Chapter 14

Multilevel Analysis of Area-based Socioeconomic Environment and Adult Obesity in China

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China's economy has experienced remarkable growth in the past few decades and Chinese people enjoyed significant nutritional improvements at the same time. However, the rate of overweight, obesity and related diseases increased dramatically in past 20 years. Obesity burdens the health care system, strains economic resources, and has far reaching social consequences. Therefore, it is urgent to identify those influencing factors related to obesity, take some measures and make corresponding policies to control the prevalence of obesity. The objective of this study is to identify the impact factors for obesity from different levels, and evaluate whether the relation between area-based socioeconomic environment and obesity can be explained by individual socio-demographic and socioeconomic factors. Multilevel logistic models were used in this paper to calculate the relation between each indicator and obesity. Our findings show that there is a strong relationship between obesity and some of individual socioeconomic factors and living habits, and this relation is mediated by regional characteristics as well. The empirical findings of this paper provide useful insights which can be expected to be of interest to public health sectors and local government in the formulation of health management policies especially on obesity and related chronic diseases.

1. Introduction

With the development of social economy and the improvement of living standard, the rate of overweight, obesity and related disease increased dramatically in past 20 years. According to statistical data of World Health Organization (WHO), there are about 1.73 billion overweight and at least 450 million people categorized as obese in the world in 2010. The rise in overweight and obesity is not only limited to developed countries, but it is also prevalent in developing countries as well.

China's economy has experienced remarkable growth in the past few decades, with annual GDP growth rates averaging 7%- 10% in the period of 1980-2011. At the same time, household incomes increased steadily. Concomitantly with economic growth, Chinese people have also enjoyed significant nutritional improvements. At the same time, some worrying trends have been detected. The numbers of overweight and obese adults and children continue to grow in recent years. As the results of China Nutrition and Health Survey shown, among Chinese adults aged from 18-75 years, the prevalence of overweight has surged from the 14.6% in 1992 to 43.38% in 2009. In the same population, obesity has nearly tripled from approximately 5.2% in 1992 to 14.09% in 2009. It is now estimated that a fifth of overweight and obese individuals in the world are located in China.

In recent years, obesity has been paid much more attention from the whole society. Identifying the risk factors at individual level and regional level are becoming important, since with knowing it, we can guide people to change their unhealthy lifestyle and diet habits to avoid overweight. Meanwhile, at provincial level, local government can make policies and take measures to change related social environment to reduce the prevalence of obesity.

The objective of this paper is to identify the risky factors from both individual level and regional level, and evaluate whether the relation between area-based socioeconomic environment and obesity can be explained by individual socio-demographic, socioeconomic factors and living habits. The remainder of the paper is organized as follows. Section 2 describes the data source we used. Section 3 discusses multilevel analysis model. The estimated models and empirical results are discussed in Section 4. Finally, some concluding remarks are given in the last section.

2. Literature review

Obesity has experienced a ubiquitous increase across demographic and social groups, and the prevalence of obesity has increased across people in all age groups, genders, ethnic groups, educational levels, and geographic regions. There are many studies concerned about the dramatic rising of obesity in all over the world. Manson (2002) suggested that obesity should be paid much more attention since there is the strong relationship between overweight and the development of chronic diseases such as diabetes, cardiovascular disease, osteoarthritis, and some cancers. Sturm (2002) found that the rising obesity rates may even constitute a greater threat to public health than either smoking or problem drinking.

Some literatures revealed that there were two main categories of causes for obesity: individual factors and environmental factors. Individual factors related to obesity included age, gender, marital status, living habits, and social economic status. Philipson and Posner (2003) pointed out that unhealthy lifestyle had negative influences on BMI, for example, people increased reliance on technology in daily life and this promoted weight gain. Drewnowski and Specter (2004) found the highest obesity rates among the poorest and least educated members of industrialized societies. Some studies demonstrated that obesity is increasing fastest in low socio-economic status subpopulations (Monteiro et al., 2004). McLaren (2006) proposed consistent evidence of a negative relationship between obesity and socio-economic status in women. However, some Asian studies present a different picture. Gill (2006) found that the prevalence of obesity in Asia is generally higher in urban areas than in rural areas as well as in higher socio-economic status. Wang's study showed the positive relationship between prevalence of obesity and socio-economic status in China. Yoon (2006) found there was a strong positive relationship between high income and obesity in males, but not in females.

