The Adjusted Measure of Body Mass Index for the Chinese and its Impact on Health

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Abstract

The aim of this paper is to examine the impact of socio-economic status (SES) on the Body Mass Index (BMI), a formula based on the ratio of height to weight, linked to health, using a four-year (1991, 1993, 1997 and 2000) panel data set which comes from the Physical Examination in China Health and Nutrition Survey. To an extent we confirm the results with respect to the linkage between SES and the documented healthy BMI found for other developing countries. Furthermore, apart from using the existing specification of BMI, we develop a little further the issue on how to define BMI with respect to the adjustment of gender and age. This leads to a slightly different formulation for the BMI and a substantially different healthy range based on self-reported health. We also find that variables such as income can modify the impact of an adverse BMI on health.

Keywords: Body Mass Index; Health; China

JEL Classification: I1, I2

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1. Introduction

The concept of a healthy weight range is based on a measurement known as the Body Mass Index (BMI). It is one of the anthropometric indices of obesity, and has been suggested as an acceptable proxy to identify individuals at risk of cardiovascular diseases[1]. From the economic point of view, some researchers have also taken BMI as an element of a life style which is closely related to health behaviours (Contoyannis and Jones, 2004). The interest in the relation between the components of socio-economic status (SES) and BMI has been renewed within the recent years. Body mass and the prevalence of obesity have been shown to be inversely associated with SES in the United States and other industrialized countries (Sobal and Stunkard, 1989; Jeffery and French, 1996; Montgomery, *et al*., 1998; Wardle, *et al*., 2004). However, for developing countries, the positive association between SES and BMI has also been observed in many studies (de Vasconcellos, 1994; Delpeuch, *et al*., 1994; Reddy, 1998).

The BMI is calculated as weight in kilograms over height in meters squared (weight (kg)/height (m)^2). The World Health Organization (WHO) has devised a classification where persons with BMIs below the range 19-25 are considered underweight, those with BMIs above this range are considered overweight or "at risk", and those with BMIs greater than or equal to 30 are considered obese. These WHO BMI classifications of overweight and obesity are intended for international use. However, a growing body of literature in anthropometry indicates that these cut-off points are likely to be lower among Asian populations because the greater prevalence of cardiovascular disease risk factors is

[1] BMI is highly correlated with body fat, and, subsequently, health risk, specifically type 2 diabetes and cardiovascular disease, which are rapidly becoming major causes of death in adults in all populations (WHO Expert Consultation, 2004).

at lower BMIs in Asian populations than in Western populations[2] (see, e.g. Moon, *et al.*, 2002). Recent data showing that excess cardiovascular morbidity at the 'normal' range of BMI have been reported in several Asian countries: China, Korea, Singapore and Japan (Misra, 2003). In response to this, the Western Pacific regional office of the WHO, the International Association for the Study of Obesity (IASO), and the International Obesity Task Force (IOTF) collaborated in the creation of new recommendations for BMI among Asian populations, and overweight is defined as a BMI>=23[3]. This recommendation is provisional and is based on a limited literature concerning the distribution of BMI in Asian populations and the associations mainly between BMI and the prevalence of cardiovascular disease risk factors (Wildman, *et al*., 2004). In addition, the BMI-mortality association also adds important information to BMI-cardiovascular morbidity data, and researchers have also investigated the effects of gender, age, smoking status and history of disease on this relation between BMI and mortality (see e.g. Calle, *et al.*, 1999; Zhao, *et al.*, 2002). Specifically for the Chinese, the overweight status is defined as a BMI>=24 for the Chinese (WHO Expert Consultation, 2004). Recent studies have also proposed and verified a BMI reference to identify overweight and obesity for Chinese school-age children and adolescents (see e.g. Ma, *et al.*, 2006).

Results of several studies have shown that the BMI is highly correlated with percentage of body fat and it is largely independent of height, *enabling an unbiased comparison between short and tall population groups*[4]. However, the BMI is gender and age dependent when used as an indicator of body fatness (Gallagher, *et al*., 1996). It may overestimate fatness among those who are muscular and vice versa. For example, when people are getting old, their body fat increases and muscle diminishes, while the BMI stays stable during these changes (Prentice and Jebb, 2001). From the perspective of body

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[2] Evidence shows that Asian populations have a higher percentage of body fat than do Western populations for a given BMI (see, e.g. Gallagher, *et al*., 2000 and Deurenberg, *et al*., 2002). This may be partially responsible for the greater prevalence of cardiovascular disease risk factors at low BMI.

[3] The World Health Organization Western Pacific Region, The International Association for the Study of Obesity, and The International Obesity Task Force. The Asia-Pacific perspective: redefining obesity and its treatment. Sydney: Health Communications Australia Pty Limited, 2000 (Wildman, *et al*., 2004).

[4] Italics are from WHO Expert Consultation, 2004.

composition, the unreliability of BMI for predicting body fat and obesity is because it does not distinguish between fat and fat-free mass (Gallagher, *et al*., 1996; Burkhauser and Cawley, 2008). Recent work has started to evaluate more accurate measures of fatness which have greater theoretical support in the medical literature (see e.g. Burkhauser and Cawley, 2008).

Following the start of social economic reform in 1978 in China, there has been increased attention on how to improve the awareness of health problems, and how these problems are distributed across people with different personal and social characteristics. In this paper, we use the panel data of the Physical Examination in China Health and Nutrition Survey (CHNS) covering the years of 1991, 1993, 1997 and 2000. We attempt to develop further the issue on how to define BMI with respect to the adjustment of gender and age. Based on this adjusted measure of BMI, we examine the ‘healthy range’ based on a self-reported measure of health (SRH), and further explore the moderating influences of an adverse BMI on health. Note that most studies relating BMI to health have focused on particular diseases and mortality. However, there is evidence to suggest that SRH is a powerful predictor of more objective measures of health, such as the future medical care usage (see e.g. van Doorslaer, *et al*., 2000; 2002) and subsequent mortality (see e.g. Idler and Kasl, 1995; Idler and Benyamini, 1997).

This paper is organized as follows: In the next section, we describe data specifications. Preliminary statistics are provided in this section. Section 3 presents the empirical results. This will be in two stages. Firstly the impact of SES on documented healthy BMI, followed by exploring alternatives. We introduce gender and age in the BMI formula, and examine the healthy range based on this adjusted measure of BMI. We conclude this paper in the final section.

