Community Context and Obesity among Chinese Adults:
A Longitudinal and Multilevel Analysis

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ABSTRACT

Overweight and obesity has posed a public health challenge not only to populations in developed countries but also those in developing countries such as China. Community context has been related to individual overweight and obesity risks in developed countries. It is unclear whether these associations will hold for the Chinese populations. Previous cross-sectional multilevel studies also ignore that community context is not constant, but may change over time. This study addresses these literature gaps by conducting a longitudinal and multilevel analysis of community effects on body weight status among the Chinese adults. Three-level random intercept multinomial regression is used to model the risks of overweight and obesity, taking normal weight as the reference. Preliminary descriptive statistics show an accelerated increase in prevalence of overweight and obese Chinese adults and community context changes that may affect individual weight. The issue of intensive computation will be addressed in next-step analysis.

INTRODUCTION

Overweight and obesity has posed a public health challenge not only to populations in developed countries but also those in developing countries such as China. Data from the 2002 National Nutrition and Health Survey showed that 14.7% of the Chinese population were overweight (body mass index (BMI) >= 25 kg/m^2) and another 2.6% were obese, increased by 38.6% and 80.6% respectively compared to that in 1992 (Wang 2005). Among the Chinese adults aged 18 years or older, the prevalence of overweight (18.9%) and obesity (2.9%) is even higher (Wang 2005). The relatively lower prevalence of overweight and obesity as compared that in developed countries such as the U.S. can be translated into huge numbers of the overweight and obese Chinese adults (245.7 and 37.7 million respectively) given China's total population (Wu 2006). More importantly, the prevalence of overweight and obese Chinese populations is increasing at a rapid pace with a tendency to catch up with that among populations in developed countries (Ma et al. 2002).

Community context has been associated with individual body weight status, including birth weight (Cerdá, Buka, and Rich-Edwards 2008; Morenoff 2003; Schempf, Strobino, and O'Campo 2009), being overweight or obese among children (Richards and Smith 2007) and adults (Chang 2006; Frank et al. 2007), and abonormal weight gain (Kahn et al. 1998). The bulk of this research focuses on developed countries. Therefore, it is unclear whether the community-level risk factors of overweight and obesity may operate in similar ways in developing countries such as China. In addition, most previous studies have conducted cross-sectional multilevel analyses of community-level effects on individual body weight status. This approach treats community characteristics as time-constant and ignores the potential lagged or cumulating effects of community-level risk factors (Entwisle 2007). Little is known about the association between changes in community characteristics and weight status. Further more, it is not clear whether the associations between community context and weight status will be mediated after controlling for individuals' physical activity level and energy intake.

This study aims to address these gaps in previous literature by conducting a longitudinal multilevel analysis of community effects on adult overweight and obesity in China, a country that is experiencing a rapid nutrition transition to the stage of diet-related non-communicable disease. Specifically, this study aims to examine: (1) how certain community-level risk factors of overweight and obesity identified in Western studies may be applicable to Chinese adults; (2) how changes in community characteristics over time may be associated with overweight and obesity risks; and (3) whether the associations between community context and body weight will be mediated by individuals' physical activity level and energy intake.

COMMUNITY CONTEXT

Built Environment

Several aspects of community context have been related to individual body weight status in the U.S. and other developed countries. Among others, built environment and access to high quality food pertains to this study most closely. Certain characteristics of a built environment such as population density, mixed land use and street connectivity are likely to reduce auto-dependence and increase walkability in a community which in turn is associated with increased time spent in physically active travel and reduced body weight among local residents (Frank et al. 2006 and 2007; Panter and Jones 2008; Rundle et al. 2008). In China where household ownership of automobile is much lower than that in developed countries, a better measure of built environment in a community should be availability of public transportation (e.g. bus) or

road conditions (e.g. paved or not). We hypothesize that built environment characterized by access to bus service and paved roads are likely to reduce residents' physical active travel and hence to increase their overweight and obesity risks.

Easy access to community recreational facilities such as parks, playgrounds and gyms is likely to encourage people to increase their physical activity (Panter and Jones 2008; Santana et al. 2009), which in turn helps to reduce the risk of being overweight and obese for both children (Gordon-Larsen et al. 2006) and adults (Poortinga 2006). Difficult access to community recreational facilities has been related to increased risk of being overweight and obese for Chinese children (Li et al. 2006). We hypothesize that presence of parks and gyms in the community is related to reduced overweight risk for individuals.