Environmental factors also had significantly impacts on BMI. Several studies found a relation between indicators of area-based socioeconomic environment and the prevalence of obesity. Ross (2000) pointed out that living in disadvantaged regions may affect BMI and obesity in at least two ways. Firstly, poorer regions may lack the resources necessary to support sufficient physical activity and a healthy diet. For example, people who live in deprived regions have less access than people living in wealthier neighborhoods to healthy food such as low-fat milk, high-fiber bread, and fresh fruits and vegetables (Moore, 2006). Lovasi et al. also found that differences in area facilities, such as the availability and price of healthy food and the absence of parks and sports and recreational facilities, may give rise to area differences in dietary intake and physical inactivity. Secondly, disadvantaged regions may present a psychosocial context that encourages obesity. In Crane's (1999) research, social contagion models suggest that people's behavior is influenced by the norms or values of those around them.

Many studies used multilevel approach to analyze the influential factors of BMI from both individual level and regional level. Corsi et al. (2012) used multilevel perspective to investigate the importance of local geographical context on shaping BMI in low and middle income countries, and the results showed that in countries with greater neighborhood variation it is possible that BMI is being influenced by local conditions more than others with lesser neighborhood variation. Matheson (2008) examined the impact of neighborhood material deprivation on gender differences in BMI for urban Canadians, and found that living in neighborhoods with higher material deprivation was associated with higher BMI by using multilevel model. In Chen's study, multilevel models integrated with geographically weighted regressions were employed to analyze the spatially varying association between area disadvantages and obesity, and the results showed the association between township disadvantages and elevated obesity risk in Taiwan was found to be area-specific, and meanwhile township disadvantages elevated obesity level only in certain areas.

3. Methodology

Multilevel statistical models allow for the estimation of contextual effects of higher level factors by accounting for the spatial clustering of individuals within region. On the basis of predictive or generalized quasi-likelihood approximation of a second-order Taylor linearization procedure, Stata 12.0 software package was used to estimate multilevel logistics models.

Since the multistage random cluster process was used in CHNS to collect data, the dependence among observations often comes from several levels of the hierarchy. In this case, the use of single-level statistical models is no longer valid and reasonable. In traditional logistic regression, since the assumptions of it requires: (1) independence of the observations conditional on the explanatory variables; (2) uncorrelated residual errors. In nested dataset, these assumptions cannot always be satisfied. Hence, in order to draw appropriate inferences and conclusions from multistage stratified clustered data we may require tricky and complicated modeling techniques like multilevel modeling. It allows the simultaneous examination of the effects of group level (cluster and division) and individual level variables on individual level outcomes while accounting for the non-independence of observations within groups. Also this analysis allows the examination of both between group and within group variability as well as how group level and individual level variables are related to variability at both levels.

The model is as equation (1), the dependent variable Yij follows a Binomials distribution Yij~ Binomial (1, πij) with conditional variance var (yij |πij), where πij is the probability of presenting the characteristic of interest for individual i of province j :

$$logit(y_{ij}) = \alpha_0 + \sum_{K=1}^{K} \alpha_k X_{kij} + \sum_{H=1}^{H} \alpha_h W_{hj} + \mu_j + e_{ij} \quad (1)$$

Xij is the independent variables at individual level and Wj represents the variables at level 2. The error term divides the unexplained part into two parts, one corresponding to individual level and the other to provincial level. It is assumed that both components of the variance have average zero mean and constant variance. Since the equation of the multilevel logit model represents the logarithm of the probability of presenting the characteristics of interest, the exponential of the parameters of the model may be interpreted in terms of odds ratios.

The modeling strategy consists of sequential model estimation. Model 1 includes only a constant term that will allow calculating ICC and MOR. This intercept-only model predicts the probability of obesity. The function form is equation (2)

$$\ln\left[\frac{p_{kij}}{1-p_{kij}}\right] = \alpha_0 + \mu_{0j} + e_{0ij} \quad (2)$$

Then the individual independent variables, including socio-demographic and socioeconomic factors, are added in model 2 to estimate to probability of obesity. Finally, the factors at provincial level which are the gross domestic product per capita and the proportion of illiterate were introduced into model 3 to test the influence of the characteristics of province on the occurrence of obesity.

4. Data

The data we used is from China Health and Nutrition Survey (CHNS) in 2009. CHNS was conducted by an international team of researchers whose backgrounds include nutrition, public health, economics, sociology, Chinese studies, and demography. This survey was designed to examine the effects of the health, nutrition, and programs implemented by national and local governments and to see how the social and economic transformation of Chinese society is affecting the health and nutritional status of its population.