2. Data Specification

The dataset we use comes from the Physical Examination in CHNS which is a four-year panel data survey including 1991, 1993, 1997 and 2000. This dataset was collected mainly by the Carolina Population Centre and it provides a valuable sample for researchers in health and nutrition fields. The CHNS, or private surveys in general, can safely rule out the possible data falsification by Chinese statistical authority or government department (Holz, 2004)[5]. CHNS utilizes a multistage, random cluster-sampling scheme. The sample households were randomly drawn from eight provinces including Liaoning/Heilongjiang, Shandong, Jiangsu, Henan, Hubei, Hunan, Guangxi, and Guizhou[6], and in each province, both rural and urban residents are sampled. While the survey is not nationally representative, and in particular does not cover the Northwestern provinces of China, the provinces which are included do vary substantially in terms of geography, economic development and health status. We restrict our sample to those between 15 and 75. After also excluding observations with less than full information, it provided 27882 observations (12233 individuals) in the four years altogether. All the variables are defined in Table 1, and Table 2 shows sample means.

Insert Table 1 and Table 2 here.

Educational attainment, occupational status and income are three dominant components of SES. In the survey, completed years of formal education were measured by primary school (1-6 years), lower middle school (1-3 years), upper middle school (1-3 years), middle technical or vocational school (1-2 years) and college/university (1-6 years or more). We aggregate these discrete values based on China's education system to obtain continuous values of the formal education years[7]. It thus takes a value from 0 to 18 with an average value of 6.6 years (7.51 for males and 5.66 females) for all four years of the

[5] Rawski (2001) questioned the accuracy of Chinese statistics, specifically the recent macroeconomic aggregates published by China's National Bureau of Statistics (NBS), based on the possibility of e.g. *administrative interference with statistical work* to accomplish certain goals by *false reporting*. Private surveys, however, have the possibility of the data falsification by the surveyed unit (Holz, 2004), although the reason to do so is not as convincing as macroeconomic aggregates.

[6] Liaoning was replaced by Heilongjiang in 1997 and both Liaoning and Heilongjiang were included in 2000.

[7] In China, basic formal education includes primary education (normally six years) and secondary education. Secondary education is divided into academic secondary education (normally three years of lower and three years of upper middle school) and specialized/ vocational/technical secondary education, i.e., after graduated from the lower middle school, one can apply for upper middle school or middle technical/vocational school.

sample together. From Table 1, we can see the information on different types of occupations in the survey. Because the number of the observations in some types of occupations is relatively small, we select seven occupations which are professionals, administrators, office staff, farmers, skilled-workers, drivers and service workers. Income is measured as deflated total annual household income[8] (ladhinc). It is the sum of household incomes from all sections including income from wages, home gardening, household farms or farming collectives, raising livestock/poultry, collective and household fishing, household business, welfare subsidies or ration coupons, housing subsidies and other sources of income. This variable is transformed to natural logarithms to allow for concavity of the health-income relationship (see e.g. Frijters, *et al*., 2003; Contoyannis, *et al*., 2004). Table 2 shows that the average value for the logarithm of this variable is 8.36 for the whole sample. We also include data on marital status.

SRH is defined by a response to the question 'how would you describe your health compared to that of other people of your age?' The responses to this question take the ordered scale: poor, fair, good and excellent. SRH has been used in previous studies to estimate the relationship between BMI and health (see e.g. Gerdtham and Johannesson, 1999; Zhao, 2005). Figure 1 describes the distribution of SRH across all four years. The distributions show that the majority of observations reflect good health, but there is a trend for the distribution of health to become worse, specifically for the year 2000 when the SRH in the fair group increased and those with good SRH declined[9]. Figure 2 describes the average health status across all four years and it shows the same trend as indicated in Figure 1[10]. This may not be too surprising as China has not only made

[8] According to CHNS, there is no published absolute consumer price index for China that provides a way to compare provinces or urban and rural areas. Rather the State Statistical Bureau publishes annually a consumer price index ratio that shows for urban and rural areas in each province the shift in the cost of living within that geographic area. The CHNS urban and rural price data are used to create a ratio of urban and rural costs for elements of the consumer goods basket, and they create their own costs (yuan) of the consumer basket for each time period for urban and rural areas in each province in the CHNS. Their deflator is based on 1988 prices.

[9] We redo Figure 1 with a fixed set of provinces, i.e. excluding observations in Liaoning and Heilongjiang, and we obtain a largely similar figure. The same exercise has been done for Figure 2 as well. Figures are upon request.

[10] To rule out the possible health-related attrition in the data, we redo Figure 2 using balanced data with 9216 observations, and we obtain a very similar figure. The figure is upon request.

progress in its economic development but also undertaken the persistent and increasing societal inequality over the last decade. The investigation has indicated that the 20 percent with higher income have got a wealth of as much as 42.4 percent of the total wealth in 1999[11] (People's Daily, 2000). The income inequality has largely increased the likelihood of reporting fair and poor health status for people regardless of their own income (Pei and Rodriguez, 2006). In addition, inequality in access to health care may also play a role in this context. Thus it is very likely that the individual's perception of his/her health status may also be influenced by social and economic conditions in China in addition to the actual experience of illness.

Table 3 gives further descriptive statistics on self-reported health across gender, urban/rural and province. In general, rural men report the highest proportion of excellent health, while urban women report the lowest. In all provinces, less than 6% people report that they have poor health. Individuals, specifically urban women, in Guangxi and Guizhou (western provinces) have the lowest percentages of excellent health. People in Heilongjiang (northeastern province), Jiangsu and Shandong (coastal provinces) have the highest percentages of excellent health[12]. The difference is striking. However, if we combine the two categories of excellent and good health, the gap becomes smaller. It is important to keep in mind that this kind of purely descriptive analysis exploits solely the cross-sectional variation in the data rather than the underlying causal relationship between these variables and health.

Insert Figure 1, Figure 2 and Table 3 here.

Figure 3 shows the distribution of those of a healthy weight, underweight and overweight based on WHO's BMI classifications across all four years. The distributions indicate that

[11] An investigation conducted by the State Statistics Bureau Urban Social Economy Investigation Group with 1.25 billion Chinese people investigated. For detailed discussions see Luo and Wen (2002).