Food Choice

On the other side of the energy balance equation lies energy intake. Concentration of fast food restaurants in community has also been widely associated with increased overweight or obesity risk, especially for children (Burdette et al. 2004; Davis and Carpenter 2009; Kipke et al. 2007) due to increased opportunities of fat and energy consumptions. On the contrast, presence of supermarkets where healthy foods characterized by better diets and lower energy intake are more likely to be found than in convenience stores is likely to promote a reduced obesity risk (Lopez 2007). Some scholars suggested that the less availability of supermarkets in low-income and African American neighborhoods may help to explain the racial/ethnical and socioeconomic variations in obesity risk (Powell et al. 2007). We hypothesize that availability of fast foods in community is associated with increased overweight risk and decreased underweight risk for individuals, resulting in lower likelihood of dual burden households but higher likelihood of clustering of overweight members within households. We also hypothesize that access to a variety of healthy foods in a supermarket nearby is related with decreased overweight and obesity risks for individuals.

Not only availability but also affordability of high quality foods may affect individuals' food choices and consumptions. Beydoun and colleagues (2008) found that higher prices of fruits and vegetables were associated with improved dietary quality and lower cholesterol and sodium intake and lower body mass index (BMI) among U.S. adults. However, Sturm and Datar (2005) found that lower prices of fruits and vegetables were related to lower gain in BMI, but lower prices of meat were related to higher gain in BMI among U.S. elementary school children. It is likely that higher prices of fruits and vegetables indicate better food quality, but meanwhile, lower prices of fruits and vegetables increase affordability and hence improved dietary intake for individuals with low income. In the context of China, we hypothesize that lower prices of fruits and vegetables are associated with lower body weight gain, but lower meat price is associated with higher weight gain.

Urbanization

Urbanization has been related to physical activity level among the Chinese population, which in turn may affect their weight status. Monda and colleagues (2007) examined the effect of urbanization on Chinese adults' occupational physical activity which may be related to energy consumption and body weight status. They found that both men and women had increased likelihood of light versus heavy occupational activity given that their communities became more urbanized over a 6-year period. Ng, Norton, and Popkin (2009) also found that urbanization explained a lot of variation in the decline in occupational, household, and leisure physical activity among Chinese adults between 1991 and 2006. We hypothesize that high level of

community urbanization tends to increase the likelihood of being overweight for household members.

DATA AND METHODS

Data Source

The data used in this study are drawn from the China Health and Nutrition Survey (CHNS), a panel project designed to study issues in fields of health, nutrition, family planning in 7 provinces in contemporary China. The CHNS collected individual- and family-level data as well as the background characteristics of the communities where they lived. One of the biggest advantages of the CHNS is that not only individual- and family-level but also community-level data were collected over time, providing an opportunity for a longitudinal and multilevel analysis. Details regarding the study population and survey strategies and components can be found elsewhere (see e.g., Monda et al. 2007). This study uses the data from CHNS 1991, 1993, 1997, 2000, 2004, and 2006 to describe the prevalence of overweight and obesity among Chinese adults in the recent two decades. We use the 2000-2006 data to examine associations between community context and body weight status, because CHNS did not collect detailed data on built environment before 2000 and many community-level measures since 2000 were not consistent with those in previous waves. The community-level data were collected from community leaders, accounts, health workers, family planning heads, and appropriate vendors. We focus on working-age adults between 18-55 years old.

Dependent Variable

Individual height and weight in CHNS were not self-reported, but clinically measured, providing more accurate and reliable measurements. We use BMI to measure body weight status and classify each individual into one of the four categories: underweight, normal, overweight, and obese. We adopt a body weight classification designed specifically appropriate for the Asia-Pacific adult populations (WHO, IASO, and IOTF 2000). For adults aged 18 years or above, a BMI less than 18.5 kg/m^2 is classified as underweight, 18.5-22.9 kg/m^2 is normal, 23-24.9 kg/m^2 is overweight, and 25 kg/m^2 or above is obese.

