in China are very different from that of the West and other developing countries. This study in China not only contributes to the obesity literature in general, but also to the growing literature in developing countries and in China itself.

Theoretical Frameworks

To better understand obesity from a social determinants approach, a sound theoretical framework from social science is necessary. Despite the evidence of social determinants of obesity, there is no ready theory regarding how to examine the social determinants of obesity. Hence I use research traditions in social studies of health for the theoretical basis to study social determinants of obesity.

In social science, health inequalities studies have actively engaged researchers from multiple disciplines, including sociology, demography, economics, epidemiology, psychology, and social medicine. Studies generally follow two research traditions: One examines socioeconomic disparities in health, while the other studies the socioeconomic inequality effects on health. The first tradition, using individual-level data, focuses on socioeconomic determinants of health such as individual income, occupation and education (or parents' education for subjects who are infants, children and adolescents). This tradition in sociology traced back to the Chicago school scholars' observation of SES and mental disorders in the 1930s (Faris 1965). SES is usually measured by determining education, income, occupation, or a composite of these dimensions. Within the first tradition, studies of socioeconomic gradient in health have reported mixed findings and debated about whether higher SES gradients were related to better health.

The second tradition, using aggregate-level or multilevel data, examines the impact of the distribution of income on population health. Researchers studied associations between inequality (measured by indices, e.g. the Gini coefficient) and health (measured by, e.g. life expectancy and mortality) at the population level or health outcomes at the individual level. Within the second tradition, mixed results have been observed with regard to whether there is a negative association between income inequality and health. The different perspectives lead to different conclusions: The first tradition generally claims that poor health is more prevalent among individuals with disadvantaged socioeconomic backgrounds, most prominently low income. The second tradition mainly blames poor health in industrialized societies on the social inequalities, especially income inequality, and claims that the health is affected by the inequality of income distribution rather than people's own income, possibly through defragmented human and social capital, social cohesion and certain psychological pathways.

There are three competing hypotheses on income-health association from the two traditions: the absolute income hypothesis (AIH), the relative income hypothesis (RIH), and the income inequality hypothesis (IIH). The wealth-health association can be studied by examining different income measures: the absolute income, the relative income and income inequality. AIH suggests that average health in society improves as the average income in society increases, and one's health improves with the increase of the absolute individual income, but income inequality or the relative income has no direct effect on health. RIH suggests that it is one's income relative to that of others in a reference group, rather than absolute material standards, is related to health, and a higher relative income is associated with better health. IIH suggests that income inequality is directly associated with health outcomes, such that the less unequal a society is, the better health status for the people in the society.

Several problems of the three approaches remain. First, the consistency and robustness of effects of income and income inequality on health continues to generate controversies. By controlling for different covariates and confounding factors, income inequality effects can be weakened and even eliminated, and may change across cohorts and periods (Fiscella and Franks 1997b). Second, the appropriate level of study is still being contested. Either the aggregate-level or the individual-level study has potential problems. Third, most studies were done in industrialized countries, leaving the relevance of income and income inequalities' effects on health in non-Western countries to be examined. There are only a handful of studies of the income and inequality effects on health in developing countries such as the health inequalities in Argentina (Fernando 2008), China (Chen et al. 2010; Li and Zhu 2006) and India (Subramanian et al. 2007). These studies reported mixed, even opposite findings with those in the industrial societies. Systematic critique of the income hypotheses in developing societies has not been addressed. In addition, the multidimensionality of SES in relation to the health inequalities among individuals is not well addressed. The current study stems from these un-addressed issues. It brings the two research traditions together and explores the robustness of the income-related hypotheses to examine the relation of SES gradient and income inequality on obesity. The relevance of the AIH, RIH and IIH will be assessed through a multilevel analysis of data.

Objectives

The main purpose of this study is to identify and evaluate the importance of social determinants of obesity as assessed by SES and income inequality in China. Bringing the two traditions of social determinants of health inequalities together, we study the patterns of both individual-level and macro-level determinants within China's social circumstances. In addition, we argue that social determinants of adult obesity in China should be contextualized by the social conditions including the regional and the urban-rural disparities, income inequality, the community characteristics and individual SES positions that put people at risk.

Data and Methods

Data

The individual- and community-level data are drawn from 2006 wave of China Health and Nutrition Survey (CHNS) with a response rate of 88%. The macro-level inequality data are calculated from 2006 Chinese General Social Survey (CGSS).

CHNS is widely recognized for studying the nutrition and health issues in contemporary China. Starting from 1989, CHNS is an ongoing longitudinal survey. It is designed for studying the effects- across space and time- of social change and economic transformation in affecting the health and nutritional status of the Chinese population. Therefore, it covers not only demographic, social and economic factors at multilevel, but also key public health risk factors and health outcomes. The project was collaborated between the Carolina Population Center (CPC-UNC) and the National Institute of Nutrition and Food Safety at the Chinese Center for Disease Control and Prevention (CCDCP). The survey is not designed to be representative of China, but randomly selected to reflect the broad array of economic and demographic circumstances that matter for public health topics. The study population was drawn from nine provinces: Guangxi, Guizhou, Heilongjiang, Henan, Hubei, Hunan, Jiangsu, Liaoning, and Shandong.

The data were collected from a multistage, random cluster sample surveyed in each of the provinces. Within each province, counties were stratified by income (low, middle and high), and four counties were selected randomly through a weighted sampling scheme. The provincial capital and lower-income cities were selected. Villages and townships in the counties and urban and suburban neighborhoods in the cities were selected randomly. The urban community was a neighborhood committee (*Ju Wei Hui*), with a mean population slightly over 3,000, and the rural community was a village (*Zi Ran Cun*) with a mean population of slightly less than 3,800 (Chen and Meltzer 2008). In each community, 20 households were randomly selected and all household members were interviewed. There were no sampling weights in CHNS data (Popkin et al. 2009). The CHNS community questionnaire, which collects information from a knowledgeable respondent, such as the official head of the specific community, was filled out for each of the primary sampling units. It surveyed a broad array of community backgrounds (such as total population, community areas, number of households, typical daily wage), community infrastructure and facilities (such as water, transport, electricity, transportation infrastructure, traditional and modern markets, educational services), and services (such as communications services and organizations, fast food restaurants availability, recreational facilities, health care facilities, medical insurance). The

household questionnaire was filled out by the household head. The adult individual questionnaire was filled out by each individual in household.

The annual or biannual CGSS, an on-going national survey of China's households, was collaborated by Renmin University of China and Hong Kong University of Science and Technology starting from 2003. The survey's aim was to monitor systematically the social structure and quality of life in urban and rural areas. The CGSS data were available in 2003 (surveyed in rural China only), 2005, 2006 and 2008 waves, with the sampling methods and participants varied from year to year. The data covered a representative sample of adult Chinese citizens including all of the 9 provinces in CHNS. To stay consistent with CHNS 2006, we chose CGSS 2006 and derived income inequality measure for the 9 CHNS provinces.

Measures

The outcome variables are BMI and obesity. BMI is the dependent variable in multilevel regression analysis. BMI is calculated from weight (in kilograms) by height (in meters) squared. Whether a subject is obese is the dependent variable in multilevel logistic regression analysis. We choose the WHO definition of obesity for Asian and Pacific adults (WHO, IASO, and IOTF 2000) and operationalize obesity as a dichotomous variable with "BMI equal to more than 25 kg/m²" coded as "1," and "BMI less than 25 kg/m²" coded as "0".

Individual-level exposure and covariates include age, gender, marital status, education, occupation, equivalized household net income, household wealth, the relative income, smoking, and alcohol consumption. Preliminary analyses show that one's obesity status is not clustered within certain households, so the household level is not taken as a separate level in the analysis. Community-level exposure and covariates include community mean education, urbanicity index as an indicator for urbanization, rural/urban indicator and Gini coefficient. The variable measures are described in Table 1.

--- Table 1 about here ---

Hypotheses

Hypothesis 1 (the education hypothesis): Chinese adults with higher educational attainment are less likely to be obese.

This hypothesis is developed from the inverse SES-obesity association found in developed countries and the developing world in transition. In the Western world, relatively lower prevalence of obesity is found among groups with higher educational attainment. As Sobal (1989) and McLauren (2007) found out, in developed countries and developing countries in transition, higher educational attainment was related to lower risk of obesity. This is probably because education promotes health literacy which translates into healthy behaviors that reduces risk of obesity (Sobal 1991). However, education-obesity association is mixed in lower-middle-income developing economies (Monteiro, Moura, Conde, and Popkin 2004b). The positive education-obesity association was found in the developing world. Since China is a low-income developing country with economic transition, and the Chinese people are experiencing the nutritional transition, it is reasonable to assume that people with higher educational attainment have more resources for a healthy lifestyle which prevents them from being obese. Hence we make the inverse education-obesity hypothesis.

Hypothesis 2 (the occupation hypothesis): Chinese adults in manual occupations are less likely to be obese.

Very few studies have examined the relationship between occupation and obesity outcome. Occupation may affect obesity outcome by the intensity of physical activity inherent in the job statistics (Ng, Norton, and Popkin 2009). Manual workers, by their nature of work, have more intense physical activity than any other occupation type. Therefore, we make the above hypothesis.

Hypothesis 3 (the absolute income hypothesis): Chinese adults with more income and household wealth are more likely to be obese.

Evidence from the developed world shows a very consistent inverse income-obesity link. However, in the developing world, studies have shown mixed results of the income-obesity association, which was interpreted by the complex effect of income on diet quantity and quality (Du et al. 2004). The major pattern is a positive SES-obesity association in the non-Western world. Studies have found that household income is positively associated with childhood and early adulthood weight status. Evidence from Cebu, Philippines suggested that increasing prenatal income was associated with lower risk of being underweight in early adulthood, while increasing income during childhood was associated with an increased risk of being overweight in early adulthood (Schmeer 2010).

China a major economic power in transition but still with a majority of low-income population. Which type of income-obesity association best describes the conditions in China? This individual income hypothesis of obesity in the Chinese population is a modification from the absolute income hypothesis in health. we consider both higher income and higher wealth as risk factors for being obese among Chinese adults. Based on previous studies reviewed earlier which report that higher mean BMI is clustered in more economically developed regions and in urban areas, we make the positive income/wealth-obesity link hypothesis since these regions are characterized by higher absolute income.

Hypothesis 4 (the relative income hypothesis): Chinese adults with a higher relative income are more likely to be obese.

The relative income hypothesis claims that one's risk of obesity depends on one's relative income status relative to the reference group, rather than the absolute income level. It must be assessed controlling for the absolute income (Wagstaff and van Doorslaer 2000a). Studies from Western nations have found evidence that a low relative income, or deprivation in comparison to one's reference group, may cause poor health. However, no agreement is reached on whether and how the relative income affected health (Kawachi and Kennedy 1999; Marmot 2005; Mellor and Milyo 2002; Subramanian and Kawachi 2004; Wilkinson and Pickett 2006). There is no relative income hypothesis on obesity yet, but it may be generated from the relative income hypothesis on health.