[12] The only exception is in Jiangsu-urban, and more noticeable for women. In general, lower percentage of women report to have excellent health compared to men. Empirical studies have observed that women report worse health than men, but the health disadvantage diminishes with age (see e.g. Roy and Chaudhuri, 2008).

the majority of observations are in the healthy weight range (19-25), and there is again a trend for the distribution of BMIs to become slightly less healthy and more overweight. More specifically, people aged under 46 show a strongly increasing trend for being overweight from 1991 to 2000[13], and they also show a decreasing trend for being in the healthy BMI range, more noticeably from 1997 to 2000. With respect to gender, the increasing trend for being overweight is largely similar for men and women across these four years[14]. Figure 4 describes the percentages of healthy weight, underweight and overweight in different health status, and it shows that the highest percentage of overweight BMIs is in the excellent health status. As a dependent variable, we calculate the variable 'healthy BMI' as follows:

$$
\begin{aligned}
&BMI_u' = BMIs < 19 \\
&BMI_o' = BMIs > 25 \\
&BMI_u = BMI_u'*(19\text{-}BMIs) \qquad (1) \\
&BMI_o = BMI_o'*(BMIs\text{-}25) \\
&\text{Healthy BMI} = BMI_u + BMI_o
\end{aligned}
$$

In equation (1), BMI_u measures the distance of the individuals' BMI values from 19 (if their BMIs are less than 19, thus they are underweight), and BMI_o measures the distance of the individuals' BMIs from 25 (if their BMIs are more than 25, thus they are overweight). The Healthy BMI increases with the distance from either side of the healthy range. For healthy people, it takes the value zero. As expected, the BMI_u and BMI_o are negatively correlated with our SRH measure[15].

Insert Figure 3 and Figure 4 here.

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[13] The age cohorts are separated by <=35, 36-45, 46-55 and >55.

[14] We have drawn separate figures for healthy BMI, underweight and overweight by genders and different age cohorts across four years. We do not report these figures here.

[15] The magnitude and significance of the coefficient of BMI_u (=-0.176; t-ratio=-12.5943) on SRH are largely bigger and stronger than the coefficient of BMI_o (=-0.023; t-ratio=-2.0094) on SRH. To put it differently, the negative correlation between BMI_o and SRH is not strongly significant. This is not surprising in developing countries, such as China, since ill nutrition is still a major cause for poor health.

3. Empirical Analysis

3.1. The Documented Healthy BMI Range

The BMI is closely related to nutrition and health behaviour, and it thus to some extent reflects individuals' *objective* health status (see e.g. Kimhi, 2003). In this section, we take the Healthy BMI calculated in equation (1) as the dependant variable, and run the regression with gender, age and SES as the explanatory variables. Recall from the last section that the Healthy BMI measures the distance of the individuals' BMI values from the healthy range (19-25), and the greater the distance from either side the less healthy people are. The total value range of BMI is from 9 to 47, and Table 2 shows that the BMI is within the healthy range for 72% of the individuals.

In addition to the regression with the Healthy BMI (full sample), the variables 'Healthy & Overweight' and 'Healthy & Underweight' are also separately included. Based on the specification of the dependant variable, a Tobit model is selected for its ability to account for the effects of censoring at the lower bound of the BMI risk ladder (i.e., at value 0). We further allow for random-effects as the estimation of a fixed-effects Tobit model is problematic (see e.g. Greene, 2004). Table 4 presents the estimation results.

Insert Table 4 here.

The first two columns of Table 4 show coefficient estimates of the pooled and random-effects Tobit with the dependant variable of Healthy BMI. The likelihood ratio test shows that the panel-level variance component is important, thus we will focus on the results of random effects. Individuals' gender is a significant predictor of healthy BMIs, and men are less frequently overweight/underweight than women[16]. People are more likely to have a healthy BMI when they are getting older, but this is only until age 20. In other words, for the majority of our observations, older people are increasingly less likely

[16] This is predicted on the assumption that the same healthy range is applicable for both men and women.

to be in the healthy BMI range. As to the impact of SES, people with healthy BMIs are most common among individuals with lower household income. Overweight/underweight is overrepresented among administrators, whereas healthy BMIs are common among farmers. In addition, people's education attainment fails to have significant effect on their BMIs for the full sample.

The third and fourth columns of Table 4 show coefficient estimates of the pooled and random-effects Tobit with the selected samples on Healthy & Overweight. Compared to the second column of Table 4, the results in the fourth column show a clearer trend of the impact of age and SES on healthy BMIs. People are more likely to be overweight when they are getting older till they are approximately 60. Being overweight is a characteristic most common among married people, and together with the results in the last two columns of Table 4, married people are generally less likely to be underweight. People living in urban areas tend to be overweight, as individuals living in rural areas usually have more outdoor activities than urban ones. In addition, urban diets are probably quite different from rural ones. Urban people tend to consume more fat and protein based on the individual daily (3-day average) nutrient intakes in the survey[17]. People's education plays a role in determining their BMIs as more educated people are less likely to be overweight. Compared to the results with the full sample Healthy BMI, the positive association between household income and overweight is more robust. This is consistent with many other studies for developing countries. Another more robust result is the linkage between administrative occupations and being overweight. It will be recalled from Table 1 that administrators include executives/managers, factory managers, government officials, section chiefs, directors, administrative cadres. Part of this linkage is because the specification of administrative occupations which gives people who engaged in these jobs 'official' powers to exploit opportunities to become rich or obtain high social status (prestige) specifically during China's transitional process[18]. This may

[17] This comes from the CHNS Individual Daily Nutrients Intake Master File, which contains information regarding the individual nutrient intakes that were converted from foods consumed during the CHNS Diet Survey.

[18] The China's reform process is characterized by the dissolution of planned, central-administrative ordering mechanisms and not always a simultaneous creation of new, more strongly market-oriented elements (Schramm and Taube, 2003). Thus people in certain

relate to the fact that the economically well-off upper strata of the population tend to consume more protein where the average population is undernourished. This may also reflect a cultural dimension of being overweight in China: to be overweight/fat is to be contented and well off. As argued by Reddy (1998), this positive association is qualitatively different from the negative association characterizing contemporary Western populations[19].