Independent Variables

Built environment is measured by several dichotomous variables at community level, including most roads were paved, presences of bus service, gym or exercise center, park or public entertainment place, and whether fewer people in the community biked to work than they were before in the previous survey. The availability of quality food is measured by one dichotomous variable (presence of fast food restaurants), and a continuous index created by summing up the availability of six goods (gains, cooking oil, vegetable, meat, fish, and bean curd) in large stores or supermarkets in the community. The affordability of quality food is measured by unit prices of vegetables (average across green vegetables, cabbage, and vegetable most commonly eaten) and meat (average across pork, chicken, beef, and mutton). Urbanization is measured by total population and population density, and percentage of work force engaged mainly in agricultural activity.

At individual level, we control for socioeconomic, demographic, energy, and dietary variables, including the followings: age, gender, educational level, employment status, daily participation in heavy physical activity, and percents of carbohydrate, protein, and fat intakes out of daily energy intake. In additional to individual characteristics, we also control for several

household-level covariates that have been examined in previous research (Doak et al. 2000 and 2006), including household per capita income, household ownership of TV and motor vehicle.

Statistical Analysis

Repeated measures of same individuals over time and individual adults sampled from same communities introduced within-individual and within-community correlations that may bias the estimates of variances of regression parameters downwards and hence result in inflated statistical significance. We adopt a similar strategy as used in previous study (Monda et al. 2007) to account for these correlations in variance estimates. Specifically, we treat measurement occasions in different years (level 1) as nested within individual adults (level 2), which in turn are nested within communities (level 3). We use a three-level random intercept multinomial model to assess the effects of risk factors at different hierarchical levels on body weight status, using normal weight as the reference. The model is estimated using the GLLAMM program in STATA (Rabe-Hesketh and Skrondal 2008).

We divide our analysis into two sets. In the first set of analysis, we address potential lagged or cumulative effects of risk factors. We use lagged values to the previous wave for all time-varying covariates different hierarchical levels. We suffer from not using the outcome data at the baseline (i.e. in 2000) in our modeling as there is no information available about independent variables in the previous wave. However, we gain the advantage of drawing temporal inference regarding the associations between time-varying covariates and the outcome and of investigating lagged or cumulative effects of community characteristics.

In the second set of analysis, we address the association between changes in community characteristics and body weight status. We create dichotomous variables to indicate whether there had been changes in community characteristics from previous to current wave (e.g., presence of gym, park in current but not in previous wave, whether prices of vegetables and meat had increased in current compared to those in previous wave, etc.). We then assess whether these changes may have impact on individuals' weight.

Sample Characteristics and Prevalence Trend

Figure 1 depicts the prevalence of overweight and obese Chinese adults from 1991 to 2006. It is clearly to see that both proportions of normal and underweight adults declined over time, whereas both proportions of overweight and obese adults increased during the same period. More importantly, the prevalence of obesity exceeded that of overweight at some point between 1997 and 2000, and kept increasing at a higher pace thereafter. All this information taken together suggests a rising public health challenge proposed by accelerated increase in prevalence of overweight and obesity among Chinese adults.

Table 1 describes individual- and household-level background characteristics between 2000 and 2006. The sample size dropped by about 19% from 2000 to 2006, probably due to lost to follow-up, which requires us to consider potential sampling bias and to adjust for it. Without going into details, there are several over time trends worth of noting: (1) the average educational level increased a little over time, thought the employment rate dropped; (2) the a lot fewer Chinese adults participated in daily heavy physical activity, though their dietary intake patterns remained almost unchanged; and (3) average per capita household income increased considerably, and so did household ownership of motor vehicle. The declined physical activity and increased motor vehicle ownership are likely to be associated with increased prevalence of overweight and obesity.

Table 2 describes key community risk factors considered in this study. Rural-urban strata remained almost unchanged between 2000 and 2006. However, a lot more communities had most common roads as paved. Interestingly, the availability of bus service declined over time. This may be related to increased household ownership of motor vehicles and hence less dependence on public transportations. On the other hand, fewer people biked to work than before. Average number of food types available in local free markets dropped a little, while fast food restaurants became more prevalent. These together may predict less access to high quality food. Both gyms and parks became more available, providing more opportunities for outdoor physical activities. The average prices of vegetables and meat did not change very much between 2000 and 2006. Total population and population density increased considerably, whereas percentage of agricultural workers dropped slightly, reflecting rapid urbanization in China which predicts increased prevalence of overweight and obesity.

