Diet, Body Mass Index, Physical Activity and the Education Connection among Adults in China

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Abstract:

Evidence of increasing obesity and poor diet among low socioeconomic status groups in developing countries is found in the literature. However, the connection between education and obesity and diet patterns is not well understood. Our analysis is rooted in a first order dynamic health production model using body mass index as gauge for health outcome and the balance between macronutrient consumption and physical activity as measures of health input. We use data for adults in the 1991, 1993, 1997 and 2000 China Health and Nutrition Survey as an application, focusing on comparison of parameters for education across equations for BMI, nutrient inputs and physical activities, between men and women, urban and rural areas. The reduced form analysis reveals important associations between socioeconomic factors and health output and input, as well as changes of such associations over time.

1. Introduction

More evidence of increasing obesity and poor diet among low socioeconomic status group in developing countries is found in the literature. However, the connection between education and obesity and diet patterns is not well understood.

The shifts in diet, physical activity and anthropometric status among adults in China, desirable or undesirable, are among the most rapid (Ge, Chen et al. 1992; Ge, Weisell et al. 1994; Popkin and Doak 1998; Popkin 1999; Popkin 2002; Du, Mroz et al. 2004; Monteiro, Moura et al. 2004; Doak, Adair et al. 2005; Mendez, Monteiro et al. 2005). In the 1990s, the Chinese dietary pattern moved toward one in which the proportion of energy intake from fat increased each year. According to the Food and Agriculture Organization estimates from the Food Balance Sheets, per capita daily protein and fat intakes rose dramatically in the 1990s, and both the percent of protein and percent of fat from vegetable products are decreasing and the percents of protein and fat from animal products are increasing (Figure 1). Similar trends in nutrition transition are found in many low-income countries (Drewnowski and Popkin 1997; Guo 1998; Popkin 2002; Adair 2004; Dien, Thang et al. 2004; Lipoeto, Wattanapenpaiboon et al. 2004; Monteiro, Conde et al. 2004; Rivera, Barquera et al. 2004), however no universal conclusions exit concerning the roles of socioeconomic determinants on the dietary transitions.

In China, during the 1990s, increased income expands a household’s budget constraint resulting in higher quantity or quality of food consumption. Urbanization and increasing exposure to western life styles may change tastes and food choices. Increased education may raise the allocative efficiency of food consumption, especially during times of technological change.

Higher education is also associated with increased income, investment in human capital and longer time prospective in decision making such as choices on food consumption and exercising. Changes in prices of foods and other community characteristics affect consumption through price or income effects. Using the framework outlined below, we study the reduced form demand function for body mass index (BMI), calorie intakes, and percent of calories from fat and protein, and physical activity levels in a manner similar to that in Thomas, Lavy and Strauss (1996).

We found strong and inverse-U-shaped effects of education for women on BMI in urban areas. The effects of education on body mass, food consumption, physical activity levels amongst men and women in rural and urban areas take distinct shapes. Higher educated individuals tend to work at less physical intensive jobs and are more likely to be physically active during their leisure time. In both rural and urban areas higher education is associated with increased percent intakes of calories from protein and fat; however, with the exception of urban women higher education is associated with lower total calorie intakes. Productive assets, food prices, water sources and sanitation conditions are all important determinants of adult BMI and macronutrient consumption in China and these factors affect men and women in regions differently.

The paper is organized as follows: Section 2 describes the methodology and empirical strategies in the analysis and reviews findings in literature regarding Chinese adult health and food consumption; Section 3 provides summary of the data and descriptive evidence for the association between health outcomes and socioeconomic factors; Section 4 contains results for the reduced-form analysis; and the last section concludes and discusses limitations of this paper.

2. Method

Our model considers a rational individual with perfect information. Assume that the preferences of household members are inter-temporally separable and that the household maximizes the present discounted value of a common utility function of all family members' consumption, health and leisure in time period *t*.

Adequate to the application of body mass index (BMI), health status at the beginning of period *t*+1 is assumed to be influenced by health status at *t* (h_{it}), health inputs (m_{it},) between period *t* and *t*+1, including the balance between energy expenditure (basic metabolism, working or exercising) and food intakes (macronutrient, energy), leisure (l_{it}), medical care and illness spells, which do not bring utility directly. More leisure time during the period *t* and *t*+1 may bring feelings of well-being and sound state of mind, which may have a positive influence of one's physique. Individual characteristics, θ_{it}, such as age, gender, and environmental factors, z_{ct}, of community *c* at time *t*, may also have a direct impact on health outcomes:

$$h_{it+1} = f_i\left(h_{it}, m_{it}, l_{it}; \theta_{it}, z_{ct}, \upsilon_{it}\right) \tag{1}$$

where υ_{it} are unobserved individual, household and community factors. This is not a general health production in that it assumes that lagged health is a sufficient summary of all past inputs and choices in periods 1 to *t*-1 and that there is no direct impact of health before *t-1* on current health. However, it is quite general.

The household maximizes utility under the standard inter-temporal budget constraints. Under the assumption of fixed interest rates, the household will equate marginal rate of substitution between health and consumption with the shadow price of health in equilibrium in each period. The shadow price of health is lower than the direct costs for medical care because improving current health decreases the future medical care need and increases healthy days or effective labor. Over time, the discounted marginal rate of substitution of health today and tomorrow equates to the ratio of this shadow prices.

The dynamic problem is solved recursively and the reduced-form demand functions for consumption goods *x*, health *h*, leisure *l*, and balance between energy intake and energy expenditure *m* are:

$$\left(x,h,l,m\right)_i^t = g_{x,h,l,m}\left(p_x, p_m, w_i, y, \theta_{it}, z_{ct}; \varsigma_i\right) \tag{2}$$

where price vectors are $p_x = \left(p_x^T, p_x^{T-1}..., p_x^0\right)$, $p_m = \left(p_m^T, p_m^{T-1}..., p_m^0\right)$, $w_i = \left(w_{iT},..., w_{i0}\right)$, and household non-wage income $y = \left(y_T,..., y_0\right)$. ς_i indicates unobserved individual, household and community heterogeneity over the life time. As noted in Rosenzweig and Schultz (1983), without specifying the exact form of the utility function in (1) a closed-form solution for the demand equation in (2) cannot be obtained.

Our estimating equation of (2) takes the form $y_{it} = X_{it}\beta + \upsilon_i + \varepsilon_{it}$, where y_{it} is person i's BMI, nutrient intakes, and physical activity level in year *t*, X_{it} is a vector of exogenous variables including the individual's age, education level and household or community resources, and υ_i is the individual unobserved heterogeneity. υ_i induces correlation over time within each individual, and for linear models υ_i is assumed to follow normal distribution and unrelated to covariates. For categorical outcomes such as physical activity levels υ_i is assumed to have a multinomial distribution. We use individual as a cluster and estimate the standard errors of the coefficients with cluster-sample method.(Wooldridge 2003)

Anthropometric measures, particularly weight and height, are commonly accepted as measures of nutritional and health status by epidemiologists and nutritionists. They have also been used by economists to study long-term trends in nutrition and mortality(Fogel 1986; Fogel 1994; Costa and Steckel 1995) and to measure standard of living over time(Whitewell and Nicholas 2001). We follow this tradition by using BMI as an indicator for adult health. The upper and lower end of the BMI spectrum can both be related to ill health. We will come to this point later. In nutrition literature, diet can be described in terms of its chemical composition, for example, its nutrient content, or alternatively, in terms of foods or food groups. Food consumption quantity in this paper refers to individual daily intakes of calories, fat and protein and food consumption quality is measured by percentages of calorie intakes from fat, protein and carbohydrates. We compare estimated coefficients of education across the equations for BMI, nutrient intakes and physical activity as to have a glimpse of the associations of education on health input and outcome. All analyses are performed using Stata 9.

3. Data and Estimation

The CHNS is a longitudinal survey that covers eight provinces that vary substantially in geography, economic development, public resources, and health indicators. A multistage, random cluster process was used to draw the sample. Counties in the 9 provinces were stratified by income (low, middle, and high) and a weighted sampling scheme was used to randomly select

4 counties (one in low, two in middle and one in high income levels) from each province. In addition, the provincial capital and a lower income city were selected. Villages and townships within the counties and urban and suburban neighborhoods within the cities were selected randomly. There are about 190 primary sampling units and 3,800 households covering approximately 16,000 individuals of all ages. A cohort of adults who were at or older than 20 years of age in 1991 and not pregnant at the time of survey is included in our analysis.

For external consistency check, we compare the CHNS data with the China-Oxford-Cornell Study (COCS) of 69 counties (Pan, Root et al. 2006) in 1989 on BMI (Figure 2) and nutrient intake (Table 1). The dietary and interview of the COCS was carried out in a random sample of two villages in each of the 69 rural counties focusing on the population 35-64 years of age. As is seen in Figure 2 there is great geographic variation in BMI (kg/m^2) across the 29 provinces surveyed in the COCS. The rural areas in the nine CHNS provinces to certain extent represent such variation and the provincial average BMI in rural CHNS and COCS are fairly close.