3.2. An Adjusted Measure of BMI and its Impact on SRH

In the previous section we based our analysis on the standard formulation for the BMI. In this section we explore alternatives. As mentioned in the introduction, despite the widespread use of the BMI in the social science research, studies in the medical literature demonstrate that BMI is considered to be a '*noisy*' measure of fatness and obesity because it does not distinguish between fat and fat-free mass (Gallagher, *et al*., 1996; Burkhauser and Cawley, 2008). This would be less of an issue if we assume this '*noise*'[20] to be random across different populations without worrying about the misclassification of individuals into weight classifications. However, the average amount of fat-free mass (in kilograms) and total body fat vary with race, and for men and women[21] (Burkhauser and Cawley, 2008). Findings by Gallagher, *et al*. (1996) indicate that when comparing young and old people with similar BMIs, the older person will have a greater percentage of body weight as fat. Similarly, women have significantly greater amounts of total body fat than do men for an equivalent BMI. In this section, we introduce gender and age in the BMI

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occupations have most opportunities to exploit institutional gaps to become rich legally or via corrupt practices. For example, the government officials of social resources hold the power of examination and approval of planned materials and the rights for the use of public funds. For further discussions see *Fighting Corruption in Asia: Causes, effects and Remedies*, edited by Kidd, J. and Richter, F. J., 2003, World Scientific.

[19] Reddy (1998) argued that in the industrialized West, the richer upper strata of the populations, at least, are known to eat a more balanced diet, more possibly exercise during their leisure time and being more conscious of the need to check their weight.

[20] Italics '*noisy*' and '*noise*' are from the paper by Burkhauser and Cawley (2008).

[21] For detailed discussion, see Burkhauser and Cawley (2008). For example, they argued that African American women have 3.56 more kg of fat-free mass than white women and African American men have 1.33 more kg of fat-free mass than white men. Data comes from National Health and Nutrition Examination Survey III (4127 females and 3606 males).

formula to indirectly take into account differences in fat-free mass or total body fat for the BMI calculation.

The empirical work is done in three phases. In the first phase we estimate the standard or normal relationship between weight and height by regressing the former on the latter. Using this we can derive an estimated BMI. We then repeat the exercise with gender and age added and then also with SES added. This raises the question, which we discuss of whether the standard BMI formulation should be adjusted for any of these variables. In phase two we regress a measure of self-reported health on the BMI index, as calculated in phase one, in relation to a healthy range for the BMI. We estimate our own healthy BMI range based on an iterative process. In stage three of the work we construct an at-risk variable based on our estimated BMI and healthy range, which represents being at risk from an adverse BMI, and use this in combination with SES to determine whether any of these modify this at-risk factor.

An Adjusted Measure of BMI

As argued before, BMI is generally calculated as weight in kilograms over height in meters squared (weight(kg)/height(m)²), and it is currently the most commonly used method in the empirical work. But this formula appears to be somewhat arbitrary. Why divide weight by exactly the square of height? Why not the cube, why not simply the ratio itself? In order to investigate this more closely, it is necessary to consider how to define BMI. Considering cross-sectional data for simplicity, we start by estimating the following equation:

$$\text{Log}\,(W_i) = \beta_0 + \beta_1 \log\,(H_i) + \boldsymbol{\beta_2 X_i} + \varepsilon \qquad (2)$$

Where W_i and H_i denote the weight and height of the i'th individual, $\mathbf{X}_i$ is a vector of gender, age and socio-economic characteristics and the log is to the base e. If we exponentiate both sides of equation (2), we get:

$$W_i = e^{\beta_0} H_i^{\beta_1} e^{\boldsymbol{\beta_2 X_i}} \quad (3)$$

Where the coefficients are now the estimated ones and we have dropped the error term (ε) to indicate that this is the predicted weight for someone of these characteristics. If we make the assumption that the average person, i.e. the person whose weight is exactly equal to his/her predicted weight, is healthy, then deviations from this predicted value imply an individual is increasing unhealthy. If the average individual is not healthy then, the methodology is still valid if we assume this to be reflected in the constant term rather than the other coefficients[22].

According to the literature, it suggests that an individual's Body Mass can be formulated by:

$$BMI_0 = W_i / H_i^{\beta_1} \quad (4)$$

Where the subscript denotes that the equation (4) is linked to the 'standard way' of calculating BMI, indeed if β_1=2, then it is exactly the equation documented in the literature. A potential problem revolves around this measure in whether there are systematic differences in people's weight given their height. Thus raising the question as to whether an individual's BMI, used as an unambiguous measure in evaluating health, should be adjusted for gender, age and also SES? In this case, equation (4) should be amended to:

$$BMI_a = W_i / (H_i^{\beta_1} e^{\boldsymbol{\beta_2 X_i}}) \quad (5)$$

Equation (5) shows an amended BMI (BMI_a) adjusted by gender, age and also SES. $\mathbf{X}_i$ presents the gender, age and SES of *i*'th individual as in equation (2). In what follows we shall first base our estimates on equation (4) without the gender, age and SES variables as

[22] The approach is implicitly based on utility maximizing behaviour. We make two assumptions. Firstly that as the BMI relationship states there is a relationship between the ratio of weight to height and health. Secondly that health enters the individual's utility function, that individuals tend to live a healthy life style and thus they tend to a healthy height weight ratio.

is consistent with the traditional approach. The estimated regression based on panel data with random-effects is:

$$\text{Log}(W_i) = 3.04 + 2.09\text{Log}(H_i)$$
$$(289.816) \quad (94.878)$$
$$R^2 = 0.40,\ n=26366 \qquad (6)$$

Where the figures in parentheses represent *t*-statistics and the time subscript is implicit. From this we can calculate the BMI as:

$$BMI_0 = W_i / H_i^{2.09} \qquad (7)$$

The coefficient is close, but slightly higher to, and significantly different from, the standard measure of 2.00 in the literature. Still, it provides some justification for it.

We now turn to consider the equations with gender, age and SES included. As previous mentioned, gender and age are reflecting people's physical characteristics (e.g. body composition), thus we start by the inclusion of gender and age. We take Log(W_i) as a dependant variable and run the regression on Log(H_i), gender and age, and we obtain a value for β_1 of 2.40. The whole regression result is as follows:

$$\text{Log}(W_i) = 2.65 - 0.039\text{gender} + 0.011\text{age} - 0.0001\text{age}^2 + 2.40\text{Log}(H_i)$$
$$(189.035) \quad (13.252) \quad (35.446) \quad (27.440) \quad (83.827)$$
$$R^2 = 0.44,\ n=26366 \qquad (8)$$

Based on these results, we can calculate BMI by:

$$BMI_a = W_i / (H_i^{2.40}\exp(-0.039*\text{gender} + 0.011*\text{age} - 0.0001*\text{age}^2)) \qquad (9)$$

Equation (8) shows that the coefficient on height has significantly increased. To put it differently, the coefficient on height changes when account is taken of gender and age.