Next Steps

We are not able to present solid regression results yet, because of time pressure and intensive computations in estimating complex random effects models with large sample size. Other study has shown that using maximum likelihood approach to estimate a two-level random intercept logistic model with a comparable sample size to this study could take more than five days (Haynes et al. 2008). This computational intensity issue has dramatically slowed down our model building and modification process. We will use powerful Unix server available at the Population Studies and Training Center at Brown University to accelerate regression analysis. We will also try alternative estimation approaches such as Bayesian analysis using Markov chain Monte Carlo (MCMC) simulation which has been found to be more computationally appealing with precise estimates (Haynes et al. 2008).

Figure 1. Time Trend of Body Weight Status among Chinese Adults (Age 18-55)

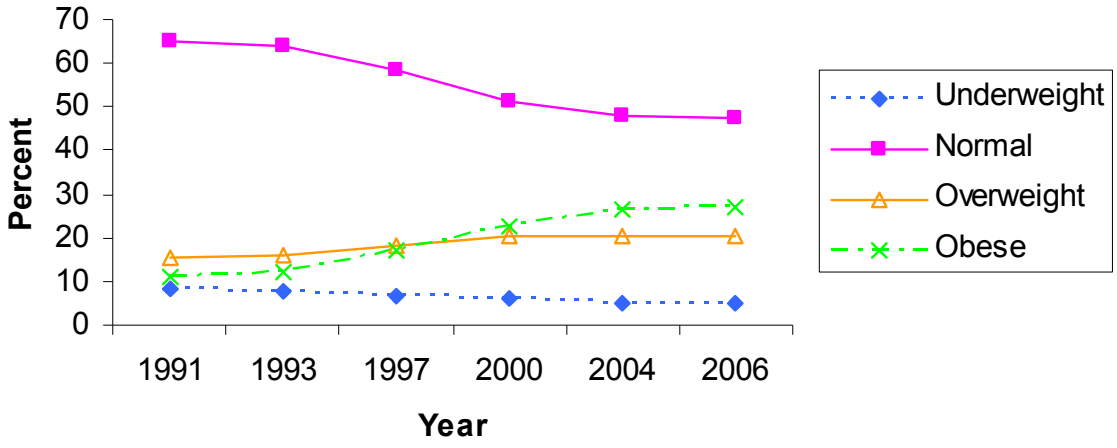

Table 1. Individual and household characteristics

	2000	2004	2006
Sample size (n)	6,897	6,080	5,785
Individual characteristics			
Mean age (years)	38.1	40.0	40.6
Male adults (%)	47.9	48.1	47.4
Educational level			
No/primary school (%)	34.5	29.1	26.8
Junior high school (%)	39.1	40.5	38.9
Senior high school/above (%)	26.4	30.4	34.3
Currently employed (%)	82.3	72.1	73.2
Participate in daily heavy physical activity (%)	47.6	40.3	40.3
Of total daily energy intake			
Mean carbohydrate (%)	59.1	58.4	58.5
Mean protein (%)	11.7	11.9	12.3
Mean fat (%)	28.3	28.7	28.3
Household characteristics			
Mean per capita household income (￥)	3946.1	5587.3	6922.6
Household ownership of TV (%)	94.9	97.3	98.2
Household ownership of motor vehicle (%)	25.6	36.9	41.8

Table 2. Community characteristics

	2000	2004	2006
Sample size (n)	215	212	216
Rural -Urban strata			
City (%)	16.7	16.0	16.2
Suburban (%)	17.2	17.5	17.1
Town (%)	16.3	16.0	17.1
Village (%)	49.8	50.5	49.5
Paved road (%)	60.9	67.9	73.2
Bus available (%)	70.7	64.2	63.4
Fewer people biked to work than before (%)	39.1	57.1	55.1
Mean number of food types in free market (n)	3.7	2.6	2.6
Fast food restaurant available (%)	13.5	16.5	17.1
Gym available (%)	7.4	11.3	15.7
Park available (%)	14.9	12.3	19.4
Mean price of vegetables (￥/500g)	0.6	0.7	0.8
Mean price of meat (￥/500g)	6.0	7.9	7.5
Mean total population (persons)	3599	4944	4356
Mean population density (persons/km2)	4179	5438	5591
Mean agricultural workers (%)	39.4	34.4	32.0

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