Very few studies have examined the relative deprivation effect on obesity in China yet. Studies on China have found minimal relative deprivation effects on one's self-reported health (Li and Zhu 2006). My hypotheses of the relative income is derived from the wide observation that the high income groups in developing countries are more likely to be obese; assuming the relative income is independent from the absolute income

in affecting health, the direction of the relative income effect may be the same as the absolute income.

The first four hypotheses are concerning individual-level factors that affect obesity. However, the effects of contextual determinants are independent from the individual SES in determining obesity. The most important macro-social contextual factors includes income inequality (at the national, state or community level) and neighborhood characteristics such as neighborhood SES or position (SEP)/neighborhood deprivation. In Hypothesis 5 and 6, we study the community SES and income inequality.

Hypothesis 5 (the community SES hypothesis): Chinese adults living in a more deprived community are less likely to be obese.

Community SES, or individuals' socioeconomic composition, is the most commonly investigated neighborhood characteristics in social context of health research (Bird et al. 2010; Diez Roux 2001; Fotso and Kuate-Defo 2005). Literature shows that living in communities with a low socioeconomic profile negatively affects one's health-promoting attitudes and behaviors, due to exposures to neighbors with low health-promoting attitudes and behaviors (Robert 1999b). Neighborhoods SES could influence health by short-term influences on behaviors, attitudes, and health-care utilization, or through a longer-term process of "weathering," whereby psychological stress, poor environmental quality, and limited access for health facilities eroding residents' physical and mental well-being over years (Ellen et al. 2001). Similarly, community SES may affect one's risk of obesity. Living in a more deprived neighborhood might be associated with higher likelihood of being obese in the more developed countries such as the U.S. (Robert and Reither 2004), Sweden (Sundquist et al. 1999), and the results might vary by race, age and sex. This hypothesis goes in the opposite direction as evidence found in the more developed world, considering the argument that obesity in China is a consequence of nutrition transition. A more deprived community may be less affected by the obesity epidemic through multiple pathways including diet, and physical environment.

Hypothesis 6 (the income inequality hypothesis): Chinese adults are more likely to be obese if they live in a community with a higher level of income inequality.

The empirical relationship between income inequality and health has generated many debates. Inequality is destructive to population health, as reported by Wilkinson and colleagues. Likewise, European studies and comparison based on OECD countries suggest that living in a more hierarchical society with higher inequality is associated with higher risks of being obese. Pickett et al. attributed this association to the psychosocial impact of inequality (Pickett et al. 2005). Similar findings of the positive inequality-BMI association at the community level are reported in the U.S. (Robert and Reither 2004) and in India (Subramanian, Kawachi, and Smith 2007). There have been very limited studies in China about the association between the regional income inequality and obesity, partly due to data limitation on regional Gini coefficient. As the 2002 Chinese National Nutrition and Health Survey reports, overall, obesity prevalence is the highest in Beijing and Bohai coast regions, followed by northern regions of China, and the lowest in southern regions (Zhuo et al. 2009). We also know that the GDP in China is higher in the coastal regions than the inland regions, but we are not sure about whether income inequality is more severe in the coastal regions than the inland regions, nor do we know the direction of income inequality-obesity association. Hence we propose the income

inequality hypothesis on obesity in consistency with the mainstream literature as described above.

Hypothesis 7 (Cross-level interaction hypothesis): Income inequality influences risk of obesity less for Chinese adults with higher income.

Hypothesis 6 concerns the main effects of income inequality on obesity. Is it equally true for everybody? Does living in a more hierarchical community have the most negative health effects on poorer individuals? According to recent studies, income inequality effects on health were stronger among people with lower SES (Subramanian and Kawachi 2006). Does this apply to income inequality-obesity scenario? Thus far, very few studies have done research on this. To better assess the relationships, cross-level interaction terms between individual income/education and Gini coefficient are tested. Since there is evidence that income inequality hurts individuals with lower SES more than individuals with higher SES, we can examine whether this is true concerning obesity. Therefore, hypothesis 7 and 8 examine the cross-level interaction between income inequality and individual SES. Hypothesis 7 is based on the widely observed detrimental health effects of income inequality for the low income adults in society (Lynch et al. 2004b; Wilkinson and Pickett 2006).

Hypothesis 8 (Cross-level interaction hypothesis): Income inequality influences obesity less for Chinese adults with higher educational attainment.

Although very few studies that examine the interaction between income inequality and individual education on obesity outcome, there are common observations on association between lack of education and poor health, and stronger detrimental income inequality effects on health for lower SES groups. As education is an important dimension of SES, Hypothesis 8 tests whether there is a detrimental effect of income inequality for the less educated adults so that the less educated are at a higher risk of obesity.

Multilevel Models

Multilevel modeling provides a technically robust framework to analyze the clustered nature of the outcome and is pertinent when predictor variables are measured simultaneously at different levels (Goldstein 1995). We use multilevel logistic regression to model obesity as a function of the ecological and individual-level variables. In addition, we study BMI using the multilevel regression methods. The goal is to estimate a series of multilevel models examining the association between body weight outcomes and individual-level SES and community-level social context among adults with a sequence of hypotheses.

Our basic form of multilevel regression model with P level-1 explanatory and control variables x_1, x_2, \dots, x_p and Q level-2 explanatory and control variables z_1, z_2, \dots, z_q for BMI has as the following form:

$$BMI_{ij} = \gamma_{00} + \sum_{p=1}^P \gamma_{p0} x_{p ij} + \sum_{q=1}^Q \gamma_{q0} z_{q ij} + u_{0j}$$

where BMI_{ij} is the BMI for individual i living in community j . Residuals are composed with two parts: u_{0j} represents the random intercept for communities, assumed to be uncorrelated to $x_{p ij}$ or $z_{q ij}$ and has a normal distribution with zero mean and variance $\sigma_{u_0}^2$.

Our basic form of multilevel logistic regression model with P level-1 explanatory variables x_1, x_2, \dots, x_p and Q level-2 explanatory variables z_1, z_2, \dots, z_q for obesity has the following form:

$$\text{logit}(Y_{ij}) = \text{logit}\left(\frac{p_{ij}}{1-p_{ij}}\right) = \gamma_{00} + \sum_{p=1}^P \gamma_{p0} x_{p_{ij}} + \sum_{q=1}^Q \gamma_{q0} z_{q_{ij}} + u_{0j}$$

where Y_{ij} is the binary outcome of obesity for individual i living in community j , p_{ij} is the probability of being obese for individual i living in community j ; $we = 1$ to 9,586, $j = 1$ to 218. γ_{00} is the grand mean. This equation consists of a fixed part $\gamma_{00} + \sum_{p=1}^P \gamma_{p0} x_{p_{ij}} + \sum_{q=1}^Q \gamma_{q0} z_{q_{ij}}$ and a random part (residuals). The fixed parameters γ_{p0} and γ_{q0} ($p=1, 2, 3, \dots, P$; $q=0, 1, 2, 3, \dots, Q$) estimate the differentials in the log odds in the obesity outcome for the different predictors and control variables. The residuals are composed with two parts: u_{0j} represents the random intercept for communities, assumed to be uncorrelated to $x_{p_{ij}}$ or $z_{q_{ij}}$ and has a normal distribution with zero mean and variance $\sigma_{u_0}^2$. The variance parameters quantify the heterogeneity in the outcome at the community level.

Analytic Methods

We first present descriptive statistics on the individual-level socio-demographic characteristics, SES and community-level contextual characteristics of the sample, and give an overview of BMI and obesity disparities by SES groups and regions in China. We then test hypotheses simultaneously at community- and individual- level, and examine bivariate and multivariate associations between the obesity outcome and various indicators of SES, the relative income, income inequality and control variables. By comparing coefficients in bivariate models with corresponding ones in a multivariate model including all the predictors, we can detect the extent to which associations between SES indicators and outcome vs. income inequality indicators and outcome are explained by other factors and interactions.

We examine obesity and BMI separately as outcome variables in random intercept models. As described in Table 2, we use a forward selection process and investigate the effects of SES, income inequality and interactions sequentially, controlling for all other variables. Eight random intercept multilevel models were fitted.

--- Table 2 about here ---

First, Model 1 is a baseline model with demographic variables. Model 2 adds the individual SES variables, thereby indicating the SES effect on the BMI and the odds ratio of being obese. Model 3 adds Deaton's RDI to Model 2 for the relative income effect. Model 4 includes the community SES measures. Model 5 examines the regional level of Gini coefficient. Model 6 adds two province indicators (Jiangsu and Guangxi) to Model 5. The second set of analyses examines cross-level interactions and behavior modifications. We create income inequality interaction variables by multiplying income inequality with the variables for individual SES, which is an approach adopted by the U.S. scholars (Subramanian and Kawachi 2006), and examine all sets of interactions one at a time and additively. For space wise reasons, we present the complete set of interaction model in Model 7, which reports interaction of income inequality by income quintile and education categories. Based on Model 7, Model 8 adds two behavior variables (smoking and alcohol consumption) which are more proximate to the outcome than the social determinants. Based on the statistical results and model goodness of fit criteria (BIC), a best mode is identified, and discussions follow.

Results

Descriptive Results

Table 3 shows detailed description of individual-level socio-demographic characteristics, SES and community-level contextual characteristics. Overall, 26.35% are classified as obese in this study. Approximately 52% of the sample is female. The mean age of respondents is 49, and 83% of them are married. 32 % of the respondents are smokers and 31% are alcohol consumers. The average length in formal schools is 7.42 years; the percentage of low, medium and high education attainments are 43%, 51%, and 6.6% respectively. 59.2% of the respondents are in the workforce. 17.1% of subjects are professionals, 63.1% are manual workers, and 19.8% worked in the service sector. The average equivalized household income in 2006 is about 11,920 yuan. The cut-off points for the income quintiles are 3,200, 6,340, 10,570 and 17,330 yuan. Considerable income variation between quintiles are observed, ranging from very poor (about -6440 yuan) to very high (as high as 315,608 yuan) levels. The wealth index, calculated from questions about asset and wealth, has a mean score of 2.32 (SD= 1.02). The cut-off points for the wealth quintiles are 1.37, 1.93, 2.54 and 3.26. As a measurement of the relative income, Deaton's RDI ranges from 0 to 1, with a mean of 0.23 (SD=.18). The Gini coefficient varies from 0.386 to 0.596 with a mean is 0.473. The mean urbanicity index score is 64.43 but ranges from 27.22 to 101.60. 68.84% of surveyed communities are rural comprised of "suburban" and "rural" neighborhoods, and 31.16% are urban comprised of "city" and "town" neighborhoods. 11% and 12% of the communities are from Jiangsu and Guangxi provinces, respectively.