We also see that for a given height and weight, the healthy BMI is different for men and women at different ages.

We can divide the part (exp(.)) in equation (9) into two components: exp(–0.039*gender) and exp(0.011*age – 0.0001*age^2), and we will look at them separately. The coefficient of gender suggests that for a given height, weight and age, a BMI_a value for a man (gender=1) is some 4% (= 1 – exp(-0.039)) lower than for a woman (gender=0). As to age, the coefficients indicate that the maximum value for exp($\beta_2$age + $\beta_3$age^2) is when age equals 55[23]. This suggests that BMI_a values are greatest for people aged 55, i.e., given an individual's weight, height and gender, a BMI_a value for someone who is 20, 40 or 70 is systematically lower than someone who is 55. To sum up, for example, the BMI_a value for a Chinese woman aged 50 is some 10% higher than a man aged 30[24]. This is consistent with the discussions mentioned before that the BMI values are age and gender dependent when used as an indicator of body fatness, and in part rules out the misclassification of individuals into weight classifications.

We now report the results of regressing Log(W_i) on Log(H_i) and all SES variables and from this way we obtain an estimate of β_1 of 2.24 as shown in Table 5. In this case, more interesting than the significance of height, gender and age, is the significance of the other variables. Education, household income and administrative and service occupations are all significant at the 1% level and urban is significant at the 5% level. In all cases weight increases with the variable, i.e. it increases with education and income and is higher for executives or those in the service sector and/or those living in towns. Hence to answer the question posed earlier there are systematic differences in people's weight given their height which are unrelated to physical characteristics such as gender and age. We cannot say that the healthy values of BMI for more educated people, for example, should be lower or higher than less educated people, it depends upon their other physical

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[23]The turning point comes when the derivative of Log(W_i) with respect to age equals zero, i.e. when $(e^{(0.011age-0.0001age^2)})' = e^{(0.011age-0.0001age^2)} * (0.011 - 0.0002age) = 0$. Within this equation, $e^{(0.011age-0.0001age^2)}$ can not equal to 0, thus we can only let (0.011 – 0.0002*age*) = 0, and get age=55.

[24] $(e^{(0.011*50-0.0001*50*50)} - e^{(-0.039+0.011*30-0.0001*30*30)})/e^{(-0.039+0.011*30-0.0001*30*30)} = 0.104$ or 10.4%

characteristics. In addition, if height is correlated with education, urban, income, etc, then the exclusion of these variables in the equation will bias the coefficient on height[25]. In addition, it seems reasonable to suggest that all of these variables are ones which tend to be associated with less exercise. For example, people who live in towns will tend to have access to better public transport and walk less than people in rural areas. Similarly less well-educated people probably tend to have more manual jobs.

Insert Table 5 here.

What does this imply about the measure of BMI? In particular should it be adjusted for people's socio-economic status as well as their physical characteristics – gender and age? The answer is no. There seems little reason why someone of a given age, gender, height and weight should have his optimal BMI adjusted because they are an executive or live in the city[26]. However, what it does suggest is that such socio-economic characteristics impact on people's BMI values and hence on health, and also that failing to take cognizance of socio-economic characteristics when estimating the relationship between weight and height can lead to biased results.

Recalculating the Healthy Range

So far we have focused on how to define BMI. We now turn to its impact on SRH together with SES. We will start with BMI_0 derived from equation (7), which is close to that used in the literature. Our main focus is on the relatively complex one (BMI_a) taking into account gender and age from equation (9). The total value ranges of BMI measure based on equation (7) is (8-42) and (5-33) when based on (9), but most observations are

[25] Such correlations may exist because of inter-generational advantages, for example, the children of richer families tend to eat better during childhood and hence arguably become taller.

[26] Of course certain life styles are unhealthy which are linked to unhealthy BMI values. An executive life style, for instance, may be a stressful one – as indeed may be a coal miner's. That is not the issue. Instead we are asking whether the characteristics of a 12 stone, 6 foot, 35 year old man should have different interpretations vis-à-vis BMI values, depending on the individuals level of education or geographic location and on this we believe the answer is no.

within (15-35) and (10-25) respectively[27]. For BMI_0, we now construct two variables BMI_0^u and BMI_0^o as follows:

$$BMI_0^u = (\alpha_L - BMI_0), \text{ operative if } BMI_0 < \alpha_L$$
$$BMI_0^o = (BMI_0 - \alpha_H), \text{ operative if } BMI_0 > \alpha_H \qquad (10)$$

and similarly for BMI_a:

$$BMI_a^u = (\alpha_L - BMI_a), \text{ operative if } BMI_a < \alpha_L$$
$$BMI_a^o = (BMI_a - \alpha_H), \text{ operative if } BMI_a > \alpha_H \qquad (11)$$

The range α_L - α_H is what we term the 'healthy range'. People outside this range are unhealthy, and the greater the distance the less healthy they are. α_L and α_H are the boundary points of the healthy range and we now seek to determine them through regression analysis. Specifically, self-reported health is regressed on (BMI_0^u, BMI_0^o) and (BMI_a^u, BMI_a^o) by an iterative search technique where the critical values for α_L and α_H include all possible combinations from (15-35) and (10-25), which amounted to 231 and 136 regressions based on equations (10) and (11) respectively. We choose the optimal combination on the basis of i) significantly negative coefficients for both (BMI_0^u, BMI_0^o) and (BMI_a^u, BMI_a^o), and ii) by identifying the best fit by the highest log likelihood ratio. Based on this, two BMI healthy ranges have been identified: using BMI_0 as in equation (10), we find critical values for α_L of 22 and α_H of 27[28]; Using the modified BMI (BMI_a) in equation (11), we identify critical values of 15 to 19. Table 6 shows the random-effects ordered probit results[29] which underlie these calculations.

Insert Table 6 here.

At this stage, the 'best' results based on the log likelihood appear marginally to be those

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[27] Both around 98%.

[28] For a comparison purpose, we also use the traditional measure of BMI based on the formula weight(kg)/height(m)², we find critical values for α_L of 23 and α_H of 28.