The COCS carried out a three-day weighed household dietary survey to estimate average daily nutrient intakes of a “reference man” defined as an adult male, 19-59 years of age, 65 kg of body weight and undertaking very light physical work. The CHNS carried out both a three-day household weighed inventory survey and a three-day individual 24-hour recall survey. Using the conversion factors used in the COCS (Chen, Campbell et al. 1990) we calculate the daily calories (kcal), protein (g), fat (g), percent calories from protein and fat per reference-man in the CHNS household food survey and compare the results in common provinces (Table 1). There is considerable variation between provinces and different time trend as well. The COCS tends to have larger daily calorie intakes per reference-man and lower percent of calories from protein and fat. This does not negate the measures in the CHNS because they were measured in later years. The comparison did provide a clue that the CHNS rural areas might be more affluent than the rural counties in the COCS at least in terms of food consumption. Overall, the external consistency check lends confidence in the representativeness and validity of the measures in both studies.

For internal consistency check we examine a subset of adults who remained in all four waves of the survey[1] and a subset of adults with consistent education information over time. Table 2 provides summary statistics of the full sample and the consecutive sample in 1991 and 2000 by gender and rural/urban residence. The significant economic development is demonstrated by increases in household income, per capita income, productive assets[2] and durable assets[3] from 1991 to 2000 in both rural and urban areas.

The full sample and the subset of individuals consecutively surveyed in four years are different in many aspects partly due to the fact that Heilongjiang and Liaoning provinces were only in the study for two and three waves respectively. The subset of consecutively surveyed individuals effectively excludes these two provinces where people are bigger in stature and have different dietary habits. Thus the full sample has higher average BMI and higher overweight prevalence.[4]

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[1] This effectively removed cohorts in Liaoning and Heilongjiang provinces by design.

[2] The nominal value of productive assets is self-reported ownership and value of tricycles, motorcycles, tractors or walking tractors, irrigation equipment, power threshers and water pumps. Items unavailable in all years are not included. Productive assets are discounted to the 1988 value. All price indices are based on the China Statistical Yearbooks (1988-2001) for urban and rural areas at the provincial level.

[3] Durable assets are self-reported worth of household durable items commonly available in all years deflated to the 1988 value.

[4] For general comparison purposes we use the international standard cutoffs of BMI>=25 for overweight, >=30 for obesity and <18.5 for underweight.

There has been a significant increase in the prevalence of overweight between 1991 and 2000, especially in urban women. Due to the restriction of being in the survey for 10 years, the subsample is necessarily older in 2000 as compared to the full sample. Since younger generations have higher education, the subsample has on average one more year of education as compared to the full sample. These sample differences prompt us to examine the selection issue further.

The level of education was measured by the number of years of formal schooling, or year of schooling categorized into three groups – no schooling, one to six years (inclusive) of schooling, and more than six years of schooling, or the highest degree achieved. If a person reported lower education levels in later years of the survey, that person's observations were considered inconsistent and excluded in the third subset. Measurement errors in education may attenuate the main effects of interest. Using this subsample of individuals with consistent education levels will mitigate the attenuation bias problem.

The average (and median) of the three-day individual 24-hour recall of all foods is used to construct individual daily nutrient intakes. One advantage of using the 24-hour recall measure is that away-from-home consumption is included and the downward bias in the weighing method is mitigated. If people don't know ingredients of cooked foods eaten away from home, however, the measurement error in recall will increase. Table 3 displays the individual level nutrient intakes for the full sample and the consecutive subsample. There is a clear decreasing trend of calorie intakes for both men and women in rural and urban areas. Even though individuals in four consecutive surveys tend to be older and smaller in stature, their average calorie intakes (kcal) tend to be larger than individuals who were surveyed at least once in 10 years, especially in rural areas.

Average protein intakes (g) per day are relatively stable over time in urban areas but decreasing in rural areas. Both urban and rural areas had an increasing trend in fat intakes (g) per day. Both the percent calories from protein and from fat tend to be smaller in the subsample of consecutively surveyed individuals as compared with the full sample. This may explain why the subsample is smaller in stature even though they consumed more calories per day.

It is also possible that the excess energy intake is attributed to greater physical activity. A comparison of physical activity levels – based on work activity with three levels (very light or light, moderate, heavy or very heavy) – between the full and consecutive subsample (Table 3) shows that individuals in four waves of surveys tended to be in more labor intensive jobs. This is consistent with the finding of higher energy intakes and smaller stature. There is a decreasing proportion of individual undertaking strenuous work over time in both rural and urban areas. .

What is the connection between education and BMI, nutrient intakes and physical activity levels? In the full sample, average years of schooling increased about one year between 1991 to 2000. In the subsample of consecutively surveyed individuals it increased about 0.3 years. We compare the estimated effect of education on the above outcomes in the full and sub-samples. This will allow us to carefully examine the effects of education in different populations over time.

We use linear mixed models with individual random effect for BMI (kg/m^2), energy (kcal), protein (g), fat (g), and percent calories from protein and fat; and use random effect proportional odds models for physical activity levels. We compare results in the full sample and in two subsamples.

4. Results

We compare the effects of education on five outcomes in three samples[5]. Three specifications of educations were employed: first, years of schooling in linear term; second, categorized years of schooling in three groups – no schooling as referent, 1-6 years of schooling, and more than 6 years of schooling; third, the highest degree achieved – no schooling as referent, some elementary education, elementary degree, middle school diploma, high school diploma, and technical collage or university or higher degrees. Even though all three specifications can pick up the nonlinear effect of education it becomes apparent that many of the U-shaped relationships are masked when we use the first two specifications of education in regressions and the last one works the best.

We first estimated the models controlling only age, age squared, year dummies and community fixed effects. Then we added individual, household and community resource covariates instead of community fixed effects to control for confounding. These variables include number of household members, number of children and elderly in the family, deflated per capita income, deflated self-reported worth of durable assets, current smoking status, employment status, ill or injured or hospitalized during last four weeks, self-reported general health status, being official

[5] Tables are available upon request.

or village cadre, community water type and excreta surroundings, free market prices for commonly consumed food, province fixed effects. The effects of education across both sets of regressions and across different samples are very close, which lends confidence on the consistency of our estimation. To summarize our results we plotted the six sets of estimators (two from each model controlling different covariates; three from each sample) for the highest education achieved in one graph for each outcome. Figure 3 shows the effects of education on BMI and total energy intakes for women and men in urban and rural areas; figure 4 for effects on work and leisure physical activities; and figure 5 for percent of energy intakes from protein and fat.

Underweight and overweight as extreme values of BMI merit separate examinations. From 1991 to 2000, measured using the consecutive subsample as to avoid inadvertently attribute regional differences to time trend, the prevalence of overweight increased from 8 to 16 percent among rural men, from 13 to 24 percent for urban men, from 12 to 23 percent for rural women, and from 17 to 32 percent for urban women. We used data from the year 2000 to examine the correlation between education and the probability for being under- or over-weight in multinomial logit models. Figures 6 and 7 depict the estimated odds ratios for education compared to the referent group with no formal education (Long and Freese 2001). The base category 2 in each figure represents normal weight group, category 1 for underweight, and category 3 for overweight. Effects to the right of the base category indicate increased odds or likelihood and effects to the left of the base category indicate decreased odds or likelihood.

Body Mass, Nutrient, and Physical Activity

There are significant different effects and distinct patterns of education on BMI, energy intakes, and physical activity levels between urban and rural areas, and between men and women.

For urban and rural women the effect of education on BMI is inversely U-shaped. For men, the opposite is found (Figure 3 upper panel). Adult men in China had higher levels of education than women; however their educational effects on BMI are not significant, except for rural higher educated men. If BMI of man is a proxy for both health condition and human capital, urban men didn't need to invest in bigger stature if their education level is higher; rural highly educated men are bigger in stature and less likely to work physically intensive jobs. This implies body size is more of an indicator for social status in rural areas for men. For women it seems appropriate that BMI plays only the role of a proxy for health condition because a woman's human capital does not depend strongly on her stature. Hence the effect of education on BMI reflects its effect on health condition only. Besides, urban men and women exhibit the highest rate of overweight and obesity. As seen in Figures 6 and 7 in urban men and women higher educated individuals were less likely to be either under- or over-weight (for men the effect is not statistically significant, see Table 4). On the other hand, for rural men and women higher educated individuals are more likely to be overweight and less likely to be underweight as compared to women with no formal education. Even though higher education is negatively associated with BMI, the decrease is not sufficient to reduce the prevalence of overweight in rural women.

Almost exact opposite effects of education were found on total calorie intakes (Figure 3 lower panel). For rural men and women and urban men, higher education is associated with significantly lower calorie intakes. Coupled with the findings for BMI, it implies that the increased stature for highly educated men was not due to more energy intakes. Rather, lower energy input was associated with lower energy expenditure related to work activity (Figure 4 upper panel) for rural men and women. Higher educated individuals are less likely to under take labor intensive work in rural area and demand less energy input. However, the difference between rural men and women indicates for rural women stature does not signal higher social classes. The results for urban men and women are less obvious. Urban men tend to consume fewer calories as education increases but women are the opposite. Both men and women have a U-shaped effect of education on work-related physical activity. However, the effects of education on BMI in urban women are inverse-U-shaped, but not for men.