--- Table 3 about here ---

Figure 1 shows the Gini coefficient by the nine CHNS survey province, indicating regional patterns of income inequality is also shown. Two coastal provinces, Jiangsu and Shandong, represent the two endpoints. Jiangsu has the highest level of income inequality and Shandong is the most egalitarian. The Northeast (Heilongjiang and Liaoning) represents the major foundations of China's heavy industry in the northeast area and they are relatively egalitarian. The inland provinces (Henan, Hubei and Hunan) have similar Gini coefficients. Two mountainous southwestern provinces (Guangxi and Huizhou) represent relatively high levels of inequality.

--- Figure 1 about here ---

Table 4 shows the various demographic, socioeconomic and contextual-related characteristics of the obese vs. non-obese subgroups, and corresponding t-statistics. Obese and non-obese people differ in SES and the exposure to different levels of income inequality. There were 2,526 obese people and 7,060 non-obese people. Significant differences are observed in age and marital status ($p<.001$). However, the sex difference in obese vs. non-obese groups is not significant. Smoking is less popular among obese people but alcohol consumption frequency is similar between the two groups. Obese vs. non-obese groups differ significantly in terms of high educational attainment ($p<0.5$), manual occupation category ($p<0.01$), income ($p<0.01$) and wealth ($p<0.01$). The obese people have significantly higher income and wealth rank than that of the non-obese (12,758 yuan vs. 11,619 yuan and 2.45 vs. 2.27 respectively). The obese group is more clustered in the top two income and wealth quintiles, whereas the non-obese group is more clustered in the bottom two income and wealth quintiles. However, the two groups

have no significant difference in the relative income. At the macro-level, group difference of mean community income, mean community education, urbanicity index, rural/urban communities and Gini coefficient are significant ($p < 0.01$ respectively).

--- Table 4 about here ---

We also present the mean BMI and obesity prevalence by various socio-demographic categories in Table 5. The mean BMI and percentage of obese population by major demographic features such as age, marital status, urban residence and work status are explicit. Women have a higher, though insignificant, mean BMI and slightly higher obesity prevalence than men (23.39 kg/m^2 vs. 23.30 kg/m^2 and 25.75% , respectively). In general, mean BMI has an inverse U shape association with aging: it peaks at middle-age, then decreases and declines. Among young adults (18 to 35 years old), mean BMI is the lowest at 22.35 kg/m^2 . The middle aged (35 to 55 years old) group's mean BMI is the highest at 23.70 kg/m^2 ; BMI decreases among the senior group (55 to 70 years old) and the average is 23.58 kg/m^2 ; the lowest mean BMI of 23.03 kg/m^2 is seen among the oldest group (70 years old and over). Married couples are more obese than unmarried (83.34% vs. 16.66%) and has a higher BMI (23.53 kg/m^2 vs. 22.44 kg/m^2).

--- Table 5 about here ---

Figure 2 summarizes the obesity prevalence by individual SES (education categories, occupation categories, income and wealth). Those with high educational attainments show significantly lower obesity prevalence (23.39%) than the other two education subgroups. Among the occupational groups, the highest mean BMI of 23.46 kg/m^2 is observed among the professionals, which also reported the highest prevalence of obesity of 26.65% . By contrast, the manual occupation category has the lowest mean BMI of 22.97 kg/m^2 and lowest prevalence of obesity of 21.57% . Individual income is positively related to the mean BMI and obesity prevalence. From the first to the second income quintile and all the way up till the fifth quintile, the mean BMI is 23.00 kg/m^2 , 23.09 kg/m^2 , 23.34 kg/m^2 , 23.65 kg/m^2 and 23.65 kg/m^2 respectively. The corresponding prevalence of obesity is 23.27% , 23.13% , 26.03% , 30.06% and 29.26% respectively. If we combine the lowest two quintiles to call it "low income," and combine the highest two quintiles to call it "high income," then there is a clear positive income-obesity pattern. Similarly, wealth quintiles and mean BMI / obesity prevalence are positively associated. From the first to the second income quintile and all the way up till the fifth quintile, the mean BMI increased from 22.96 kg/m^2 , 23.15 kg/m^2 , 23.20 kg/m^2 , 23.69 kg/m^2 and 23.73 kg/m^2 . The corresponding prevalence of obesity is 20.69% , 24.68% , 4.82% , 30.44% and 31.15% respectively. Urban respondents' mean BMI is 23.71 kg/m^2 , higher than that of rural respondents (23.18 kg/m^2). The prevalence of obesity in is substantially higher in urban communities than in rural communities (30.13% vs. 24.64%).

--- Figure 2 about here ---

Mean BMI and obesity prevalence in different regions. Gini coefficient, mean BMI and percentage of obesity by CHNS provinces are presented in Table 6. Shandong Province in Eastern China has the highest percentage of population reported as obese (42.10%), followed by Liaoning and Heilongjiang (37.10% and 31.42% respectively), then Jiangsu Province (28.35%). The inland provinces' prevalence of obesity is lower (Henan: 25.65% , Hubei: 24.95% , and Hunan: 20.23%). Southern China provinces shows low prevalence of obesity (Guizhou: 17.90% ; Guangxi: 11.85%). A more unequal province is related to lower obesity prevalence and a smaller mean BMI.

--- Table 6 about here ---

Bivariate Analyses Results

Bivariate analyses that examine the associations between predictors and control variables and BMI vs. obesity outcome are presented in Table 7. As expected, at the individual-level, income is positively associated with higher BMI and increased risk of obesity. High income status as shown by those staying at the fourth and fifth income quintiles have significant higher risk of obesity (OR=1.417 and OR=1.364) and higher BMI (increased by 0.643 and 0.649, respectively). Similar association between wealth (material wealth measured by the high rank in quintiles of wealth index) and the outcomes are observed: the fourth and fifth wealth quintiles have significant higher risk of obesity (OR=1.686 and OR=1.742) and higher BMI (increased by 0.745 and 0.783, respectively). The association between education attainment and obesity seems to be inverse (OR=0.831, $p<0.05$). Manual workers are less likely to be obese (OR=0.651, $p<0.001$). Deaton's RDI, like other relative income measures, shows no significant associations with BMI or obesity.

At the area-level, the associations between community SES-related measures and the obesity outcome are significant, so is the association between inequality measure and obesity. A higher mean community income is associated with an increased likelihood of obesity (OR=1.020, $p<0.05$) and a higher BMI by 0.030; a higher average community education is also associated with an increased likelihood of obesity (OR=1.079, $p<0.001$) and a higher BMI by 1.141. Each point increase in urbanicity score is positively associated with an increased likelihood of obesity (OR=1.009, $p<0.001$). Urban communities are associated with higher likelihood of obesity compared with rural communities (OR=1.319, $p<0.01$) and increase the mean BMI by 0.525. Unlike community urbanicity effect, each 0.01 increase in Gini coefficient is associated with the lower likelihood of obesity (OR= 0.956, $p<0.001$), and a decrease BMI by 0.085. There are also significant bivariate associations between demographic factors and outcomes. Age is significantly positively associated with the odds ratio of reporting obesity (OR=1.011) and BMI (BMI increases by 0.015 with each additional year of age increase). Being in a marital relationship increases one's risk of obesity by 1.089 times compared with the single marriage status. In addition, smoking is significantly related to a lower BMI and lower odds ratio of being obese.

--- Table 7 about here ---

Multivariate Analyses Results

Table 8 presents estimates of fixed effects coefficients and model fit statistics for BMI outcome. Table 9 presents estimates of fixed effects coefficients in the form of odds ratios of being obese, the ICC, Level-2 variance and the BIC statistic for model goodness-of-fit. The results in both tables report very similar association between predictors and the body weight outcomes. Therefore, we focus on the interpretation of Table 9 on obesity outcome.

---Table 8 about here---

---Table 9 about here---

Models 1 to 6 estimate the demographic and SES main effects on obesity. Model 1, a baseline model with demographic variables, shows significant age effect and quadratic age effect along with the marital status effect. It suggests that the odds of

obesity increases by 11.9% with every 10 years of age (OR=1.119, $p<.001$), but the increase declines at the rate of 0.1 percent every year older over the life course (OR=0.999, $p<.001$), representing a curvilinear and concave age effects. Being married also increase the odds of obesity by 24.9% compared with that of single people (OR=1.249, $p<.001$). However, the sex effect is small and not significant. ICC is 0.102; suggesting 10.2% of the variation in one's likelihood of being obese can be explained by community-level variables.

Model 2 adds the individual SES variables to Model 1, thereby indicating the SES effect on the obesity outcome adjusting for demographic factors. As expected, high educational attainment and a manual occupation are negatively related to obesity; more individual income and more wealth are positively related to obesity. Those with high educational attainment are associated with a 26.1% reduction in the risk of obesity (OR=0.739, $p<.05$). The effect of intermediate education is not significant. Having a manual occupation reduces the risk of obesity at 0.73 times as low as the reference group (service occupations) (OR=0.732, $p<.001$). However, the risk of obesity for those in the fourth wealth quintile is 1.358 times as high as the reference group (bottom quintile), and those on the top wealth quintile's odds ratio is 1.415 times as high as the reference group; both are significant at the 0.001 level. Likewise, the risk of obesity for those in the fourth income quintile is 1.322 times as high as the reference group (bottom quintile), and those on the top wealth quintile's odds ratio is 1.278 times as high as the reference group; both are significant at the 0.001 level.

Model 3 adds Deaton's RDI to Model 2 for the relative income effect. It suggests that, when adjusting for demographic factors and individual SES, the effect of the relative income is not significant. Moreover, the inclusion of the relative income does not improve the model fit as the BIC for Model 3 is larger than that of Model 2. Model 4 includes the community SES measures in addition to the individual-level variables in Model 3. However, none of the community SES indicators (mean income, mean education, urbanicity) are significant. Model 5 shows that, controlling for demographic characteristics, individual SES, the relative income, and community SES, the inclusion of regional level of Gini coefficient improves the model fit (BIC is smaller than those of Model 2 to Model 4). The risk of obesity is significantly reduced by 5% with a 0.01 increase of Gini coefficient (OR=0.951, $p<.001$). From Model 5 to Model 8, the mean community education is negatively associated with obesity, and the urbanicity score is positively associated with the obesity outcome. Both are statistically significant at the 0.05 level, suggesting some independent effects of community SES.

Because the descriptive results of provincial Gini coefficient and mean BMI have found a neat inverse pattern except for Jiangsu and Guangxi, assuming there might be some regional specialties affecting obesity, Model 6 adds two province indicators (Jiangsu and Guangxi) to Model 5. The inclusion of the indicator variables does not change other predictor's effect, while both Jiangsu (OR=2.493) and Gurangxi (OR=0.496) have significant associations with body weight outcomes. Smaller BIC statistic indicates a better model fit for Model 6 than any of the previous models developed from the demographic model.