[29] Note that we obtain the same healthy ranges based on pooled and random-effects results.

based on the standard measure. Note that the healthy BMI range based on BMI_0 in equation (10), i.e., (22-27) per se is higher than (19-25) as documented in literature. The potential reason perhaps is that we are using different measure of health. People with BMIs above 25 are considered overweight or 'at risk', however, these risks are mainly relevant to obesity-related diseases, instead of self-report measure of health which we use in our estimate. In addition, there is some suggestion from the size of the coefficients in Table 6 that BMI_0^u and BMI_a^u may have greater impact on health than BMI_0^o and BMI_a^o, i.e. being underweight has less secure consequences than being overweight. Although this is not something we develop further in this section. The significance of the other variables is largely as before.

Moderating Influences on an Adverse BMI

We now construct a 'New BMI' variable based on BMI_a with the optimal value range of 15 (α_L) and 19 (α_H) obtained from equation (11). It is defined as the sum of BMI_a^u and BMI_a^o. The distance between the BMI_a values and either 15 (α_L) or 19 (α_H) represents a deviation of BMI_a from its healthy range. We attempt to estimate how this healthy range is associated with SES in its impact on health. We construct the following interaction terms: New BMI*gender, New BMI*age, New BMI*age^2, New BMI*education, and New BMI*log(household income). Being as we are using panel data, we also include year dummies. Table 7 shows the results.

Insert Table 7 here.

The first two columns of Table 7 show the estimated coefficients for the ordered probit models based on pooled and random-effects specifications with the inclusion of the New BMI variable. The coefficient of New BMI is significantly negative as expected, which shows that when a person's BMI (based on the equation of BMI_a) value moves away from the healthy range, he/she tends to be less healthy[30]. We now look at whether the

[30] For a comparison purpose, I also run the regression with the NEW BMI calculated by the standard BMI formula and cut-off points, and the coefficient of this variable is significant as

impact of this New BMI on health changes according to different SES. Through the last two columns of Table 7, we can see that the impact of New BMI on health is affected by gender, age, education and income[31]. Males are basically healthier than females, but this is changed when account is taken of the interaction with the New BMI. The coefficient of New BMI*gender is significantly negative, which indicates that, for a given BMI, there is a greater adverse impact on health for a man than a woman. Similarly, the impact of New BMI on health also depends on age, and more specifically, it is convex, first increasing and then decreasing after reaching a certain age. In addition, higher income neutralizes to some extent an adverse New BMI. To put it differently, there is the possibility that the consequences of an adverse BMI can be reduced by greater income, possibly because of better access to medical facilities. Finally and interestingly, a given value of New BMI has a greater adverse impact on health with more education. Viewed in another light, we have concluded that educated people tend to be healthier than less educated people, presumably because they have increased awareness of what constitutes 'healthy living'. An adverse BMI for an educated person, however, suggests that they are not utilizing this knowledge, thus reducing the 'educational advantage' in health.

4. Conclusions

As the prevalence of obesity increases and the public awareness of obesity as a health problem increases, the BMI, as one of the anthropometric indices of obesity, has received considerable attention in recent years. The main contribution of this research has been to test the validity of the BMI formula and to extend it with the adjustment for gender and age for the Chinese population. Our results provide information which can contribute to the formulation of national strategies on obesity and obesity-related diseases. We believe this to be a generally new contribution to the literature, and one which has the potential to be built upon in other countries, including the developed ones such as in North American and Europe.

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expected, but less strong than the adjusted-BMI based one. I do not report results in Table 7.

[31] Note that we have also included the New BMI interactive variables with married, urban and occupations, however, all of them fail to be significant. Results do not be reported in Table 7.

SES is frequently studied in relation to the BMI. However, as previously mentioned, the pattern of this correlation varies with the economic status of a country. We use a four-year (1991, 1993, 1997 and 2000) panel data set and find consistent results with many other studies for developing countries on the positive association between income and administrative occupations and overweight status for the Chinese. This is possibly related to the fact that the economically well-off upper strata of the population in developing countries tend to consume more protein/fat and exercise less. This is also consistent with the recent nutrition transition in China towards a more energy-dense diet, together with less clear changes in activity levels (Wang, *et al.*, 2007). Part of this may be a cultural dimension of the perceived relationship between income and being overweight in China and other parts of the developing world. Future research exploring these 'cultural dimensions' and their implications for being overweight and health would be valuable. As to the impact of education, we find that being overweight is least common among the more highly educated.

The BMI is generally calculated as the weight in kilograms over height in meters squared, however, this formula appears to be somewhat arbitrary. Why divide weight by exactly the square of height? Based on this, we derive an estimated BMI by regressing weight on height, gender and age. Our results suggest that the standard BMI formula is not far of the mark, but nonetheless is in error. We provide a formula for researchers to calculate the estimated BMI with the inclusion of gender and age. This formula is only applicable to China, but the approach could be the foundation for similar work in other countries, enabling a more accurate calculation of the BMI globally. The WHO has defined a healthy range and a person with a BMI outside this range, implying they are underweight or overweight, is deemed at risk. In our work we estimate the healthy range for the Chinese based on SRH by an iterative process. Since we are using different measures of BMI and health, thus the comparison of the healthy range with other studies is rather difficult. Finally, for a given BMI, its adverse impact on health is different for men and women at different ages, and this gives further credence to the view that in interpreting BMI we need to make distinctions on the basis of both gender and age. We also note that variables such as income can modify the impact of an adverse BMI, possibly because of better access to medical facilities.

The research is not without limitations. Firstly, health research in this context generally has focused on the least ambiguous outcomes, such as the use of the prevalence of cardiovascular disease and mortality (Schultz, 1994). We admit the possibility that the self-reported measure may not be as accurate as these outcomes, still, it is of interest in its own right. In addition, these alternative measures of health are in themselves restricted. Secondly, the WHO's BMI can be easily calculated by hand without any knowledge of statistics. The value of our research is mainly to researchers and policy makers as they attempt to evaluate and understand the BMI. Further research to simplify the calculation of gender and age adjusted BMI is certainly needed.