There are nine provinces covered in this survey. All provinces vary substantially in geography, economic development, public resources, and health indicators. A multistage, random cluster process was used to draw the samples surveyed in each of the provinces. Counties in these nine provinces were stratified by income (low, middle, and high), and a weighted sampling scheme was used to randomly select four counties in each province. In 2009, there were 216 primary sampling units: 36 urban neighborhoods, 36 suburban neighborhoods, 36 towns, and 108 villages. Almost 16000 individuals participate.

In CHNS, all questions that have related to individual activities, lifestyle, health status, marriage and birth history, body shape, and mass media exposure, etc., have been moved to two sets of individual questionnaires: for adults age 18 and older and for children and adolescents under age 18. Adults received detailed physical examinations that included weight, height, arm and head circumference, mid-arm skin-fold measurements, and blood pressure.

In this study, we only used the data set of adults in 2009, and restricted the age of adults between 18 to 65 years old. Retirees, students, and those sick for a long period of time were excluded, leaving a final sample of 7831 respondents from 9 provinces, of these 839 from Liaoning province, 821 from Heilongjiang province, 937 from Jiangsu province, 818 from Shandong province, 762 from Henan province, 792 from Hubei province, 699 from Hunan province, 956 from Guangxi province, and 757 from Guizhou province. From figure1, we see that Shandong and Henan province had higher proportion of obesity and overweight than others, and the lowest ratio of obesity was in Hunan province.

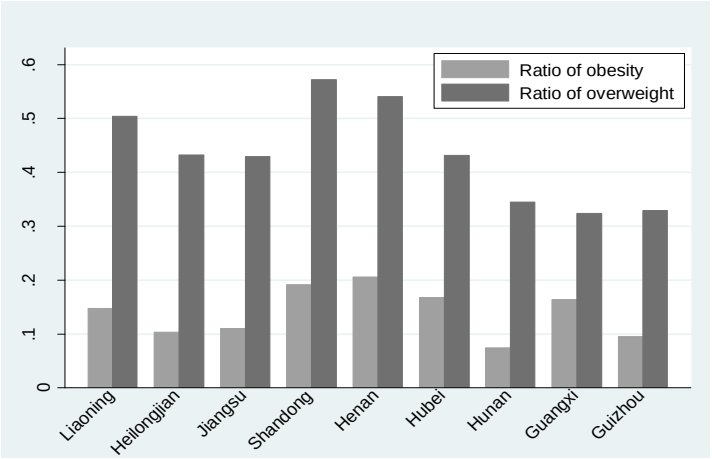

Figure1. Proportion of overweight and obesity in nine provinces

Dependent variables

BMI was chose to estimate the dependent variable obesity, since BMI is a population-based measure which has been found in clinical settings to be a good approximation for assessment of total body fat for a majority of patients (Gallagher et al., 1996). Body Mass index (BMI) was calculated from the respondents' weight (in kilograms) divided by their height in square meters. Usually, according to the standard of WHO, the BMI is classified into four categories, a BMI< 20 kg/m^2 is called underweight, a BMI is at between 20~25 is defined as normal weight, a BMI of ≥ 25kg/m^2 is "overweight", and a BMI of ≥ 30kg/m^2 is defined as "obese". However, some experts proposed that these standards should be revised for Asian populations since lower BMI is associated with increased risk of many chronic diseases, such as high blood pressure, diabetes, apoplexy, myocardial and etc. For Asian population, there are much debate about the most appropriate BMI cutoff points to distinguish normal weight, overweight and obesity. Many researchers tends to reduce the BMI cutoff points for Asian population, thus the true levels of obesity are likely to be higher in most Asian countries. Many researches revealed that those with lower BMI had the same major metabolic morbidities as Americans with higher BMI. On the basis of previous studies and according to the standard proposed by Ministry of Health of P.R China, this paper used a BMI standard value of 28 kg/m2 for obesity. Obesity is classified as binary variable, if BMI value is greater than 28 then obesity is 1, otherwise obesity is 0.

Independent variables

Individual independent variables covered many aspects. Firstly, in the aspect of socio-demographic, age, gender, and marital status were included. Age was continuous variable, and it was centralized. Gender and marital status were binary variables, marital status was measured as currently married (1) vs. others (0).

Secondly, three measures of socioeconomic position were used: educational level, individual income, and employment status. Education was categorized into four levels: primary school or below (reference group), 6~9years of education (middle school), 10~12 years of education (high school and technical school), and over 13 years of education (college, university and above). Annual individual income was classified into 5 levels, with the lowest income as the reference group. The employment status was a binary variable, with unemployment as the reference group.