The second set of analyses, represented by Model 7 and Model 8, examines cross-level interactions and behavior modifications. In the first interaction model (Model 7), the main effects for Gini coefficient indicate that income inequality affects obesity negatively

in the reference income category and reference education category. The coefficients for the interaction variables indicate how income inequality affects outcome for each of the specific income and education category, relative to the Gini effect for the reference group. However, none of the interaction effect set is statistically significant. The final model, Model 8, adds two behavior variables (smoking and alcohol consumption) which are more proximate to the outcome than the social determinants. However, the inclusion of cross-level interactions and behaviors variables does not improve model goodness-of-fit based on BIC statistics from Model 6.

The best model is Model 6, based on the comparison of BIC statistics and predictors' contribution to the outcome. The coefficients from Model 6 suggested that, at the individual-level, sex differentials on obesity are not significant. As people age, the odds ratio of being obese increased in a non-linear pattern. With each unit of increase in age, the risk is 12.3% times higher, significant at the 0.001 level. But the increase declines at the rate of 0.1 percent every year older over the life course (OR=0.999, $p<0.001$), representing a curvilinear and concave age effects. Being married increase one's risk for obesity by 21.7%, compared with the single (OR=1.217, $p<.001$). Compared with other provinces, residents in Jiangsu Province had over twice the risk of developing obesity while the residents in Guangxi had half the risk; both were significant at the 0.001 level.

Hypothesis 1 (the education hypothesis) is supported. High educational attainment is associated with a 27.5% reduction in the risk of obesity. The effect of intermediate education is not significant. Having a manual occupation reduces the risk of obesity by 28%. The other two occupational categories, namely the professional occupation group and the service occupation group, are associated with slightly lower odds ratios of being obese compared with the reference group, but the associations are not statistically significant. Such findings for occupational effects on obesity support Hypothesis 2 (the occupation hypothesis) that the risk of obesity for a Chinese adult is higher among the manual occupation category than other occupation categories after controlling for covariates at the individual and contextual-level.

There is an increased risk of obesity for individuals with higher income and more wealth, supporting Hypothesis 3 (the absolute income hypothesis). The risk of obesity for those in the fourth wealth quintile is 1.448 times as high as the reference group (bottom quintile), and those on the top wealth quintile's odds ratio is 1.457 times as high as the reference group; both are significant at the 0.001 level. The middle income category has 1.249 times higher risk of obesity, significant at the 0.5 level. Likewise, the risk of obesity for those in the fourth income quintile is 1.307 times as high as the reference group (bottom quintile), and those on the top wealth quintile's odds ratio is 1.363 times as high as the reference group; both are significant at the 0.001 level.

In addition, at the individual level, the relative income's effect on obesity seems to be minimal. The odds ratio for Deaton's RDI is not statistically related to the outcome, neither in bivariate or multivariate analysis. Not only Deaton's RDI, but also the other three measures of the relative income are irrelevant for the outcome in all models. Therefore, Hypothesis 4 (the relative income hypothesis) is not supported.

As we examine Hypothesis 5 (the community SES hypothesis), results are mixed. Each 1000 yuan increase in community mean income is linked with 1% lower obesity risk, and each additional year more of community average education results in 5% lower

obesity risk. However, only community mean education is statistically significant at the 0.5 level. A higher level of urbanization showed by larger urbanicity index score increases one's risk of obesity. The rural or urban community effect is not significant statistically.

Strong evidence supports the inverse inequality-obesity link. Overall, the results show that area-level income inequality have an independent effect on obesity over and above the effects of individual income, wealth and individual-level relative deprivation. The effect of the macro-level income inequality on the risk of obesity for a Chinese adult is significant at the 0.001 level, regardless of how the individual-level absolute income or the relative income is measured. Specifically, with each 1% increase in Gini coefficient (i.e. from an egalitarian income distribution to total income being concentrated by one individual), the odds ratio of being obese is decreased by 7%. However, the results are opposite to my Hypothesis 6 (the income inequality hypothesis).

No significant cross-level interaction effect is found in either Model 7 or Model 8, regardless of the measurement of the absolute income, relative deprivation, and the interaction terms. Income inequality effect on obesity does not favor any income subgroup (for example, the higher quintile individual income group) over the reference group (such as the lowest absolute income quintile group). Therefore, there is no support for Hypothesis 7 or Hypothesis 8 (cross-level interaction hypothesis).

Discussions and Conclusion

Individual-level SES and Obesity

The results show a strong positive association between individual income/household wealth and obesity: with increase in income and wealth, the risk of obesity is increased¹. When the relative income and income inequality are added into the model, the effect of the individual-level absolute income is still robust, and the direction of association between the absolute income and the obesity outcome is still positive. The trend is consistent in all models, both bivariate and multivariate, suggesting that a substantial part of the SES-obesity association can be attributed to the non-linear association between individual income and obesity, and the association between wealth and obesity. The association is not simply linear, in line with previous studies on the concave effects of income on health. The steepest relation between income and obesity is observed at higher levels of income: adults of the top two quintiles or top 40% of the income/wealth distribution are at significantly higher risk of obesity. The curve becomes flatter at lower ends of income and wealth. Besides individual income, other two dimensions of individual-level SES also had effects on obesity. A high level of educational attainment of 12 years or more, such as college education, is associated with significant lower risk of obesity. A manual occupation is a further protective factor against obesity. Manual occupations, compared with other occupation categories such as professional occupation and service occupation, predicted a lower risk of obesity for

¹ In sensitivity analyses, there are three different measures for the absolute income: (1) absolute income measured by equivalence scale adjusted household income in 1000 *yuan* and its quadratic term; (2) logarithmically transformed absolute income; (3) absolute income quintiles. Results show that the different measures are not influential cases. Therefore, I present the income quintiles.

adults in my sample and the association is significant at the 0.001 level. The results are consistent from Model 2 through Model 6.

Earlier studies found inverse relations between individual- or area-level SES measures and obesity industrialized societies. Developing countries, however, usually display an opposite trend. McLaren's extensive review of literature found the inverse SES-obesity association for both men and women became increasing positive from developed countries to developing countries. As for the importance of different SES indicators, in highly developed countries, the inverse SES-obesity association is most common with education and occupation, whereas in developing countries, income and material possessions are positively related to higher BMI (McLaren 2007). In the Western societies, extensive evidence reported that a lower educational level is often associated with a higher prevalence of overweight and obesity, while the developing countries present an opposite trend (Roskam et al. 2010).

The findings presented here are consistent with the positive income/wealth-obesity association found in most developing countries, but inconsistent with the inverse education-obesity association in less developed countries. Rather, like many developed countries, the well-known phenomenon of inverse educational gradients in health (the higher education achievements, the better health status) is found consistent for the case of obesity in China: the higher education achievements, the lower obesity prevalence in the Chinese adults, probably due to the healthy lifestyle of the well-educated people. In fact, within the on-going trends of nutrition transition, the highly educated in China are equipped with relatively high health literacy and tend to keep a more health-conscious diet and lifestyle. Therefore, a higher level of education is protective against obesity and a high BMI.

Such mixed results on income and education on obesity seem to be surprising in a society where income/wealth and education are highly related. However, in the context of China's economic reform and social institutions, educational attainment and income/wealth do not necessarily stay on the same page. One may be rich but without high education, and another may be well-educated but only have a moderate level of income. In addition, at the population level, the majority of Chinese adults have less than nine years of education. Therefore, a substantial part of the SES-obesity association can be explained to the non-linear association between individual income and obesity, rather than education dimension of SES. The occupation-obesity link is consistent with Ng et al's occupation-related physical activity argument of obesity (Ng, Norton, and Popkin 2009). The nature of manual work is related to intensive physical activity, compared with that of professional and service workers. Hence underlying China's obesity story, it is not a simple SES-obesity association, but a combination of income, wealth, education and occupation.

Community-level SES and Obesity

Our findings of the community SES effects on obesity in China do not follow a single pattern. At the community-level, slightly lower odds of obesity are found in a community with higher average education attainment. However, a higher level of urbanization (i.e. higher urbanicity index score) increases one's risk of obesity. The rural or urban community effect on obesity is not significant statistically, but obesity prevalence is higher in urban than in rural areas. Compared with Western studies, the

inverse association between obesity and community-level SES assessed by average education is consistent.

Three studies have examined the relationship between SES and overweight/obesity using multilevel analyses approach, all supporting the increased community deprivation-higher risk of obesity association (King et al. 2005; Robert and Reither 2004; Sundquist, Malmström, and Johansson 1999). Compared with these studies, China's pattern is similar to the reverse SES-obesity association. However, compared with studies in the developing world, such as India, where average levels of state economic development were strongly associated with degrees of overnutrition and obesity (Subramanian, Kawachi, and Smith 2007), China's case is similar in that higher urbanization level is positively related to obesity risk. The fact that higher urbanicity score's positive association with obesity suggest that China is still a developing country. The coexistence of supportive and inconsistent evidence shows the complexity of community SES effect on obesity in China.

The Relative Income and Obesity

This study shows no evidence on the association between relative deprivation and obesity. To thoroughly assess the hypothesis, four different measures (Yitzhaki's RDA, Deaton's RDI, log difference relative deprivation, income percentile rank) of the relative income are included one at a time, respectively to three different measures of the absolute income. The results are that lower levels of relative deprivation (larger values of Yitzhaki's RDA, smaller Deaton's RDI, log difference relative deprivation, or higher community income percentile rank) would increase the risk of obesity. However, after controlling for the absolute income and wealth, none of the measures of relative deprivation has significant effects on obesity. These findings are consistent with a previous study on self-reported health status of Chinese adults using 1993 CHNS data (Li and Zhu 2006). However, it is different from a previous study of mortality using 1988-1991 National Health Interview Survey, where researchers found Yitzhaki's measure of relative deprivation is associated with higher body mass index besides other health risks (Eibner and Evans 2005).

One possible interpretation could be that the relative income at the individual-level is less relevant in the mechanism paths than the absolute income. It is quite possible that the effects of the relative income are already explained by the absolute income at the individual-level and income inequality at the community-level. The three measures of the relative income—Yitzhaki, Deaton's and the log difference measure of relative deprivation- have two basic similarities. First, all of them are convex functions of individual income that decline with the increase of one's income, holding the income distribution constant; second, all of them increased with the increase in income inequality, holding constant one's income and the mean reference group income (Reagan, Salsberry, and Olsen 2007). The association between the relative income and obesity, if any, could simply be a statistical correlation, rather than a causal link. The relative income is, at best, a very weak predictor of obesity. Now that the effects of the relative income on health and on obesity are not convincing, the effect of income inequality affecting individual health seemed to be more important.