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Table 1 Data Description

Variables	Data Description
Education (Educ)	A continuous value from 0 to 18
Gender	A dummy variable: Males ('1') & Females ('0')
Age	A continuous value, restricted from 15 to 75. Age and age-squared are used in the main regressions.
Marital Status	A dummy variable: Married ('1') & Non-married ('0'). Non-married includes never married, divorced, widowed and separated.
Living Area	A dummy variable: Urban ('1') & Rural ('0')
Household Income (ladhinc)	Total deflated (by 1989 price index) annual household income, log value is used in the regression.
Occupation	Dummy variables. Seven occupations have been chosen based on the sample size, which include: Professionals[1], Administrators, Office Staff, Farmers, Skilled-workers, Drivers and Service Workers.
Regions	Dummy variables. Nine provinces include Liaoning, Heilongjiang, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi and Guizhou.
BMI	Body Mass Index (weight (kg)/height (m)^2) – Healthy range is identified with BMIs of 19-25[2].
Self-Reported Health	Ordinal scales: Excellent ('3'), Good ('2'), Fair ('1'), and Poor ('0')[3].

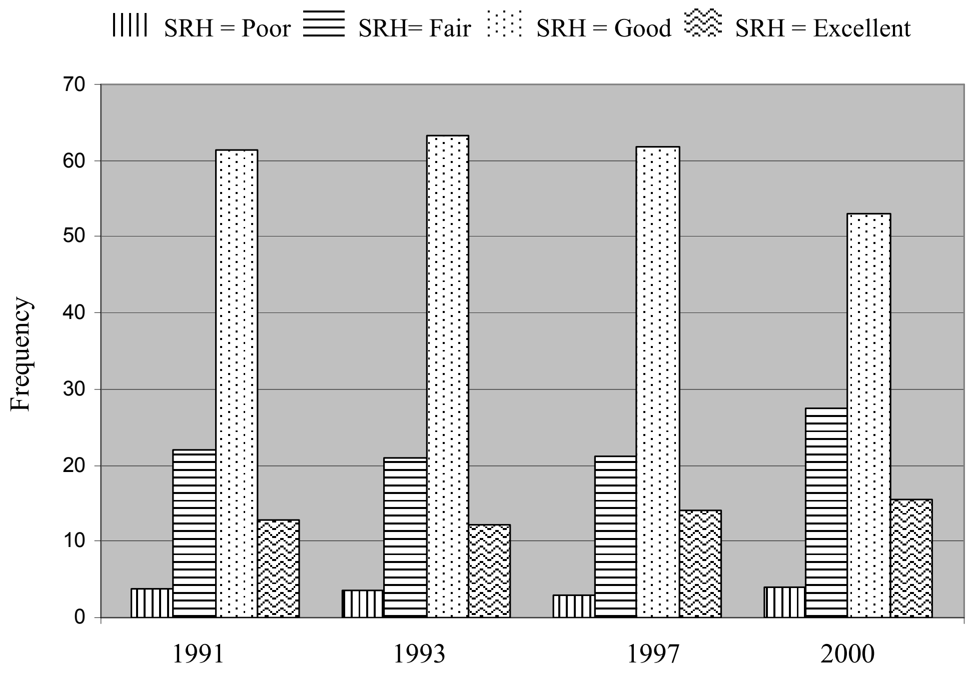
Notes: [1] Professionals include senior professional/technical personnel (doctor, professor, etc.) and professional/technical personnel (editor, photographer, etc.); Administrators include executive/manager, factory manager, government official, section chief, director, administrative cadre; and Service Workers include housekeeper, cook, waiter, doorkeeper, barber/beautician, counter sales, launderer, and childcare. The remaining occupation is the base category in the regression which includes such as non-technical/ non-skilled worker (laborer), homemaker-with no other work, student and others. [2] The figures come from the World Health Organization. [3] We have reversed the scales of the health measure in the CHNS survey to emphasize that higher numbers correspond to better health.

Table 2 Sample Means

	Whole Sample		Males		Females	
Health Status	1.84		1.88		1.80	
Males	0.51		-		-	
Education	6.60		7.51		5.66	
Age	40.24		40.62		39.84	
Married	0.80		0.80		0.80	
Urban	0.29		0.29		0.29	
Ladhinc	8.36		8.36		8.36	
Professionals	0.05		0.06		0.05	
Administrators	0.04		0.07		0.02	
Office Staff	0.03		0.04		0.03	
Farmers	0.57		0.51		0.62	
Skilled-workers	0.07		0.09		0.05	
Drivers	0.01		0.03		0.00	
Service workers	0.07		0.05		0.08	
Liaoning	0.07		0.07		0.07	
Heilongj	0.05		0.06		0.05	
Jiangsu	0.13		0.13		0.13	
Shandong	0.11		0.11		0.10	
Henan	0.12		0.12		0.12	
Hubei	0.13		0.13		0.13	
Hunan	0.11		0.12		0.11	
Guangxi	0.14		0.14		0.14	
Guizhou	0.14		0.14		0.14	
BMIs in healthy range (19-25)		0.72		0.73		0.70
BMIs underweight (<19)		0.13		0.13		0.13
BMIs overweight (>25)		0.15		0.14		0.17
No. of the Observations	27882	26366	14285	13356	13597	13010

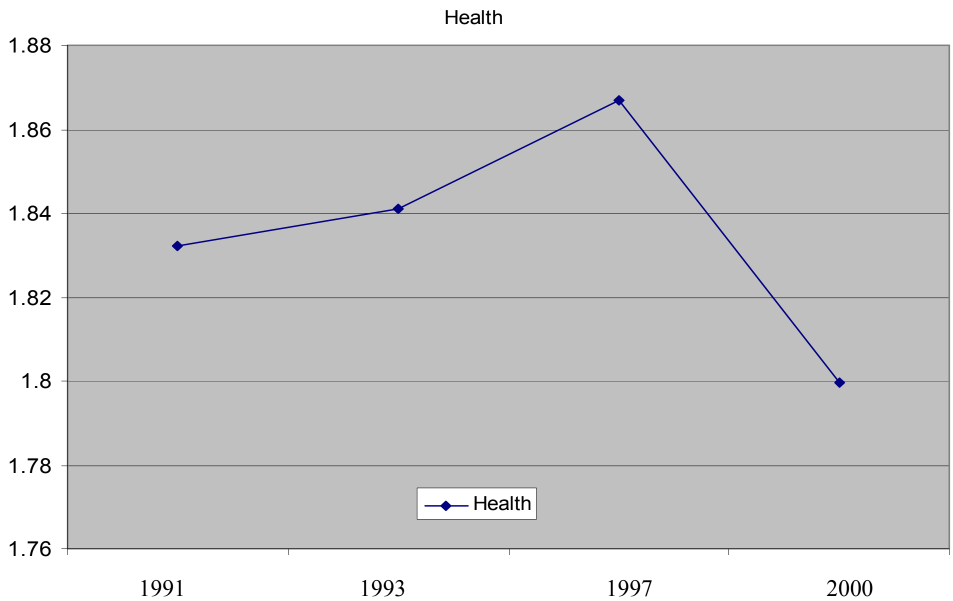
Source: Physical Examination in China health and Nutrition Survey, various years.