Even though work related physical activity levels do affect daily energy expenditure and in turn determine body size, the effect of education may be contaminated by reverse causality. It is entirely possible that individuals bigger in stature may invest less in education and work on labor intensive jobs. Hence, we examine the effects of education on leisure time physical activities. In 2000, individuals aged 18 and above were asked a series of questions about the total number of hours per week participating in leisure physical activities.[6] The strongest effects of education on increased leisure physical activity were among urban highly educated women, and then urban men. On average urban men and women with college or more education spent 0.6 more hour per week on leisure physical activities. The shapes of the effects on leisure physical activity for urban men and women are curiously close to that on BMI in urban areas. In rural areas there is

[6] Items such as martial arts, gymnastics, dancing, acrobatics, track and field, swimming, soccer, basketball, volleyball, badminton or tennis were included. We didn't include other board games as it is not clear how physically intensive they were. We didn't include the time walking or biking to and from work, school or shopping since that was not part of leisure physical activities.

less leisure related physical activity in general and no significant effect of education. The strong effects of education in urban areas are consistent with the interpretation of increased education being related to longer time prospective and healthier habits.

In terms of food quality, or percent of energy intakes from fat and protein, similar patterns emerged for both men and women in rural and urban areas. Higher educated individuals tend to consume more calories from fat and protein as compared to carbohydrates. Recall higher educated individuals (with the exception perhaps of urban women) also tend to take in less total energy from food. As discussed earlier there is a decreasing trend of percent calories from fat and protein of vegetable products and an increasing trend of animal products. Thus, the change in dietary habit in the higher educated individuals may be toward a worse case since animal protein and fat have been shown to be related with increased risks for certain diseases (Campbell and Chen 1999; Campbell 2000).

Trend of Under- and Over-weight

Controlling for the same covariates as the most elaborated model, we used the full sample to test the trend of coexistence of under- and over-weight in CHNS from 1991 to 2000 (Figure 8). Rural men led the trend for increased overweight and decreased underweight. Significant reduction in malnourishment was first seen in 1993 among rural men followed by rural and urban women in 2000. Significant increase in overweight and obesity was first seen in 1997 among rural and urban men followed by rural and urban women in 2000. Given that the baseline rate for overweight and obesity was highest among urban women, the large odds ratio for 2000 in this group is alarming. Even though the highly educated women are less likely to be obese, the majority of the urban residents may be heading toward a chronic disease ridden era. The process of urbanization and influence of western food culture had all been shown to impact this change. Rural women, especially the older age cohort, may have grown up in a more hostile environment. There is an increasing body of literature that examines the association between restricted fetal and childhood growth and diseases in adulthood (Oken and Gillman 2003; Power, Li et al. 2003; Power, Manor et al. 2003; Hardy, Wadsworth et al. 2004). We tested this hypothesis in a separate paper using the great famine in 1959-1962 as exposure among those who were born during that period. We found significantly increased body mass among rural women (Luo, Mu et al. 2006).

Men in rural and urban areas had a relatively lower baseline prevalence of overweight and obesity. However they had an earlier and faster growing trend as compared to women. The most dominant problem of nutrition status of adult Chinese had experienced a transition from malnourishment to coexistence of over and under nourishment, and now toward mostly overweight and obesity.

Other Factors

Our elaborate model specifications allow us to examine the associations of BMI, nutrient intakes and physical activities with other factors. As in the case of education, we do not interpret these factors as causal in our reduced form analysis. In a dynamic health production function given proper instruments for health input we may be able to study causality (Luo 2004). Since they are not the focus of this article, we only briefly discuss some of the findings next.

Household and Community Resources

Poorer households live in areas where fewer health facilities and practitioners are available and the living and sanitary conditions are worse. If such is the case, it is essential to control for household resources so that the estimates of education were not confounded by these factors. The partial effects of per capita income on BMI were only significant among rural men, controlling for education levels and other characteristics listed above. Even though the partial effects of per capita income are not significant for total calorie intakes, higher income were associated with increased percent energy from protein and fat among all individuals.

The types and sources of household water and toilet facility are aggregated from 40 to 80 households in each community. They represent the percent of households within a community with water from different sources and with different toilet facilities. They are measures of quality of water and sanitation in the community. Using the aggregated measures helps avoid the selection biases due to migration. Drinking from yard-piped water, well water or other water and household excreta surroundings are significantly associated with body mass in rural populations.

The effect of the prices of rice and the price of edible oils were positive and significant for men and women before adding community dummies. The effects of the prices of eggs and pork for men and women were all negative and significant. Eggs and pork constitute of high calorie intakes, hence the increase in prices may have a substitution effect for other foods with lower calorie and result in lower BMI. Edible oils and rice, on the other hand, can be thought of as substitute for red meat and wheat flour. The increase in oils and rice prices will hence result in more consumption of less healthy foods and increased BMI. The effects of prices on calorie, fat and protein intakes and the quality of diet measures can go either way. Improvements in sanitation are associated with more energy and protein intakes in urban areas.

5. Concluding Remarks

Biologically, increase in body weight is the result of energy intake in excess of energy expenditure, regulated in part by peptide hormones in the brain and gut. Many studies have found the changing body weight patterns among the Chinese related to shifts in diet and activity, a large increase in fat from animal sources, reduced daily physical activity, urbanization, and westernization of lifestyle (Sundquist and Johansson 1998; Popkin 1999; Popkin 2001; Stookey, Adair et al. 2001). We systematically and carefully examine the relationship between body mass index, macronutrient intakes, and physical activity levels with education in adult Chinese.

Even though overweight and obesity have been found to be more prevalent among the well-to-do population, higher education may be protective of women from it. As we have demonstrated urban women with higher education tend to have lower BMI, consume fewer calories, and participate more in leisure physical activity compared to the lower education group. The dietary pattern among higher educated groups is consistent with published findings on the dietary pattern among higher income groups. Mass education on healthy nutrition may benefit the highly and the less educated alike. It is of tremendous importance for China leading to a healthier aging population.

Figure 1 Food and Agriculture Organization (Food Balance Sheet) Estimates of Calories, Protein and Fat availability and percent of Protein and Fat from vegetable and animal products in 1961-2000

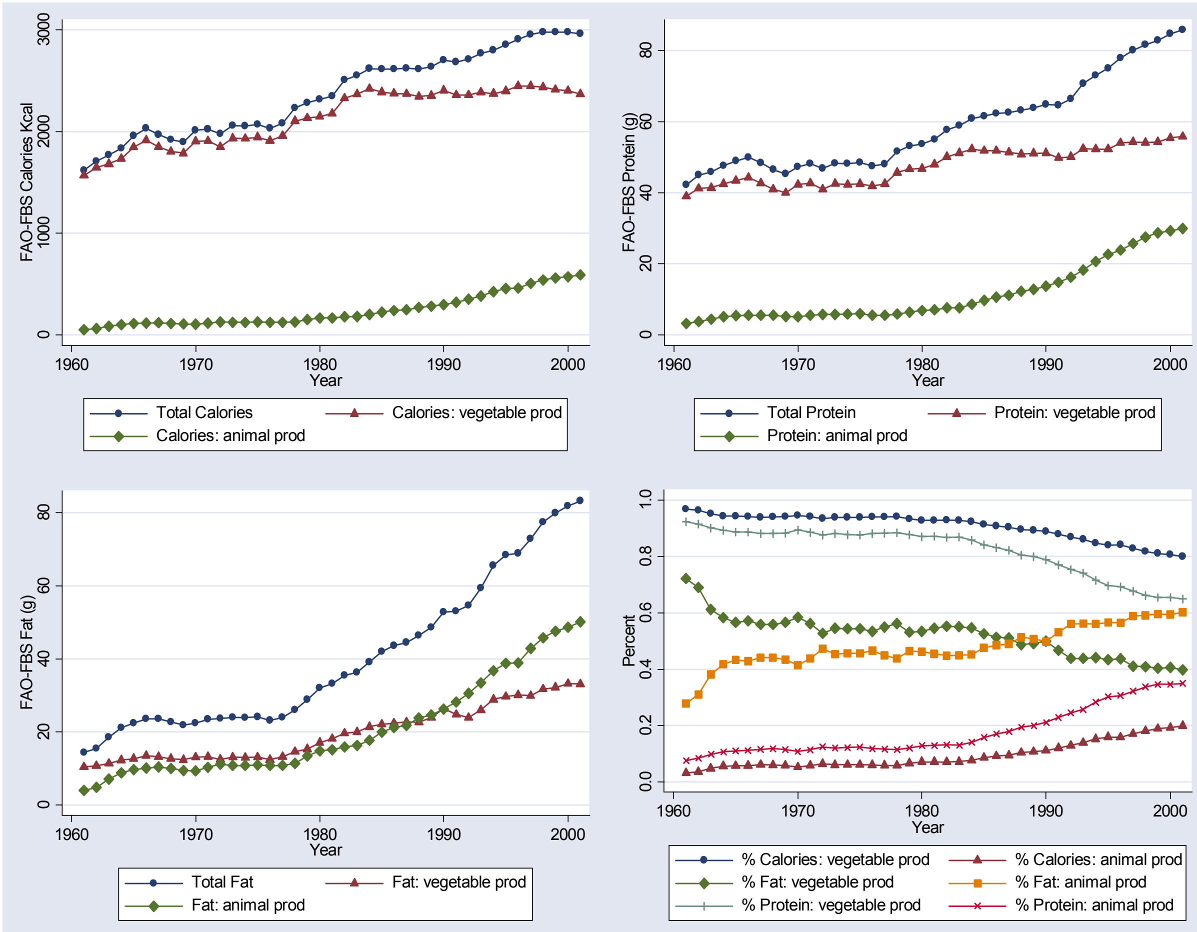


Figure 2 Comparison of Body Mass Index in the China Health and Nutrition Survey (1991, 1993) and the China-Oxford-Cornell Study (1989, 1993)