Income Inequality and Obesity

We use multilevel data to study the effect of income inequality with the presence of absolute income and relative deprivation. A major observation from the study is that,

after controlling for individual income and wealth, as well as community-level income, there is an independent effect of income inequality on obesity². The magnitude of the association between Gini coefficient and obesity is quite sizable, and the direction is opposite to that of the individual income. This is against my hypothesis that a higher Gini coefficient is associated with increased obesity risk, which is based on findings reported in most developed countries in the U.S. (Robert and Reither 2004), Europe (Pickett et al. 2005), OECD countries (Su, Esqueda, Li, and Pagan 2012) and India (Subramanian, Kawachi, and Smith 2007).

The results agree with a recent study that there is an inverse association between community Gini coefficient and nutritional intake among Chinese residents (Ling 2009). Ling found that community-Gini coefficient had a significant and negative impact on the probability of being overweight for the whole sample of CHNS 1989-2004 (Ling 2009). However, Ling's study was inconclusive since she found significant, positive Gini effect on the waist circumference and significant, negative Gini effect on being overweight and insignificant Gini effect on obesity our results are inconsistent with one based on rural sample of CHNS 1989-2000 (Chen and Meltzer 2008). Of note, both Ling and Chen and Meltzer's studies used an average of 20 houses in a community for generating the community income inequality, which was not appropriate and not a good assessment of societal inequality. There is very limited study on China using quality data to show income inequality effects on obesity. Even though it might be tricky to differentiate the effect of income inequality among provinces where the Gini coefficients are relatively high, this study is the first to find strong negative effect of inequality on obesity.

Bringing back the international literature, the strong and negative effect of income inequality on obesity, first observed in China, is obviously contradictory to the positive correlation between income inequality and obesity prevalence observed in OECD countries (Su, Esqueda, Li, and Pagan 2012). This finding adds to major debates over the income inequality hypothesis on obesity in particular, and on health in general. So far, current knowledge is inconclusive on the health effect of income inequality (Gerdtham and Johannesson 2004). Although many studies by Wilkinson and colleagues (1992, 1996, 1997, 1998, 2002, 2006, and 2009) reported the detrimental inequality effect on health in the OECD countries, results of income inequality and mortality, morbidity and self-reported health status elsewhere are still mixed (Subramanian and Kawachi 2004). It is possible that the positive association between income inequality and poor health reported by Wilkinson and colleagues only work for the more developed countries, but not for the developing countries. Ideally, a convincing answer to the income inequality hypothesis would depend on a combination of quality data, sophisticated analytical

² Is the change in BMI and obesity over the past years (between 1989 and 2006) highly related to inequality rather than the characteristics of the provinces? I further examined the obesity prevalence and mean BMI by province in 1989, and compared the results with those in 2006. In 1989, the income inequality in China was lower and the regional differences were smaller than those in 2006. In 1989, obesity prevalence in each province was much lower than that in 2006, and the provincial difference in the obesity prevalence were much smaller. The Pearson correlation between the change of obesity prevalence and Gini coefficient in 2006 was -0.43 ($p < 0.001$). Similarly, the mean BMI in each province was lower than that in 2006, and the provincial difference in the mean BMI was smaller. The Pearson correlation between the change of mean BMI and Gini coefficient in 2006 was -0.21 ($p < 0.001$). Hence, inequality, rather than fixed characteristics of the provinces, is highly related to the change in BMI and obesity over the years.

methods, and rigorous application of theory and mechanism (Subramanian and Kawachi 2004). The negative association between Gini coefficients and obesity which is observed in China warrants further investigation of the income inequality thesis.

Patterns and Explanations

China has undergone profound economic and social changes during the past two decades. Those specifically related with health outcomes are China's urbanization and nutritional transition (Popkin et al. 1993; Popkin 2001). An alarming inequality in China has been reported. The World Bank reported that the Gini index in China went up by 2.0 percent a year between 1990 and 2001. In 2005, the Gini index in China reached an alarming point at 41.5, which was much higher than that in developed countries and most developing countries (World Bank 2005).

This study has found pervasive patterns suggesting incremental income and wealth gradients for the obesity outcome but an inverse education–obesity association among Chinese adults at the individual-level. At the aggregate-level, the less deprived communities (in terms of mean income and mean education) have a slightly inverse association with obesity. Perhaps most notably of all, the income inequality is inversely associated with obesity; the direction of association is opposite to previous studies reported in more developed countries. Individual level income is an important SES marker for obesity, but the relative income is immaterial for obesity. Very similar patterns are observed for the BMI outcome. Such patterns of social determinants influencing obesity are unique to China, compared with the developing and developed countries' patterns reviewed.

When we bring back the literature, obesity is more prevalent in the lower socioeconomic classes in the Western world (Chang and Christakis 2005; McLaren 2007; Mokdad et al. 2001; Robert and Reither 2004; Schoenborn et al. 2004; Sobal and Stunkard 1989). For example, using NHANES data in recent decades, researchers have shown that low-SES groups in the U.S. were at an increased risk of obesity (Wang and Beydoun 2007). In the non-Western world, obesity is more prevalent in the higher socioeconomic classes. Further, cross-national evidence shows there is a varying relation of SES with obesity between countries at different stages of development (McLaren 2007). As income inequality effect on obesity is mainly examined in the Western nations, most studies have observed an inverse association while more egalitarian countries have observed a null association. This is the background in our examination of socioeconomic gradients in obesity.

Examining China's patterns described above against the literature, we may realize that the patterns tell us that China is a developing country in transition; hence some dimensions of socioeconomic disparities in obesity resemble that of the West (such as the education-obesity link), some dimensions follow the pattern observed in the less developed nations (such as the income-obesity link), while a few patterns (such as inequality-obesity link) exist in their own right. The heterogeneous patterns of socioeconomic gradients with respect to obesity are accompanied by the dynamic social processes characterized by economic development, deepening inequality, urbanization and nutrition transition in China. This study shows that it is higher income rather than other dimensions of SES that is the strongest predictor of obesity.

Mechanisms through which income may positively influence obesity have been proposed. For example, as China continues to become a global economic power, more and more people are involved in the nutrition transition characterized by a shift toward an unhealthy diet of higher fat and calories and increased inactivity at work or leisure (Du, Lu, Zhai, and Popkin 2002). In the transition, peoples' daily diets rely more on animal food sources, and their lifestyles are increasingly sedentary, with less physical activity. As previous studies found, those in the higher SES rank were more susceptible to diet transition. Higher income might be related to higher quality food, moreover, it could also be linked with excessive consumption of higher calories and fat condensed food (such as animal foods and processed food) (Du, Mroz, Zhai, and Popkin 2004). In addition, high income people were at increased risk of snacking and shifting away from traditional healthy cooking patterns to less healthy cooking patterns and less healthy food (Wang et al. 2008). Hence people with higher income and more wealth may increase their risk of obesity. Likewise, China's massive urbanization process has transformed the job functions and dramatically reduced occupation-related physical activity (Ng, Norton, and Popkin 2009). While the professionals and service workers do not differ significantly in their risk of obesity, manual workers have more intensive levels of physical activity which prevents them from being obese. However, high educational attainment modifies the effects exerted by income and education. This is similar to the protective effects of education on general health, and the interpretation may be that people with higher educational attainment have more resources for a healthy lifestyle which prevents them from being obese. It is consistent with a previous study which found education could influence obesity through its association with health literacy which translates into healthy behaviors (Sobal 1991).

The most consistent finding in model building is that income and education have independent effects for one's obesity risk: income tends to be a risk factor for obesity, whereas education tends to be protective against obesity. Such a pattern, although quite different from what was observed in developed countries, was reported in a previous study on the Brazilian adult population. Researchers studied cross-sectional randomly selected samples of the adult population (>20 years) living in a more developed vs. a less developed regions of Brazil. While income was positively associated with the Brazilian adults' risk of obesity for both sexes and both regions, education was slightly inversely associated with obesity for men in a developed region, and strongly inversely associated with obesity for women in both regions (Monteiro et al. 2001). In this study, we observed a very similar pattern in China. This could suggest that in societies in transition, income-obesity gradients remain that of a typical developing country's pattern, whereas education-obesity gradients have shifted to that of a typical developed country's pattern.

Compared with other provinces, residents in Jiangsu Province had over twice the risk of developing obesity, while the residents in Guangxi had half the risk; both were significant at the 0.001 level. This result indicated a less-known pattern of regional disparities on one's risk of obesity independent from SES or inequality. The explanations might be found in the energy intake and physical activity patterns related with cultural factors and even ethnicity. Previous studies have suggested some geographical and cultural factors which were independent from the socioeconomic and inequality factors, but these factors may interfere with obesity outcome. For example, according to a study on how a vegetable-rich food pattern was related to obesity in China, Shi et al. claimed

that Jiangsu people were at a higher risk of obesity due to excessive intake of energy from their cooking preferences. Jiangsu people's diet included generous portions of vegetables and fruits, but they had a high intake of energy due their cooking methods, namely a generous use of oil for stir-frying vegetables (Shi et al. 2008). This cooking preference might be due to local cultural reasons. In addition, Jiangsu people may have a relatively higher or excessive intake of sugar in daily cooking and sweet fruits. Compared with other eight provinces with majority Han people, Guangxi Autonomous Region is multi-ethnic. There are considerable numbers of ethnic groups in Guangxi, including the largest groups of the Zhuang, followed by Han, Yao, Miao, Dong, and other 25 smaller ones³. According to a comparative study of obesity in the Han ethnic group and the minor ethnic group, there are ethnic differences in overweight and obesity between the Han and minority ethnic groups, and a lower prevalence existed in minor ethnic group (Zhang et al. 2009). Specifically, in a regional study using data collected in Guangxi in 2003-2005 and comparing obesity rates among the Han and the Zhuang ethnic group in Guangxi, it was found that the Han were significantly higher than the Zhuang in adults in being overweight and obese, and in central obesity rates (Li 2011). In this study, the significantly lower risk of obesity in Guangxi adults might be due to the ethnic composition in Guangxi and the fact that the minor ethnic groups had lower obesity prevalence. These are social conditions beyond SES or inequality that should be considered when comparing regional obesity disparities.

Of note, the Gini coefficient is strongly and inversely associated with BMI and obesity. Even when individual income and relative income were included in the regression, income inequality was still significantly related to obesity. The effect is consistent throughout the additive models, so it indeed is worthy of attention and needs further investigation. The association shows inverse pattern, opposite to what was observed in literature of European countries, OECD countries, and the U.S. This unique finding in China may indicate that the inequality may be much higher and more variable in China than in the developed countries, and it is possible that this is the reason that we observed a significant negative association between income inequality and obesity in this study. It is probably through psychosocial pathways that a high income inequality undermines social capital and increases stress that causes general health issues but prevents people from weight gain.

Finally, both individual-level and community-level socioeconomic factors make an independent contribution to the odds of being obese in China. Different dimensions of SES have independent, albeit unequal effects on obesity. The pattern is consistent regardless of the macro-level inequality. Meanwhile, the inverse association between Gini coefficients and obesity risk warrants further investigation.