Thirdly, some unhealthy lifestyle habits, such as smoking, intake of sugared soft drink, less daily fruit and vegetable consumption and physical inactivity, have been shown to be risky factors for obesity. All of these factors were also considered as independent variables. All factors related to lifestyle were binary variable, and the reference individuals are no smoking, no sugared soft drink and no regular exercises.

For the second level, the provincial socioeconomic environment was measured by two indicators. In each of the province: gross domestic product per capita as the indicator of wealth, and the proportion of illiterate population, which were defined as cannot read or write, as the deprivation of each province. Information on these indicators was obtained from China Statistic Year Book 2009.

5. Results

Table1 shows that approximately 72% of respondent were married, with an average age of around 43 years old. As expected, the average BMI is lower among women (22.01 kg/m2) than among men (24.21 kg/m2). More than 60 percent respondents finished 9 years education, and only about 7% respondents finished higher education. Approximately 73% respondents were employed. About 17% respondents earned more than 30000 Yuan per year and among them the proportion of men (21.8%) is higher than of women (11.5%). Women (4.9) have higher frequency of weekly consumption of fruits and vegetables than men (3.6). For those who are smoking, on average, men report smoking 17 cigarettes per day compared with an average of 11.9 for women. More man (60.8%) than women (51.7%) report that they do regular exercise. Compared with men (31.63%), women (40.27%) prefer drinking sugared soft drink. All gender comparisons are statistically significant at the level of 95% except that of marital status, age and region.

TABLE 1: Summary statistics of the variables in the multilevel model, China, 2009. (*n*=7831)

	Gender		
Characteristics	Total	Men	Women
Total	7381	50.96%(3761)	49.06%(3620)
BMI (kg/m^2)	23.1 (3.39)	24.21 (3.32)	22.01 (3.46)
Obesity	14.09% (1037)	14.9% (542)	13.2% (495)
Social demographic variables			
Age	42.86 (14.3)	43.09 (14.18)	42.62 (14.01)
Marital status (married %)	71.9% (5306)	69.8% (2625)	73.9%(2675)
Socioeconomic variables			
Education (%)			
<6 years	39.12% (2,886)	30.67% (1153)	47.89% (1733)
7~9 years	34.24% (2526)	39.53% (1486)	28.74% (1040)
10~12 years	20.21% (1491)	22.32% (839)	18.02 (652)
>13 years	6.44% (475)	7.48% (281)	5.36% (194)
Employment (%)	72.95%(5380)	78.46%(2954)	67.24%(2434)
Annual personal income (%)			
<10000 Yuan	22.6% (1628)	18.51% (696)	25.75% (932)
10000~16000 Yuan	16.83% (1242)	14.6% (549)	19.14% (693)
16000~22000 Yuan	24.86% (1835)	23.05% (867)	26.74% (968)
22000~30000 Yuan	19.77% (1238)	22.04% (716)	17.52% (522)
>30000 Yuan	16.48 % (1437)	21.81% (933)	11.15% (504)
Region (%)			
Urban	32.53% (2401)	32.41% (1219)	32.65% (1182)
Rural	67.47% (4980)	67.59% (2542)	67.35% (2438)

Lifestyle habits			
Regular Exercise	56.3% (4160)	60.8% (2289)	51.7% (1871)
Fruit &Vegetables	4.2 (2.8)	3.6 (2.9)	4.9 (2.6)
Daily cigarettes	16.76 (8.21)	17.05 (9.87)	11.91 (8.2)
Drink sugared soft drink	35.87% (2646)	31.63% (1189)	40.27% (1457)

Note: Standard deviations and *n* in parentheses.

Table 2 summarizes results from the multilevel logit regression model using individual-level obesity as the dependent variable. In model 1 (the empty model), for the reference individual the probability of suffering obesity was 15.6%, assuming that it did not change with the individual or provincial characteristics. From the Model 2, we see that being married and being a male increased the probability of suffering obesity. The level of education appeared negatively related to obesity. Meanwhile, unhealthy lifestyle behaviors also increase the probability of obesity. From Model 3, we can see the association of socioeconomic environment with obesity. People living in the provinces with lower per capita income had an odds ratio for obesity 1.237 times greater than those living in the provinces with higher per capita income. The association between obesity and the indicator based on the percentage of illiterate population had an odds ratio for obesity 1.32 times higher than those with lower proportion of illiterates.