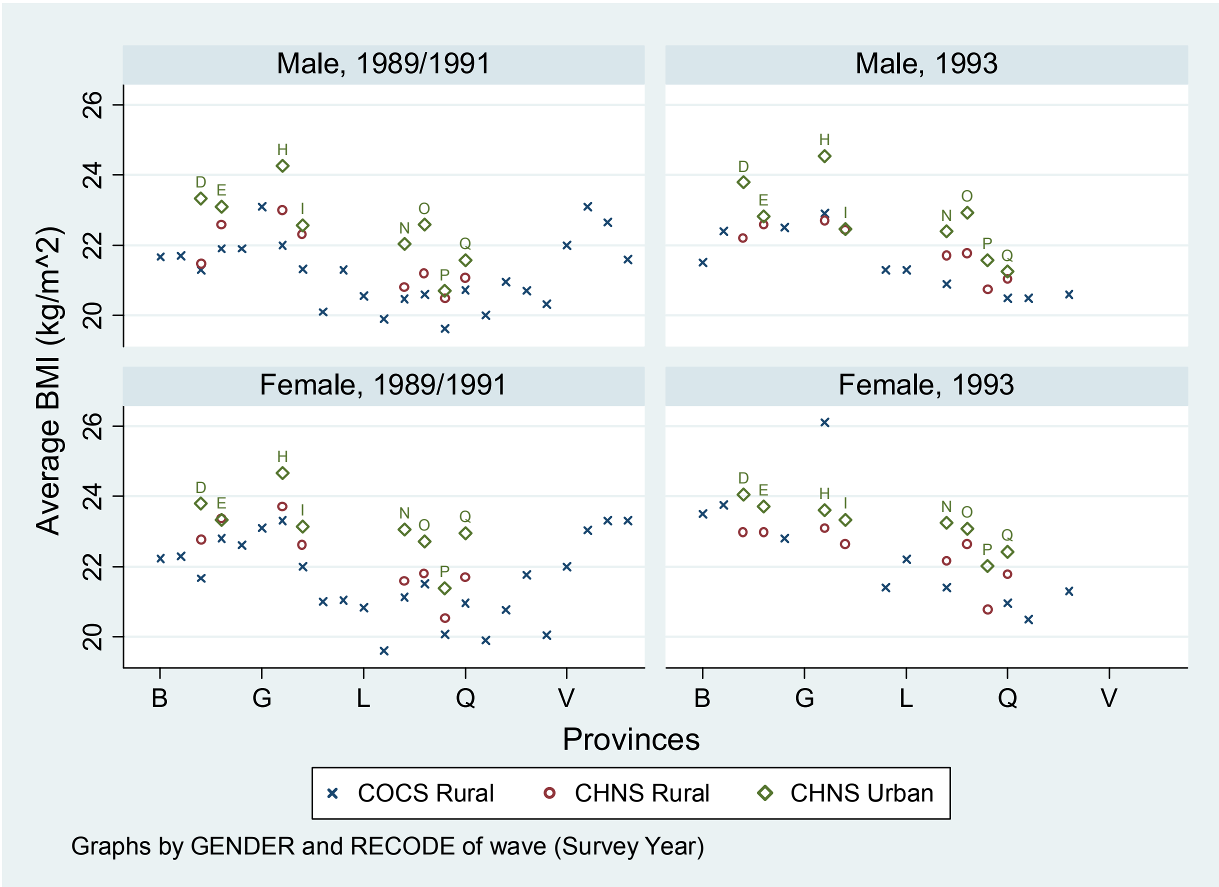
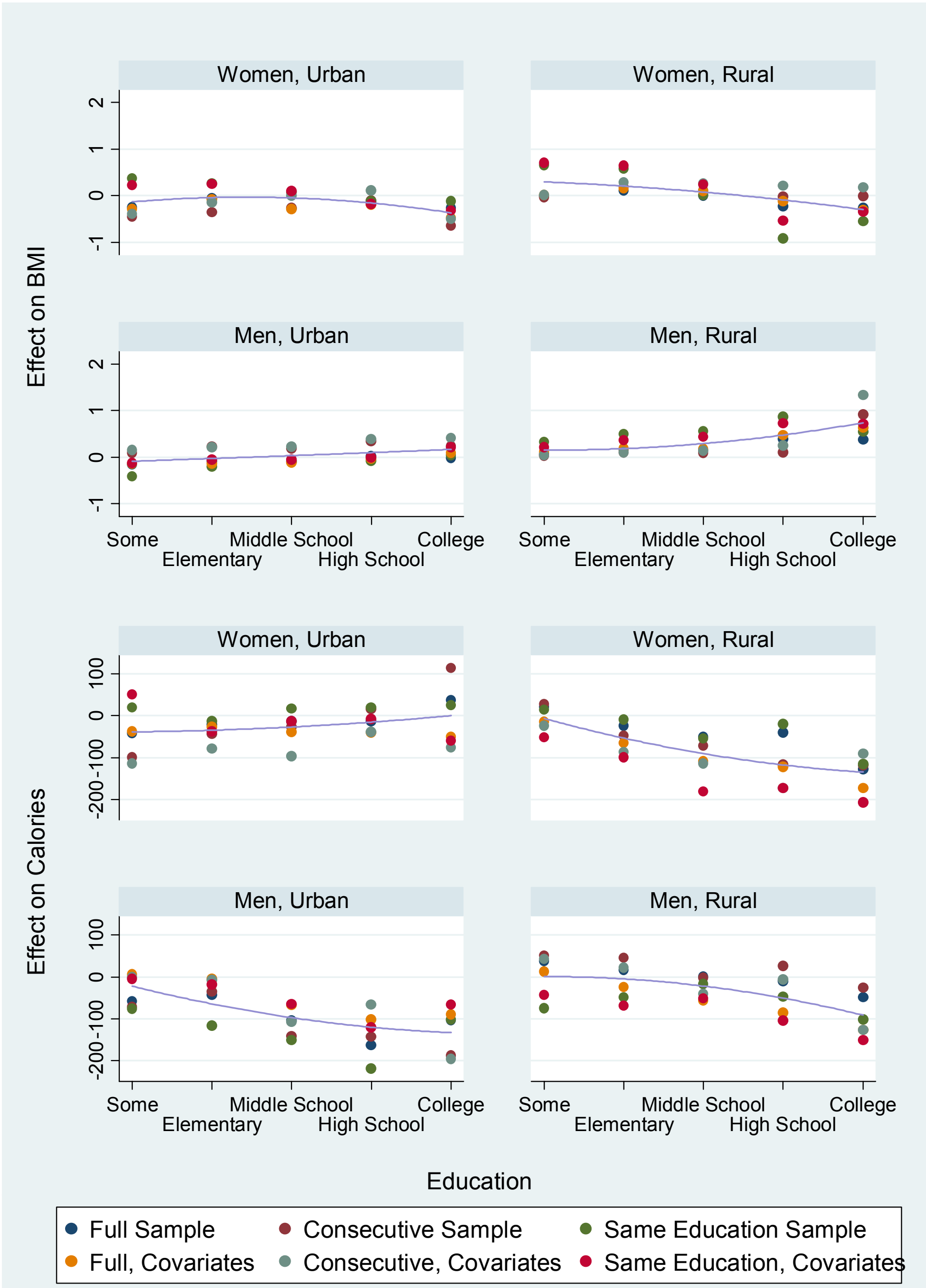
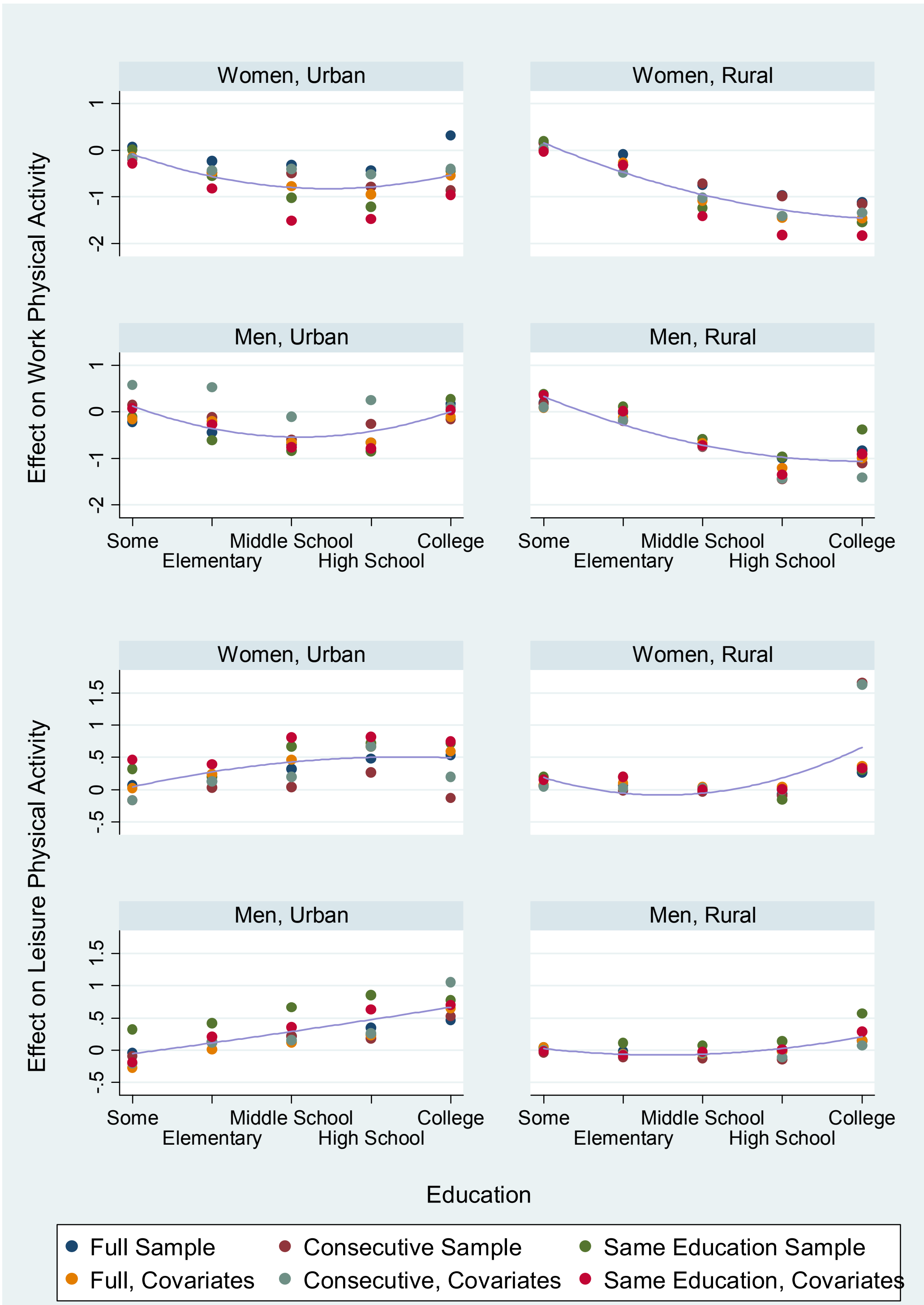