Strengths and Limitations

The study has several strengths. First, it considered a non-Western country on income and inequality effects on obesity, while such studies are rather scant. A few studies of the income and inequality effects on self-reported health in Argentina (Fernando 2008), China (Chen, Yang, and Liu 2010; Li and Zhu 2006) and India (Subramanian, Kawachi, and Smith 2007) reported mixed, even opposite findings with those in the industrial societies. This study adds up to the complexity of the ongoing

³ <http://www.china.org.cn/e-xibu/2JI/3JI/guanxi/guangxi-ban.htm>

debate of the health effects from SES and inequality, especially in the developing world. The associations between obesity and SES, as well as between obesity and inequality in China will shed new light on the literature of health inequalities.

Second, the study targets the gap in the literature and considers both individual- and community- effects on the risk of obesity. Among the published studies based on data collected in the non-Western countries, multilevel studies on the macro-micro effects on health are very limited. The community SES is not often considered in health studies of developing societies, probably due to data limitations. Thus, a systematic examination of the income hypotheses in developing societies becomes very difficult. In this study, the income-related hypotheses are evaluated at multiple levels, and also investigated for potential cross-level interactions.

Third, the study uses different approaches to evaluate a hypothesis. The absolute income and the relative income hypotheses are examined whether they are sensitive to different measures used. This study shows that different measures of the absolute income and the relative income do not affect the patterns of association presented, suggesting that the results are not by chance, but very reliable.

In addition, with full awareness of the difficulty to obtain the quality data, we calculated provincial Gini coefficients from the national representative data from the same year CGSS 2006. This approach has never been done before, but it is very useful to properly assess the associations between the area-level income inequality and health outcomes. Wilkinson and Pickett (2006) strongly argued against the testing of the income inequality hypothesis when income inequality is measured in relatively small areas (such as communities), as communities are too small to reflect the scale of unequal income distribution in a society. Rather, states, larger regions are more proper geographic units. This issue is well-taken in this study. Besides, the cross-sectional analysis presented in this study is based on the data collected in 2006. The pattern of the association between SES and obesity and inequality and obesity found in this study can be applicable to the current situation.

This study, however, is subject to several limitations. First, this single-year, cross-sectional study prevented it from evaluating any causal inferences, the directionality of associations or the time lag effects. For example, previous studies indicate that the direction of the association between the individual-level SES, inequality and obesity could also be bi-directional, as found in the U.S. (Pan American Health Organization (PAHO) 2000; Wang and Beydoun 2007). The exposure to income inequality affects mortality risk in later years (Lynch et al. 2004b; Subramanian and Kawachi 2006). Although this paper has observed effects of SES and inequality on obesity, this cross-sectional design does not provide convincing answers for questions on directionality, causal and time lag effects which are interesting topics for further research in the area. Plausible answers will only be possible by analyzing quality longitudinal data through conceptually sound mechanisms.

Second, while the sample size is sufficient to draw inferences for the population of individual and communities, caution should be taken about drawing extensive inferences, because CHNS is not a nationally representative sample of the whole Chinese population but only representing the nine provinces. Provinces surveyed in CHNS have a more compact income distribution than national income distribution (Chen and Meltzer 2008); therefore, the results could not be inferred to other parts of the country that were

not part of the survey. A related issue of the data quality is the confidentiality restrictions of geographic identifiers: although CHNS is widely regarded as one of the best available datasets on China, the smallest geographic unit identifiable is province, not county or neighborhoods that are held confidential. Therefore, it is not possible to match county-level inequality data from the CGSS with county-level CHNS data.

In summary, this study considered both traditions in social studies of health, and investigated the relationship between socioeconomic disparities, income inequality and obesity among Chinese adults, using an explicitly multilevel analytical framework. The study has systematically examined whether the link between the absolute income, relevant income, income inequality and obesity exist at individual- and community-level, as shown by key hypotheses in health inequality. The study has found strong evidence supporting the effects of the absolute income and income inequality on obesity, although the direction of association is opposite to most studies on self-reported health status. The effect of relative deprivation on obesity is not well supported by my sample. This study suggested the necessity to test the income inequality hypothesis on obesity in non-Western countries including China, which is more unequal than most developed countries.

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Table 1 Definition of study variables, CHNS 2006

Variables	Definition
Dependent Variables	
BMI	Body mass index derived from weight (in kilograms) by height (in meters) squared
Obesity	1 if BMI is equal or larger than 25 kg/m ² , 0 if otherwise
Independent Variables	
<i>Individual level</i>	
Female	1 if gender is female, 0 if gender is male
Age	The sample's age is restricted to 18 years and older
Age Squared	a squared term of one's age
Marital Status	1 if married , 0 otherwise
Smoking	1 if ever smoked , 0 if otherwise
Alcohol	1 if one consume alcoholic drinks, 0 if never drinking
Consumption	
Educational Attainment	
Low	1 if one has no formal schooling or up to 6 years of education, 0 otherwise
Intermediate	1 if one's highest level of education is 7 to 12 years , 0 otherwise
High	1 if one's highest level of education is over 12 years , 0 otherwise
Work Status	1 if currently working; 0 if otherwise
Occupation	
Professional	1 if one's occupation belongs to a category of officers, administrators, and cadres
Manual	1 if one's occupation belongs to a category of farmers, fishers, hunters, soldiers, and laborers
Service	1 if one's occupation belongs to a category of cooking, driving, and housekeeping
Wealth Index	Household wealth index based on wealth and asset questions.
Individual Income	Equalized household income derived from net household income (in 1000 <i>yuan</i>)
Relative Income	Deaton's Relative Deprivation Index
<i>Community level</i>	
Mean Income	Community mean income (in 1000 <i>yuan</i>)
Mean Education	Community mean education in years
Urbanicity Index	An index made from 12 dimensions to reflect the community urbanicity level
Urban Indicator	1 if the community is urban, 0 otherwise
Gini Coefficient	Provincial Gini coefficient based on the CGSS 2006
Jiangsu	1 if the community is located in Jiangsu Province, 0 otherwise
Guangxi	1 if the community is located in Guangxi Province, 0 otherwise

Table 2 Modeling sequence and descriptions

Mode		
1	Description	Added Variables
0	Null model	intercept only
	Demographic	
1	model	age, age ² , female, marital status
2	SES effects	education, occupation, income, wealth
	Relative income	
3	effect	Deaton's RDI
4	Community SES	Community mean income, mean education, urbanicity
	effect	score, urban indicator
5	Inequality effect	Gini coefficient
6	Regional effect	Jiangsu indicator, Guangxi indicator
7	Interaction effects	Gini x education, Gini x income
	Behavior	
8	modification	Smoking, alcohol consumption

Table 3 Descriptive statistics for all variables in the analysis (N=9,586)

Variables	Mean	SD	Min	Max
<i>Dependent Variable</i>				
BMI	23.35	3.63	15	40
Obesity (Yes=1)	0.26	0.44	0	1
<i>Independent Variables, individual-level</i>				
Female	0.52	0.50	0	1
Age	49.34	15.29	18	97
Marital status (Married=1)	0.83	0.37	0	1
Work Status (Working=1)	0.59	0.49	0	1
Education	7.42	4.43	0	19
Low (0-6)	0.43	0.49	0	1
Intermediate (7-12)	0.51	0.50	0	1
High (12+)	0.07	0.25	0	1
Occupation				
Professional	0.17	0.37	0	1
Manual	0.63	0.48	0	1
Service	0.20	0.40	0	1
Smoking	0.32	0.47	0	1
Alcohol Consumption	0.31	0.46	0	1
Wealth Index	2.32	1.02	0	5.00
1st Qunitile	0.91	0.36	0	1.37
2nd Qunitile	1.67	0.16	1.38	1.93
3rd Qunitile	2.20	0.16	1.93	2.54
4th Quintile	2.86	0.20	2.54	3.26
5th Qunitile	3.76	0.36	3.26	5.00
Income (in 1000 <i>yuan</i>)	11.92	15.28	-6.44	315.61
1st Qunitile	1.68	1.07	-6.44	3.2
2nd Qunitile	4.74	0.89	3.21	6.34
3rd Qunitile	8.29	1.21	6.34	10.57
4th Quintile	13.55	1.96	10.57	17.33
5th Qunitile	31.35	24.72	17.36	315.61
Deaton's RDI	0.23	0.18	0	1
<i>Independent Variables, community-level</i>				
Mean Income (in 1000 <i>yuan</i>)	11.92	7.52	2.58	55.01
Mean Education (in years)	7.43	2.17	2.24	13.64
Urbanicity Index	64.43	20.40	27.22	101.6
Urban Community (Urban=1)	0.31	0.46	0	1
Gini Coefficient * 100	47.30	7.02	38.63	59.61
Jiangsu	0.11	0.32	0	1
Guangxi	0.12	0.33	0	1

Table 4 Descriptive statistics of characteristics for obese vs. non-obese people in China (N=9,586).

Variable	Mean and SD				t-Statistic
	Obese	SD	Non-Obese	SD	
Individual-level (Level-1) Variables					
Socio-demographic background					
Female	0.53	0.50	0.52	0.50	-1.28
Age	51.25	13.49	48.65	15.83	-7.34***
Marital status (Married=1)	0.88	0.32	0.82	0.39	-8.04***
Behavior Control					
Smoking	0.29	0.45	0.33	0.47	3.46***
Alcohol Consumption	0.74	1.16	0.75	1.16	0.02
SES					
Education	7.37	4.38	7.45	4.45	0.79
Low Education (0-6)	0.44	0.50	0.42	0.49	-0.98
Intermediate Education (7-12)	0.51	0.50	0.51	0.50	0.10
High Education (12+)	0.06	0.24	0.07	0.25	1.76*
Work Status (Currently working=1)	0.53	0.50	0.62	0.49	7.59**
Occupation					
professional	0.10	0.30	0.10	0.30	-0.22
Manual	0.31	0.46	0.40	0.49	8.24**
Service	0.12	0.33	0.12	0.32	-0.60
Wealth Index					
1st Quintile	0.15	0.35	0.20	0.40	6.03**
2nd Quintile	0.18	0.38	0.20	0.40	1.82*
3rd Quintile	0.19	0.39	0.20	0.40	1.70
4th Quintile	0.22	0.41	0.18	0.38	-4.39**
5th Quintile	0.25	0.44	0.20	0.40	-5.58**
Income (in 1000 yuan)					
1st Quintile	0.18	0.38	0.21	0.41	3.43**
2nd Quintile	0.18	0.38	0.21	0.41	3.58**
3rd Quintile	0.20	0.42	0.20	0.39	0.36
4th Quintile	0.23	0.42	0.19	0.39	-4.13**
5th Quintile	0.22	0.42	0.19	0.39	-3.24**
Relative Income (RDI)	0.23	0.18	0.23	0.17	-0.96
Community-level (Level-2) Variables					
Community Mean Income (in 1000 yuan)	12.78	8.09	11.61	7.28	-6.76**
Community Mean Education (in years)	7.69	2.13	7.33	2.18	-7.21**
Urbanicity Index	67.20	20.03	63.44	20.44	-7.99**
Urban Community (Urban=1)	0.36	0.48	0.30	0.46	-5.66**
Gini Coefficient*100	45.74	7.34	47.86	6.81	13.16**
Jiangsu	0.12	0.33	0.11	0.31	-1.58
Guangxi	0.06	0.23	0.15	0.36	12.271**

Notes: Heteroscedastic *t*-test.