TABLE 2. Odds ratios from the multilevel logistic regressions on obesity

Independent variables	Model 1		Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95% CI
Intercepts	0.156	[0.122, 0.199]	0.218	[0.154, 0.308]	0.215	[0.151, 0.302]
Individual level (Level 1)						
Age			1.003	[0.997, 1.009]	1.001b	[0.994, 1.007]
Gender [Male]						
Female			0.823	[0.696, 0.974]	0.831	[0.719, 0.992]
Marital status [Single]						
Married			1.218	[1.001, 1.439]	1.227	[1.092, 1.519]
Education [<6 years]						
7~9 years			0.930	[0.857, 1.009]	0.921	[0.849, 1.002]
10~12 years			0.826 a	[0.703, 0.981]	0.830a	[0.707, 0.989]
>13 years			0.733	[0.621, 0.903]	0.729	[0.614, 0.911]
Employment [unemployed]			0.933	[0.799, 1.089]	0.926	[0.791, 1.083]
Annual personal income[<10000 Yuan]						
10000~16000 Yuan			1.002 a	[1.002, 1.123]	1.012 a	[1.008, 1.112]
16000~22000 Yuan			0.937	[0.847, 1.016]	0.941	[0.849, 1.011]
22000~30000 Yuan			1.075	[1.019, 1.135]	1.063	[0.873, 1.015]
>30000 Yuan			1.276	[1.102, 1.445]	1.282	[1.081, 1.465]
Region [Rural]			1.43	[1.192, 1.609]	1.39	[1.191, 1.583]

Regular Exercise[No]	0.921	[0.849, 1.008]	0.918	[0.837, 1.006]
Smoking[No]	0.765	[0.639, 0.914]	0.772	[0.649, 0.931]
Drink sugared drink [No]	1.136	[0.983, 1.312]	1.143	[0.989, 1.337]
Provincial variables [Level2]				
Gross domestic product per capita in 2009 [>45000 Yuan]				
29000~45000 Yuan			1.061	[0.912, 1.273]
<29000 Yuan			1.237	[1.051, 1.482]
Proportion of illiterate 2009 (<5%)				
5%~9%			1.09	[0.986, 1.371]
>9%			1.32	[1.173, 1485]

Note: Brackets are reference groups.

a This category is not statistically significant, but it is maintained in the model while it is part of a group.

b This variable is not statistically significant, and it is removed from the model

6. Concluding remarks

Adult obesity is associated with both immediate and long-term health problems (e.g., hypertension, type II diabetes, asthma, myocardial, apoplexy) and psychosocial problems (e.g., social isolation, depression, disordered eating behaviors). Approximately 57% of all diabetes cases, 23% of all ischemic heart disease cases, and 8~41% of certain types of cancers are attributable to being overweight.

Obesity burdens the health care system, strains economic resources, and has far reaching social consequences. Much of the rise in healthcare costs today can be attributed to the increase in chronic diseases such as diabetes, hypertension, pulmonary conditions, and chronic back pain. One major cause is the epidemic rise in obesity rates. Many of today's most commonly prescribed drugs are for obesity-related conditions, and as such, obese individuals spend two to four times more on prescription medications than adults who are non-obese. Annual mortality from coronary heart disease, stroke, and non-communicable diseases to which over-nutrition is a significant contributor, is estimated to reach 800,000 and 3 million respectively by 2030 in China. Therefore, it is crucial for government to identify those risky factors related to obesity at both individual level and provincial level, and then make corresponding policies and take effective measures to reduce the prevalence of obesity.

Our results show a graded association between socioeconomic environment based on indicators reflecting wealth or deprivation and obesity. Through analysis, it can be seen that urban residents and high income population have higher probability of suffering obesity. And those people who do not like doing exercise and prefer smoking and drinking sugared soft drink have higher risk of suffering obesity. Meanwhile, the obesity ratio is also significantly influenced by provincial characteristics. There exists a negative relationship between the probability of obesity and the provincial economic conditions. This result is consistent with various studies in developing countries which have also found that the prevalence of obesity in adults is higher in more disadvantage areas.

There are some limitations of this study should be considered. Some characteristic indicators of province related to obesity, such as the number and distribution of sports facilities, are not included in multilevel model since the data is difficult to obtain. In addition, as we know, socioeconomic environment is unlikely to have an instantaneous effect on obesity. A longitudinal approach, rather than cross-sectional study, would be better alternative to determine the effect, so it will be considered in future research.

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