Figure 3 Estimated Effects of Education on BMI



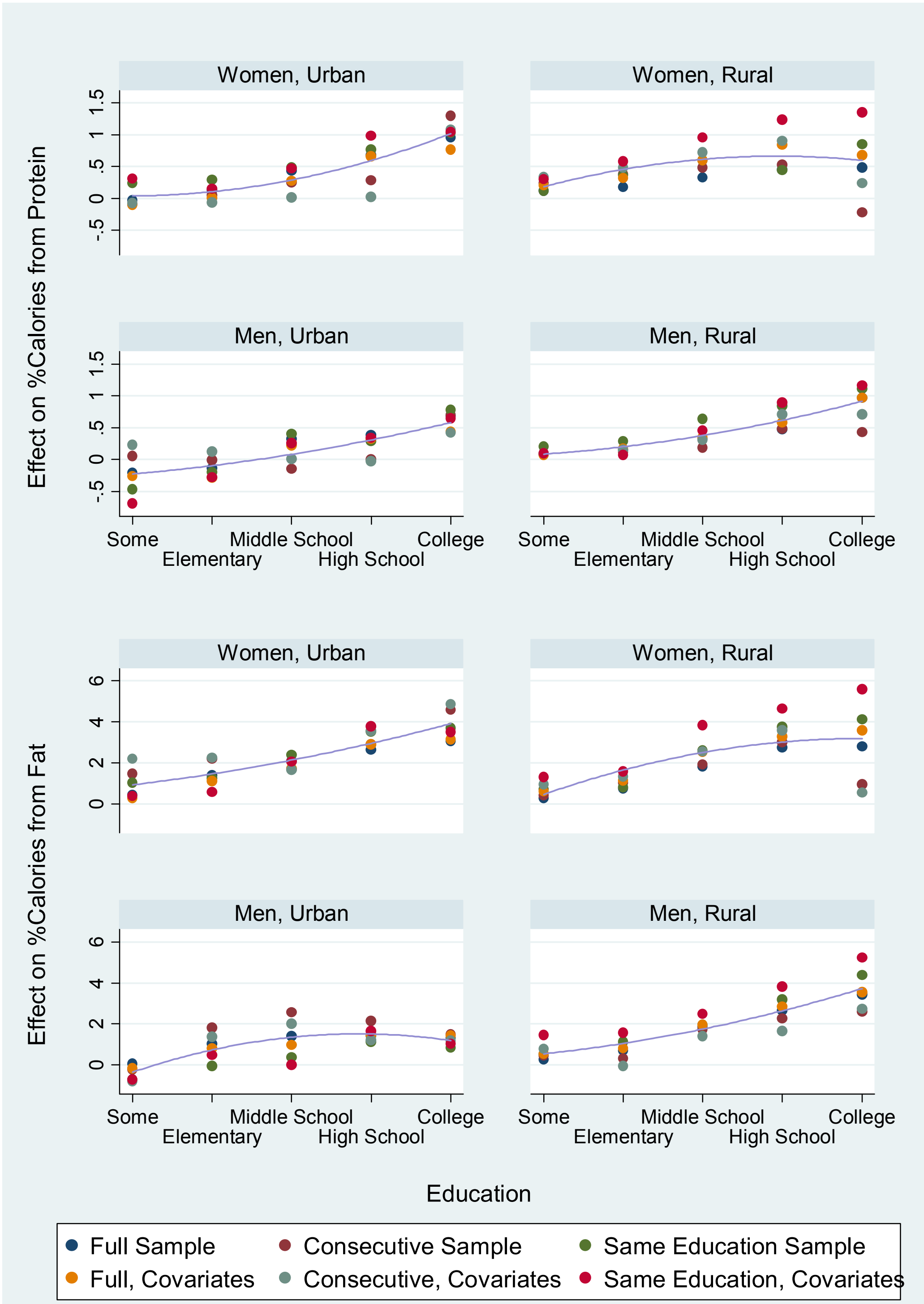
Note: Scatter plot of the estimated effects of education on body mass index, based on different samples and different specifications in regressions. In the first specification included are age, age-squared, community fixed effects and year dummies; in the second specification adding covariates are age, age-squared, current smoking status, working, ill or injured or hospitalized during last four weeks, self-reported general health status, official or village cadre, number of household members, number of children and elderly in the household, deflated per capita income, deflated self-reported worth of durable assets, community environmental factors for water type and excreta surroundings, free market prices for commonly consumed fish, province fixed effects and year dummies.

Figure 4 Estimated Effects of Education on Probability of Undertaking More Physically Intensive Work Activities



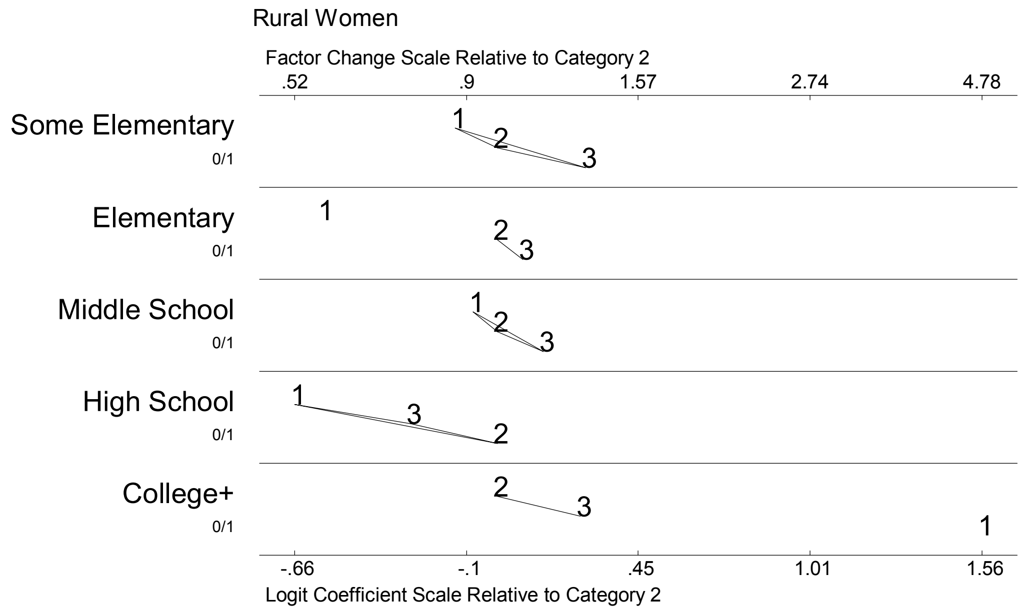
Note: Same as in figure 3. Leisure physical activity levels are estimated using CHNS 1997 and 2000 only.