*Significance at 5% level; ** significance at 1% level; *** significance at 0.1% level

Table 5 Mean BMI and prevalence of obesity by categorical socio-demographic characteristics and SES (N=9,586)

Variable	N	Percentage (%)	Mean BMI	Percentage of Obesity (%)
Socio-demographic background				
Gender				
Male	4583	47.81	23.30	25.75
Female	5003	52.19	23.39	26.9
Age (year)				
18-<35	1810	18.88	22.35	15.47
35-<55	4403	45.93	23.70	29.25
55-<70	2361	24.63	23.58	30.16
≥70	1012	10.56	23.03	24.31
Marital Status				
Married	7988	83.34	23.53	27.97
Single	1598	16.66	22.44	18.28
SES				
Education				
Low (0-6)	4095	42.72	23.31	26.86
Intermediate (7-12)	4854	50.64	23.40	26.31
High (12+)	637	6.65	23.13	23.39
Work Status				
Currently Working	5648	0.59	23.12	23.53
Not Working	3938	0.41	23.67	30.46
Occupation				
Professional	942	9.83	23.46	26.65
Manual	3584	37.39	22.97	21.57
Service	1122	11.7	23.32	27.09
Wealth				
1st Quintile	1788	18.99	22.96	20.69
2nd Quintile	1848	19.63	23.15	24.68
3rd Quintile	1910	20.29	23.20	24.82
4th Quintile	1810	19.23	23.69	30.44
5th Quintile	2058	21.86	23.73	31.15
Income				
1st Quintile	1921	20.04	23.00	23.27
2nd Quintile	1915	19.98	23.09	23.13
3rd Quintile	1917	20	23.34	26.03
4th Quintile	1916	19.99	23.65	30.06
5th Quintile	1917	20	23.65	29.26
Urban Residence				
Urban	2987	31.16	23.71	30.13
Rural	6599	68.84	23.18	24.64

Table 6 Gini coefficient, mean BMI and percentage of obesity by CHNS provinces, 2006
(N=9,586)

Province	Gini Coefficient	Mean BMI	SD	Obesity (%)	N
Liaoning	0.3902	24.29	4.15	37.10	1,035
Heilongjiang	0.4002	23.92	3.98	31.42	977
Jiangsu	0.5961	23.42	3.54	28.35	1,076
Shandong	0.3863	24.56	3.44	42.10	1,088
Henan	0.4257	23.86	3.56	25.65	1,080
Hubei	0.4533	23.33	3.35	24.95	942
Hunan	0.5043	22.74	3.34	20.23	1,112
Guangxi	0.5027	21.89	3.04	11.85	1,198
Guizhou	0.5563	22.36	3.32	17.90	1,078

Note: In the following tables that report results from bivariate or multivariate analysis, the Gini coefficient is replaced by the Gini index (i.e. Gini coefficient \times 100) so that interpretation of the result can be based on each unit of change of the Gini index (i.e. each 0.01 change in the Gini coefficient).

Table 7 Bivariate analysis of BMI vs. obesity outcome (N=9,586)

	BMI		Obesity (Yes=1)	
	Coefficient	SE	Odds Ratio	SE
Level-1 Variables:				
Demographic Control				
Female	0.093	0.074	1.061	0.049
Age	0.015***	0.002	1.011***	0.002
Married	1.089***	0.099	1.735***	0.120
Education				
Low (0-6)				
Intermediate (7-12)	0.086	0.077	0.972	0.047
High (12+)	-0.188	0.155	0.831*	0.083
Work Status (ref.=not working)	-0.546***	0.075	0.702***	0.033
Occupation				
Professional	-0.134	0.128	0.860	0.069
Manual	-0.616***	0.079	0.651***	0.033
Service				
Wealth Index				
1st Quintile				
2nd Quintile	0.197	0.117	1.262**	0.098
3rd Quintile	0.251*	0.116	1.271**	0.098
4th Quintile	0.745***	0.118	1.686***	0.128
5th Quintile	0.783***	0.114	1.742***	0.128
Income (in 1000 yuan)				
1st Quintile	0.020***	0.004	1.010***	0.002
2nd Quintile	0.087**	0.117	0.992	0.076
3rd Quintile	0.334***	0.117	1.16*	0.087
4th Quintile	0.643***	0.117	1.417***	0.104
5th Quintile	0.649***	0.117	1.364***	0.101
Relative Income (RDI)	0.211	0.210	0.882	0.116
Behavioral Control				
Smoker	-0.301***	0.080	0.840***	0.043
Alcohol Consumption	0.019	0.032	1.000	0.020
Level-2 Variables:				
Mean Income (in 1000 yuan)	0.030***	0.005	1.020***	0.003
Mean education (in years)	0.141***	0.017	1.079***	0.011
Urbanicity Index	0.014***	0.002	1.009***	0.001
Urban (ref.=Rural)	0.525***	0.080	1.319***	0.065
Gini Coefficient *100	-0.085***	0.005	0.956***	0.003
Jiangsu	-0.157	0.117	0.996	0.072
Guangxi	-1.681***	0.112	0.338***	0.032

Notes: *Significance at 5% level; ** significance at 1% level; *** significance at 0.1% level

Table 8 Estimates from random intercept multilevel models of BMI (N=9,586)

Variables	Model 1		Model 2		Model 3		Model 4	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Fixed effects								
Intercept	18.332***	0.339	18.193***	0.377	18.367***	0.443	18.025***	0.629
Level-1 Variables:								
Demographic Control								
Female	0.086	0.070	-0.002	0.073	-0.002	0.073	-0.005	0.073
Age	0.188***	0.015	0.200***	0.015	0.200***	0.015	0.199***	0.015
Age ²	-0.002***	<0.001	-0.002***	<0.001	-0.002***	<0.001	-0.002***	<0.001
Married	0.364***	0.110	0.368***	0.110	0.371***	0.110	0.374***	0.110
SES								
Education (ref.=0-6)								
Intermediate (7-12)			-0.049	0.090	-0.052	0.090	-0.076	0.092
High (12+)			-0.4408	0.185	-0.442*	0.185	-0.489**	0.189
Work Status (ref.=not working)								
Occupation (ref.= service)			-0.355**	0.128	-0.353**	0.128	-0.346**	0.128
Professional			-0.161	0.168	-0.159	0.168	-0.171	0.169
Manual			-0.343**	0.127	-0.340**	0.127	-0.316**	0.128
Wealth (ref.=1st Q)								
2nd Quintile			0.047	0.126	0.043	0.126	0.031	0.126
3rd Quintile			0.035	0.129	0.027	0.130	0.000	0.131
4th Quintile			0.334**	0.141	0.320**	0.142	0.274*	0.146
5th Quintile			0.349**	0.149	0.329**	0.151	0.275*	0.159
Income (ref.=1st Q)								
2nd Quintile			0.105	0.114	0.147	0.127	0.140	0.136
3rd Quintile			0.367**	0.116	0.440**	0.152	0.429*	0.177
4th Quintile			0.547***	0.121	0.649***	0.182	0.628**	0.222
5th Quintile			0.601***	0.132	0.743***	0.231	0.720**	0.298
Relative Income (RDI)					-0.302	0.404	-0.268	0.518
Behavioral Control								
Smoker								
Alcohol Consumption								
Level-2 Variables:								
Community Characteristics								
Mean Income (in 1000 yuan)							-0.011	0.015
Mean Education (in years)							0.067	0.054
Urbanicity Index							0.000	0.006
Urban (ref.=Rural)							0.106	0.215
Gini Coefficient*100								
Province Indicator								
Jiangsu								
Guangxi								
Cross-level Interaction								
Gini*Low Income (Q2)								
Gini*Middle Income (Q3)								
Gini*High Income (Q4)								
Gini*Top Income (Q5)								
Gini*Middle Education								
Gini*High Education								
Random-effects Parameters								
Random Intercept	1.056	(0.063)	0.979	(0.060)	0.978	(0.060)	0.971	(0.060)
Level-1 Residual	3.417	(0.025)	3.403	(0.025)	3.403	(0.025)	3.403	(0.025)
Model Fit Statistics (BIC)	51,175.360		51,193.960		51,202.570		51,236.030	

Table 8 Estimates from random intercept multilevel models of BMI (N=9,586)
(Cont.)

	Model 5		Model 6		Model 7		Model 8	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Fixed effects								
Intercept	22.516***	0.762	23.930***	0.759	23.681***	0.950	23.948***	0.950
Level-1 Variables:								
Demographic Control								
Female	0.003	0.073	-0.003	0.073	-0.005	0.073	-0.318	0.097
Age	0.198***	0.015	0.197***	0.015	0.197***	0.015	0.203***	0.015
Age ²	-0.002***	<0.001	-0.002***	<0.001	-0.002***	<0.001	-0.002***	<0.001
Married	0.370***	0.110	0.338**	0.110	0.342**	0.110	0.340**	0.110
SES								
Education (ref.=0-6)								
Intermediate (7-12)	-0.070	0.091	-0.067	0.091	0.690	0.531	0.600	0.531
High (12+)	-0.478*	0.188	-0.473*	0.187	0.139	1.053	0.120	1.052
Work Status (ref.=not working)	-0.314*	0.128	-0.274*	0.127	-0.262*	0.127	-0.257*	0.127
Occupation (ref.= service)								
Professional	-0.201	0.168	-0.252	0.167	-0.263	0.167	-0.260	0.167
Manual	-0.3098	0.128	-0.363**	0.127	-0.374**	0.127	-0.376**	0.127
Wealth (ref.=1st Q)								
2nd Quintile	0.034	0.124	0.043	0.122	0.043	0.122	0.032	0.121
3rd Quintile	0.040	0.129	0.039	0.126	0.041	0.126	0.038	0.126
4th Quintile	0.306*	0.144	0.296*	0.140	0.309*	0.140	0.309*	0.140
5th Quintile	0.388*	0.156	0.333*	0.152	0.340*	0.152	0.341*	0.152
Income (ref.=1st Q)								
2nd Quintile	0.133	0.134	0.118	0.132	1.173	0.835	1.082	0.834
3rd Quintile	0.407*	0.172	0.375*	0.166	0.138	0.832	0.127	0.831
4th Quintile	0.612**	0.215	0.547**	0.206	0.050	0.842	0.072	0.841
5th Quintile	0.716*	0.289	0.616*	0.276	-0.297	0.888	-0.288	0.887
Relative Income (RDI)	-0.226	0.499	-0.122	0.474	-0.144	0.474	-0.186	0.473
Behavioral Control								
Smoker							-0.563***	0.100
Alcohol Consumption							0.013	0.037
Level-2 Variables:								
Community Characteristics								
Mean Income (in 1000 yuan)	-0.001	0.014	-0.024*	0.012	-0.024	0.012	-0.023	0.012
Mean education (in years)	-0.089	0.049	-0.053	0.041	-0.056	0.041	-0.060	0.041
Urbanicity Index	0.010*	0.005	0.011*	0.004	0.011*	0.004	0.011*	0.004
Urban (ref.=Rural)	0.165	0.181	0.210	0.151	0.211	0.151	0.199	0.151
Gini Coefficient *100	-0.090***	0.010	-0.120***	0.011	-0.115***	0.016	-0.116	0.016
Province Indicator								
Jiangsu			1.444***	0.231	1.393***	0.232	1.366***	0.232
Guangxi			-1.032***	0.177	-1.020***	0.177	-1.028***	0.177
Cross-level Interaction								
Gini*Low Income (Q2)					-0.016	0.011	-0.014	0.011
Gini*Middle Income (Q3)					-0.013	0.022	-0.013	0.022
Gini*High Income (Q4)					-0.022	0.017	-0.020	0.017
Gini*Top Income (Q5)					0.005	0.017	0.006	0.017
Gini*Middle Education					0.011	0.017	0.011	0.017
Gini*High Education					0.019	0.018	0.020	0.018
Random-effects Parameters								
Random Intercept	0.566	(0.051)	0.566	(0.051)	0.565	(0.051)	0.566	(0.051)
Level-1 Residual	3.404	(0.025)	3.404	(0.025)	3.402	(0.025)	3.396	(0.025)
Model Fit Statistics (BIC)	51173.050		51,110.050		51,157.590		51,143.450	