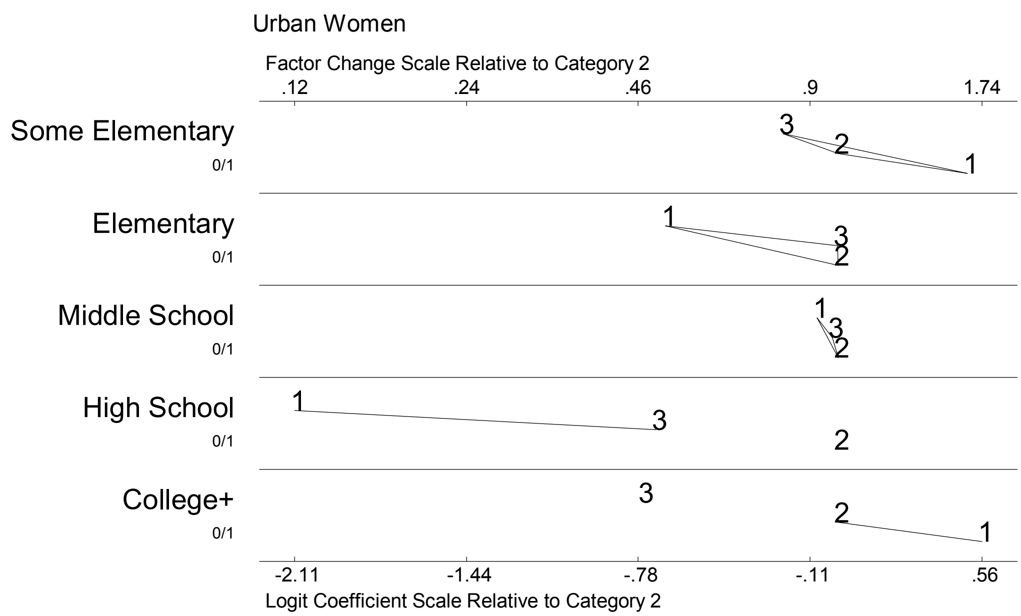
Figure 5 Estimated Effects of Education on Protein and Fat Intakes



Note: Same as in figure 3.

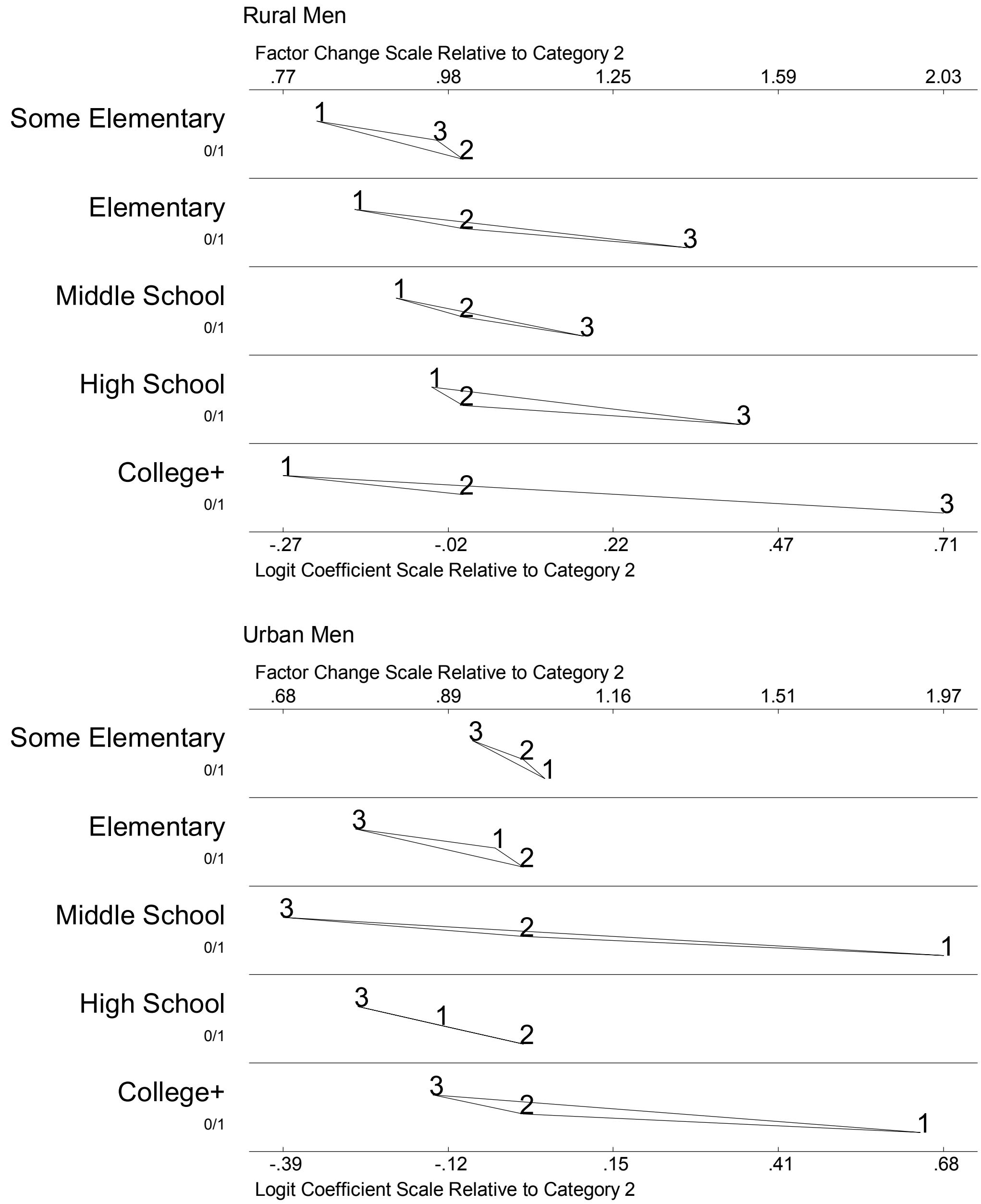
Figure 6 Odds Ratio for Under- or Over-weight Compared to Normal Weight, Effect of Education for Women (results in Table 17)





Note: Category 2 represents normal BMI (18.5~25), category 1 represents underweight, and category 3 represents overweight. The base category is normal weight (OR=1). When two categories are connected the effect of education is not significant.

Figure 7 Odds Ratio for Under- or Over-weight Compared to Normal Weight, Effect of Education for Men (results in Table 17)



Note: Category 2 represents normal BMI (18.5~25), category 1 represents underweight, and category 3 represents overweight. The base category is normal weight (OR=1). When two categories are connected the effect of education is not significant.

Figure 8 Trend of under- and over-weight coexistence in CHNS from 1991 to 2000

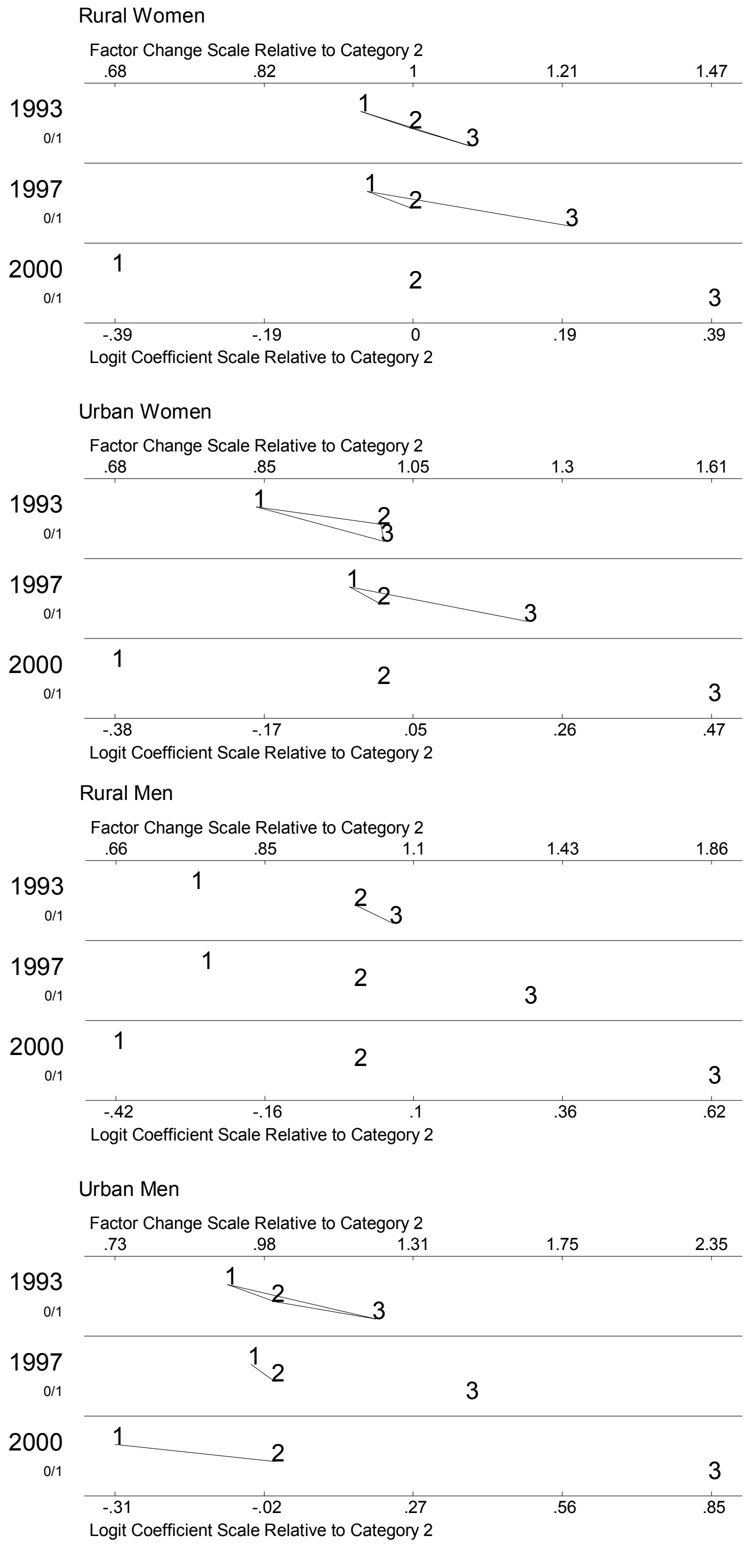


Table 1 Geographic and Chronological Variation in Nutrient Intake in rural areas in China Health and Nutrition Survey (1991-2000) and the China-Oxford-Cornell Study (1989)

	Energy (kcal)/day/reference man				
Provinces	COCS1989	CHNS1991	CHNS 1993	CHNS 1997	CHNS 2000
Liaoning E	2339.00	2754.55	2254.61	.	2278.69
Heilongjiang G	2785.00	.	.	2401.07	2016.00
Jiangsu I	2489.71	2338.57	2423.00	2421.04	2714.85
Shandong H	2141.00	2062.09	1951.15	2050.76	2108.83
Henan D	2571.00	2145.61	2138.37	2176.62	2166.72
Hubei O	2610.00	2016.06	1958.35	1983.00	2249.02
Hunan N	2516.00	2334.02	2422.87	2639.57	2623.29
Guangxi P	1983.75	1994.33	2138.26	2136.81	2157.43
Guizhou Q	2415.67	2408.27	2448.97	2440.46	2246.84
	Protein (g) /day/reference man				
Provinces	COCS1989	CHNS1991	CHNS 1993	CHNS 1997	CHNS 2000
Liaoning E	66.90	81.51	65.29	.	69.78
Heilongjiang G	75.50	.	.	64.83	57.30
Jiangsu I	57.80	71.42	72.83	72.80	85.53
Shandong H	62.70	66.16	65.31	69.89	69.50
Henan D	70.37	62.59	63.03	64.87	62.02
Hubei O	57.95	58.30	53.55	55.36	59.90
Hunan N	52.87	71.56	73.43	79.72	92.82
Guangxi P	45.05	61.18	66.17	67.46	63.64
Guizhou Q	55.73	67.25	67.55	71.24	64.81
	Fat (g) /day/reference man				
Provinces	COCS1989	CHNS1991	CHNS 1993	CHNS 1997	CHNS 2000
Liaoning E	38.60	63.87	55.65	.	78.62
Heilongjiang G	70.00	.	.	67.32	62.98
Jiangsu I	53.97	59.29	62.18	73.64	90.33
Shandong H	68.90	55.81	53.41	53.49	68.15
Henan D	25.87	48.07	46.03	52.42	57.14
Hubei O	47.90	52.03	52.28	58.65	72.68
Hunan N	61.53	82.27	79.25	89.55	95.11
Guangxi P	41.67	59.34	64.17	65.98	73.89
Guizhou Q	51.50	62.42	66.43	63.70	69.95
	% Energy from Protein/day/reference man				
Provinces	COCS1989	CHNS1991	CHNS 1993	CHNS 1997	CHNS 2000
Liaoning E	11.30	11.80	11.63	.	12.40
Heilongjiang G	10.80	.	.	10.73	11.33
Jiangsu I	9.36	12.24	11.96	12.09	12.52
Shandong H	11.60	12.75	13.63	13.67	13.18
Henan D	10.93	11.48	11.87	11.97	11.48
Hubei O	9.00	12.01	11.24	11.12	10.78
Hunan N	8.48	12.51	12.57	12.46	13.51
Guangxi P	9.22	12.41	12.67	12.85	11.99
Guizhou Q	9.27	11.56	11.38	11.73	11.55
	% Energy from Fat /day/reference man				
Provinces	COCS1989	CHNS1991	CHNS 1993	CHNS 1997	CHNS 2000
Liaoning E	14.80	19.67	21.34	.	29.33
Heilongjiang G	23.00	.	.	23.23	26.74
Jiangsu I	19.57	24.07	24.34	27.55	29.77
Shandong H	27.60	25.54	24.71	24.34	29.17
Henan D	9.10	22.12	20.75	23.39	24.05
Hubei O	16.25	28.32	28.23	28.32	29.23
Hunan N	21.73	33.73	30.74	30.35	32.26
Guangxi P	18.32	29.48	28.35	28.49	31.71
Guizhou Q	18.97	24.40	23.84	23.92	27.07

Note: Heilongjiang province is not available in 1991 and 1993; Liaoning province is not available in 1997.

Table 2 Household and Individual Characteristics in CHNS 1991-2000

	Rural				Urban			
	Full Sample		Consecutive sample		Full Sample		Consecutive sample	
	1991	2000	1991	2000	1991	2000	1991	2000
Household (N)	2392	2529	910	1011	1107	1278	346	389
HH income (yuan)	4660.18	10394.69	4522.38	10281.72	6499.44	14606.28	6658.48	13909.98
PC income (yuan)	1668.17	2907.45	1580.91	2699.03†	2328.74	4629.04	2458.36	4321.20†
Real Productive Assets (yuan)	319.37	899.33	350.51	792.07	182.54	679.65	245.18	882.29†
Real Durable Assets (1000 yuan)	1384.04	2989.99	1197.39†	2675.18	2786.75	3895.58	2464.21†	3892.54
Land Cultivated Mean (mu)	4.49	7.57	4.70	5.34	2.45	5.05	2.19	4.39
Men (N)	2493	2245	825	825	1,189	1,165	327	327
Mean Age	41.52	48.16	41.21	50.23†	43.19	49.91	41.66†	50.72
Mean Years of Education	6.68	7.29	6.57	6.54†	7.96	8.95	7.46†	7.73†
% No Formal Education	10.67	8.20	10.42†	10.91†	10.51	7.04	10.70	10.09†
% Some Primary	19.41	15.37	20.73	20.73	16.06	10.47	17.13	15.29
% Primary Diploma	24.39	25.03	23.52	22.91	14.89	15.36	15.90	17.43
% Lower Middle School	30.77	33.59	33.33	33.45	27.84	29.18	29.36	29.36
% Higher Middle School	11.75	11.67	9.94	9.58	14.55	15.97	15.90	14.98
% Technical/College	3.01	6.15	2.06	2.42	16.15	21.97	11.01	12.84
Mean BMI	21.34	22.70	21.25	22.25†	22.03	23.43	21.79	22.92†
% Undernourished (<18.5)	10.51	5.61	8.48†	6.06†	8.33	4.21	8.26	6.12†
% Normal weight (18.5-25)	80.39	73.50	83.39	77.70	77.12	65.32	79.20	70.03
% Overweight (≥25)	9.11	20.89	8.12	16.24	14.55	30.47	12.54	23.85
% Obese (≥30)	0.88	1.96	0.48	1.09	0.93	3.35	0.92	2.75
Women (N)	2727	2475	1,055	1,055	1,342	1,304	382	382
Mean Age	41.43	47.98	41.03	50.06†	43.01	49.72	40.68†	49.75
Mean Years of Education	4.47	5.30	3.88	4.24†	6.37	7.19	5.79†	6.04†
% No Formal Education	34.80	26.18	38.77†	33.55†	26.23	18.87	26.18†	24.61†
% Some Primary	17.05	17.09	18.58	20.19	14.53	13.65	18.85	15.18
% Primary Diploma	19.77	22.59	20.38	21.23	10.66	15.11	13.09	17.02
% Lower Middle School	20.54	23.80	16.30	19.34	25.04	23.31	24.61	21.99
% Higher Middle School	6.56	7.07	5.59	5.02	13.41	14.19	11.52	13.61
% Technical/College	1.28	3.27	0.38	0.66	10.13	14.88	5.76	7.59
Mean BMI	21.85	23.08	21.61	22.83†	22.29	23.60	22.31	23.68
% Undernourished (<18.5)	10.74	6.38	10.52†	7.68†	9.09	4.91	6.28†	3.14
% Normal weight (18.5-25)	75.14	68.57	77.73	69.19	71.76	63.57	76.44	64.40
% Overweight (≥25)	14.12	25.05	11.75	23.13	19.15	31.52	17.28	32.46
% Obese (≥30)	1.65	3.52	1.04	1.80	2.24	3.60	1.31	3.66

Note: † indicates statistically significant difference ($p<0.05$) between the full and subset of consecutively surveyed individuals.