Notes: Number of observation = 9586; Number of community = 218.
Numbers are coefficients. Random-effects parameters have standard errors in parentheses.
*Significance at 5% level; ** significance at 1% level; *** significance at 0.1% level

Table 9 Odds ratio estimates from random intercept multilevel logistic models of obesity (N=9,586)

Fixed effects	Model 1		Model 2		Model 3		Model 4	
	OR	SE	OR	SE	OR	SE	OR	SE
<i>Level-1 Variables:</i>								
Demographic Control								
Female	1.069***	0.052	1.002	0.051	1.001	0.051	1.000	0.051
Age	1.119***	0.013	1.125***	0.013	1.125***	0.013	1.124***	0.013
Age ²	0.999**	<0.001	0.999***	<0.001	0.999***	<0.001	0.999***	<0.001
Married	1.249	0.102	1.249**	0.102	1.256**	0.103	1.258**	0.103
SES								
Education (ref.=0-6)								
Intermediate (7-12)			0.925	0.058	0.920	0.057	0.911	0.058
High (12+)			0.739*	0.097	0.736*	0.096	0.723*	0.097
Work Status (ref.=not working)			0.893	0.079	0.895	0.079	0.897	0.079
Occupation (ref.= service)								
Professional			0.867	0.100	0.869	0.100	0.868	0.100
Manual			0.732***	0.065	0.738	0.066	0.747***	0.067
Wealth (ref.=1st Q)								
2nd Quintile			1.158	0.105	1.148	0.104	1.139	0.104
3rd Quintile			1.139	0.105	1.122	0.104	1.105	0.104
4th Quintile			1.358**	0.133	1.321**	0.130	1.290*	0.132
5th Quintile			1.415***	0.144	1.361**	0.141	1.321*	0.146
Income (ref.=1st Q)								
2nd Quintile			0.993	0.082	1.064	0.095	1.061	0.102
3rd Quintile			1.165	0.096	1.311**	0.135	1.307*	0.158
4th Quintile			1.322***	0.111	1.558***	0.187	1.548**	0.233
5th Quintile			1.278**	0.117	1.605**	0.241	1.597*	0.322
Relative Income (RDI)					0.607	0.158	0.611	0.212
Behavioral Control								
Smoker								
Alcohol Consumption								
<i>Level-2 Variables:</i>								
Community Characteristics								
Mean Income (in 1000 yuan)							0.996	0.009
Mean education (in years)							1.015	0.033
Urbanicity Index							1.002	0.004
Urban (ref.=Rural)							1.005	0.129
Gini Coefficient *100								
Province Indicator								
Jiangsu								
Guangxi								
Cross-level Interactions								
Gini*Low Income (Q2)								
Gini*Middle Income (Q3)								
Gini*High Income (Q4)								
Gini*Top Income (Q5)								
Gini*Middle Education								
Gini*High Education								
ICC	0.102	(0.012)	0.086	(0.011)	0.084	(0.011)	0.084	(0.011)
Level 2 variance	0.374	(0.002)	0.309	(0.002)	0.304	(0.002)	0.303	(0.002)
Goodness-of-fit (BIC)	10,576.170		10,612.530		10,618.050		10,653.790	

Table 9 Odds ratio estimates from random intercept multilevel logistic models of obesity (N=9,586) (Cont.)

Fixed effects	Model 5		Model 6		Model 7		Model 8	
	OR	SE	OR	SE	OR	SE	OR	SE
<i>Level-1 Variables:</i>								
Demographic Control								
Female	1.005	0.051	1.000	0.051	0.999	0.051	0.822**	0.055
Age	1.124***	0.013	1.123***	0.013	1.124***	0.013	1.129***	0.013
Age ²	0.999***	<0.001	0.999***	<0.001	0.999***	<0.001	0.999***	<0.001
Married	1.252**	0.103	1.217*	0.099	1.222*	0.100	1.218*	0.100
SES								
Education (ref.=0-6)								
Medium Education (7-12)	0.914	0.058	0.918	0.058	1.843	0.647	1.763	0.621
High Education (12+)	0.722*	0.096	0.725*	0.096	0.518	0.367	0.509	0.362
Work Status (ref.=not working)	0.920	0.081	0.948	0.083	0.958	0.084	0.959	0.084
Occupation (ref.=service)								
Professional	0.847	0.097	0.815	0.093	0.806	0.092	0.812	0.093
Manual	0.752***	0.067	0.720***	0.064	0.714***	0.064	0.715***	0.064
Wealth (ref.=1st Q)								
2nd Quintile	1.144	0.102	1.157	0.101	1.156	0.100	1.147	0.100
3rd Quintile	1.135	0.105	1.131	0.101	1.129	0.101	1.128	0.102
4th Quintile	1.320**	0.132	1.307**	0.126	1.319**	0.128	1.319**	0.128
5th Quintile	1.428***	0.155	1.363**	0.143	1.370**	0.143	1.372**	0.144
Income (ref.=1st Q)								
2nd Quintile	1.056	0.100	1.042	0.097	1.168	0.674	1.108	0.640
3rd Quintile	1.285*	0.152	1.249*	0.141	1.011	0.572	0.999	0.566
4th Quintile	1.526**	0.222	1.448**	0.200	0.898	0.506	0.924	0.521
5th Quintile	1.585*	0.309	1.457*	0.269	0.669	0.394	0.689	0.407
Relative Income (RDI)	0.648	0.217	0.702	0.220	0.687	0.215	0.665	0.209
Behavioral Control								
Smoker							0.718***	0.050
Alcohol Consumption							0.993	0.026
<i>Level-2 Variables:</i>								
Community Characteristics								
Mean Income (in 1000 yuan)	1.002	0.008	0.989	0.007	0.989	0.007	0.989	0.007
Mean education (in years)	0.933*	0.028	0.951*	0.023	0.951*	0.023	0.949*	0.024
Urbanicity Index	1.007*	0.003	1.008**	0.003	1.008**	0.003	1.008**	0.003
Urban (ref.=Rural)	1.044	0.114	1.077	0.097	1.081	0.097	1.071	0.097
Gini Coefficient*100	0.951***	0.006	0.932***	0.006	0.933***	0.010	0.932***	0.010
Province Indicator								
Jiangsu			2.493***	0.353	2.414***	0.345	2.391***	0.343
Guangxi			0.496***	0.061	0.502***	0.062	0.498***	0.062
Cross-level Interactions								
Gini*Low Income (Q2)					0.998	0.012	0.999	0.012
Gini*Middle Income (Q3)					1.005	0.012	1.005	0.012
Gini*High Income (Q4)					1.011	0.012	1.010	0.012
Gini*Top Income (Q5)					1.017	0.012	1.017	0.012
Gini*Middle Education					0.985	0.007	0.986	0.007
Gini*High Education					1.008	0.015	1.007	0.015
ICC	0.054	(0.009)	0.025	(0.006)	0.025	(0.006)	0.025	(0.006)
Level 2 variance	0.187	(0.001)	0.085	(0.001)	0.084	(0.001)	0.086	(0.001)
Goodness-of-fit (BIC)	10,600.2		10,532.720		10,579.030		10,572.670	

Notes: Number of observation = 9586; Number of community = 218.

Numbers are odds ratios. ICC and Level 2 variances have standard errors in parentheses.

*Significance at 5% level; ** significance at 1% level; *** significance at 0.1% level

Figure 1 Gini coefficients by province, CHNS 2006

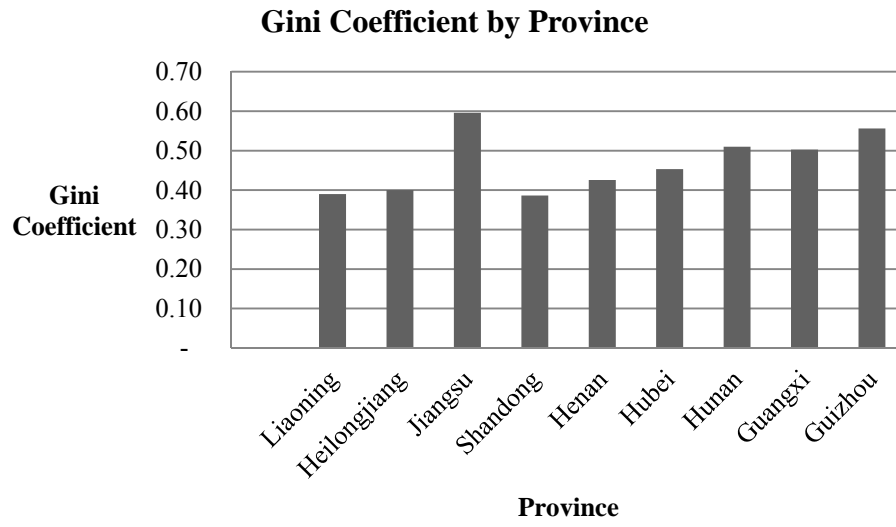


Figure 2: Prevalence of obesity by individual SES, CHNS 2006