Table 3 Trends of Average Daily Calories, Fat, Protein and Carbohydrate Intakes in CHNS 1991-2000

		Rural				Urban			
Full Sample		1991	1993	1997	2000	1991	1993	1997	2000
Men	Energy /day (kcal)	2562.40	2459.15	2207.07	2221.05	2313.31	2213.21	2178.85	2113.44
	Protein/day (g)	82.71	80.90	74.30	75.90	83.32	81.56	82.24	82.62
	Fat/day (g)	32.73	33.75	29.51	35.89	42.20	45.75	48.34	52.76
	% protein/day	13.00	13.25	13.66	13.76	14.51	14.93	15.30	15.64
	% fat/day	11.60	12.34	12.17	14.22	16.05	18.36	19.89	21.88
	% Moderate activity	15.04	14.69	13.32	14.39	24.98	29.41	23.78	20.52
	% Very light/light activity	21.62	19.41	26.45	26.77	48.70	46.19	53.50	58.54
	% Heavy/very heavy activity	63.34	65.91	60.23	58.84	26.32	24.40	22.72	20.94
Women	Energy /day (kcal)	2237.24	2128.17	1896.52	1900.91	1947.10	1879.96	1855.51	1778.52
	Protein/day (g)	73.31	70.94	64.36	65.68	70.46	69.99	71.63	70.69
	Fat/day (g)	28.08	28.12	24.68	30.44	34.97	39.33	41.10	44.21
	% protein/day	13.20	13.41	13.72	13.93	14.55	15.04	15.63	15.93
	% fat/day	11.33	11.86	11.81	14.12	15.82	18.46	19.70	21.52
	% Moderate activity	12.47	12.27	10.48	9.86	19.08	18.13	15.84	12.04
	% Very light/light activity	25.23	20.39	30.04	33.33	54.17	54.55	63.18	66.95
	% Heavy/very heavy activity	62.30	67.34	59.48	56.81	26.75	27.32	20.98	21.01
Consecutive Sample									
Men	Energy /day (kcal)	2635.35[†]	2519.00[†]	2289.84[†]	2286.67[†]	2366.81	2214.09	2147.93	2121.41
	Protein/day (g)	84.02	80.78	76.16[†]	77.05	83.70	79.73	82.25	82.94
	Fat/day (g)	31.37	32.10[†]	31.24[†]	36.60	40.92	42.08[†]	47.67	50.92
	% protein/day	12.82[†]	12.97[†]	13.50[†]	13.54[†]	14.25[†]	14.65	15.62	15.64
	% fat/day	10.64[†]	11.40[†]	12.37	13.93	15.22[†]	16.97[†]	20.27	21.13
	% Moderate activity	12.00[†]	10.67[†]	12.12[†]	13.58[†]	22.94[†]	25.99[†]	26.30[†]	18.04[†]
	% Very light/light activity	14.18	15.39	20.73	20.48	38.23	38.53	48.32	53.21
	% Heavy/very heavy activity	73.82	73.94	67.15	65.94	38.84	35.47	25.38	28.75
Women	Energy /day (kcal)	2316.34[†]	2181.05[†]	1951.76[†]	1987.65[†]	1987.37	1939.23[†]	1878.07	1800.88
	Protein/day (g)	74.92[†]	71.09	65.76[†]	67.23[†]	70.28	70.17	72.58	70.99
	Fat/day (g)	26.40[†]	27.00	25.68[†]	30.39	32.54[†]	38.73	41.67	43.69
	% protein/day	13.00[†]	13.13[†]	13.62	13.65[†]	14.23[†]	14.65[†]	15.77	15.76
	% fat/day	10.28[†]	11.06[†]	11.98	13.44[†]	14.47[†]	17.71	20.07	20.74
	% Moderate activity	9.67[†]	9.29[†]	8.53[†]	9.86[†]	18.06[†]	17.54[†]	19.63[†]	12.04[†]
	% Very light/light activity	16.02	13.46	22.37	24.27	39.53	43.46	56.81	58.12
	% Heavy/very heavy activity	74.31	77.25	69.10	65.88	42.41	39.01	23.56	29.84

Note: [†] indicates statistically significant difference ($p<0.05$) between the full and subset of consecutively surveyed individuals. The daily intakes of energy, fat, protein and carbohydrates are based on the 1991 China Food Composition Table (FCT). All food items are included. The major food categories are: alcoholic beverages, cereals, condiments, dairy products, egg and egg products, fish, fresh beans, fruits, leafy vegetables, legumes, meats, melons, milk substitute and infant foods, mushrooms, nightshades, nuts and seeds, shrimp and crab, pickled vegetable, roots and stems, poultry, and shellfish.

Table 4 Multinomial Model of Underweight or Overweight on the Full Sample for Men and Women

	Rural Men		Urban Men		Rural Women		Urban Women	
	OR Underweight [95%CI]	OR Overweight [95%CI]	OR Underweight [95%CI]	OR Overweight [95%CI]	OR Underweight [95%CI]	OR Overweight [95%CI]	OR Underweight [95%CI]	OR Overweight [95%CI]
Some Elementary	0.81	0.96	1.03	0.92	0.87	1.33	1.65	0.81
	[0.38, 1.69]	[0.53, 1.74]	[0.24, 4.42]	[0.42, 2.01]	[0.49, 1.56]	[0.94, 1.88]	[0.56, 4.84]	[0.48, 1.35]
Elementary degree	0.85	1.39	0.95	0.76	0.57*	1.08	0.51	1.00
	[0.39, 1.85]	[0.79, 2.46]	[0.22, 4.17]	[0.36, 1.59]	[0.29, 1.11]	[0.77, 1.54]	[0.12, 2.23]	[0.60, 1.64]
Lower Middle School	0.91	1.20	1.97	0.68	0.92	1.16	0.92	0.98
	[0.41, 2.02]	[0.68, 2.11]	[0.48, 8.13]	[0.33, 1.39]	[0.47, 1.82]	[0.80, 1.68]	[0.26, 3.28]	[0.58, 1.65]
Upper Middle School	0.96	1.51	0.87	0.76	0.52	0.76	0.12*	0.49**
	[0.35, 2.64]	[0.80, 2.84]	[0.15, 5.14]	[0.35, 1.65]	[0.16, 1.65]	[0.45, 1.27]	[0.01, 1.22]	[0.27, 0.91]
Technical/College	0.77	2.03*	1.90	0.86	4.78***	1.31	1.74	0.47**
	[0.15, 4.00]	[1.00, 4.14]	[0.37, 9.87]	[0.41, 1.83]	[1.77, 12.87]	[0.67, 2.57]	[0.39, 7.75]	[0.25, 0.87]

Note: Using CHNS 2000, also included are age, age-squared, current smoking status, working, ill or injured or hospitalized during last four weeks, self-reported general health status, official or village cadre, number of household members, number of children and elderly in the household, deflated per capita income, deflated self-reported worth of durable assets, community environmental factors for water type and excreta surroundings, free market prices for commonly consumed fish, province fixed effects; * significant at 10%, ** significant at 5%, and *** significant at 1%

Table 5 Education and Leisure Physical Activity*

	# hours per week for leisure physical activity			
	Rural Men	Urban Men	Rural Women	Urban Women
Some Elementary	0.04	-0.27	0.08	0.02
	(0.08)	(0.25)	(0.06)	(0.13)
Elementary degree	-0.06	0.01	0.10	0.24
	(0.07)	(0.28)	(0.06)	(0.17)
Lower Middle School	-0.06	0.12	0.04	0.46**
	(0.07)	(0.29)	(0.04)	(0.18)
Upper Middle School	-0.02	0.24	0.04	0.67***
	(0.08)	(0.32)	(0.07)	(0.24)
Technical/College	0.15	0.65*	0.36*	0.59**
	(0.13)	(0.35)	(0.18)	(0.25)

*Note: Outcome measures total number of hours per week participating in martial arts, gymnastics, dancing, acrobatics, track and field, swimming, soccer, basketball, volleyball, badminton or tennis, using 2000 data. We didn’t include other board games as it is not clear how intensive they were. We didn’t include the time walking or biking to and from work, school or shopping since that was not part of leisure physical activities.

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