Figure 1 Self-reported Health Status by Year



Source: Physical Examination in China health and Nutrition Survey, various years.

Figure 2 Average Status of Self-reported Health by Year



Source: Physical Examination in China health and Nutrition Survey, various years.

Table 3 Self-Reported Health by Genders, Urban/Rural and Provinces

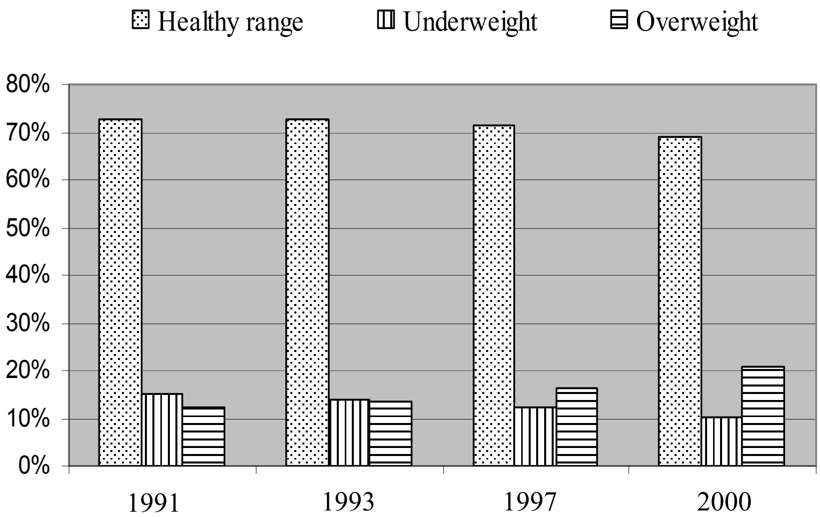
			Whole Sample	Liaoning	Heilongjiang	Jiangsu	Shandong	Henan	Hubei	Hunan	Guangxi	Guizhou
Rural_Male	Poor	Freq.	336	30	5	35	16	53	42	36	49	70
		%	3.32%	4.55%	0.89%	2.72%	1.37%	4.44%	3.38%	3.05%	3.50%	4.86%
	Fair	Freq.	1953	116	54	176	163	255	251	248	376	314
		%	19.27%	17.58%	9.57%	13.69%	13.93%	21.36%	20.23%	21.03%	26.82%	21.82%
	Good	Freq.	6224	387	303	762	698	674	830	751	908	911
		%	61.41%	58.64%	53.72%	59.25%	59.66%	56.45%	66.88%	63.70%	64.76%	63.31%
	Excellent	Freq.	1622	127	202	313	293	212	118	144	69	144
		%	16.00%	19.24%	35.82%	24.34%	25.04%	17.76%	9.51%	12.21%	4.92%	10.01%
	Total	Freq.	10135	660	564	1286	1170	1194	1241	1179	1402	1439
		%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Urban_Male	Poor	Freq.	140	12	13	15	6	18	29	10	18	19
		%	3.37%	3.08%	5.86%	2.98%	1.63%	3.76%	5.26%	1.99%	3.19%	3.33%
	Fair	Freq.	1024	74	68	136	63	152	158	112	164	97
		%	24.67%	19.02%	30.63%	26.98%	17.12%	31.73%	28.68%	22.31%	29.08%	16.99%
	Good	Freq.	2452	238	101	287	202	252	313	299	352	408
		%	59.08%	61.18%	45.50%	56.94%	54.89%	52.61%	56.81%	59.56%	62.41%	71.45%
	Excellent	Freq.	534	65	40	66	97	57	51	81	30	47
		%	12.87%	16.71%	18.02%	13.10%	26.36%	11.90%	9.26%	16.14%	5.32%	8.23%
	Total	Freq.	4150	389	222	504	368	479	551	502	564	571
		%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 3 continued

			Whole Sample	Liaoning	Heilongjiang	Jiangsu	Shandong	Henan	Hubei	Hunan	Guangxi	Guizhou
Rural_Female	Poor	Freq.	366	24	7	39	23	71	48	28	64	62
		%	3.80%	3.75%	1.56%	2.99%	2.08%	6.09%	3.86%	2.70%	4.97%	4.41%
	Fair	Freq.	2280	145	58	255	204	301	297	262	433	325
		%	23.65%	22.66%	12.92%	19.56%	18.43%	25.84%	23.86%	25.24%	33.64%	23.12%
	Good	Freq.	5784	390	241	749	638	623	825	668	747	903
		%	59.99%	60.94%	53.67%	57.44%	57.63%	53.48%	66.27%	64.35%	58.04%	64.22%
	Excellent	Freq.	1211	81	143	261	242	170	75	80	43	116
		%	12.56%	12.66%	31.85%	20.02%	21.86%	14.59%	6.02%	7.71%	3.34%	8.25%
	Total	Freq.	9641	640	449	1304	1107	1165	1245	1038	1287	1406
		%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Urban_Female	Poor	Freq.	146	15	13	15	8	13	25	22	26	9
		%	3.69%	4.14%	5.94%	3.30%	2.63%	2.77%	4.73%	5.37%	4.03%	1.60%
	Fair	Freq.	1072	82	81	142	56	141	152	93	206	119
		%	27.10%	22.65%	36.99%	31.21%	18.42%	30.06%	28.79%	22.68%	31.94%	21.10%
	Good	Freq.	2346	206	91	260	170	261	316	243	385	414
		%	59.30%	56.91%	41.55%	57.14%	55.92%	55.65%	59.85%	59.27%	59.69%	73.40%
	Excellent	Freq.	392	59	34	38	70	54	35	52	28	22
		%	9.91%	16.30%	15.53%	8.35%	23.03%	11.51%	6.63%	12.68%	4.34%	3.90%
	Total	Freq.	3956	362	219	455	304	469	528	410	645	564
		%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

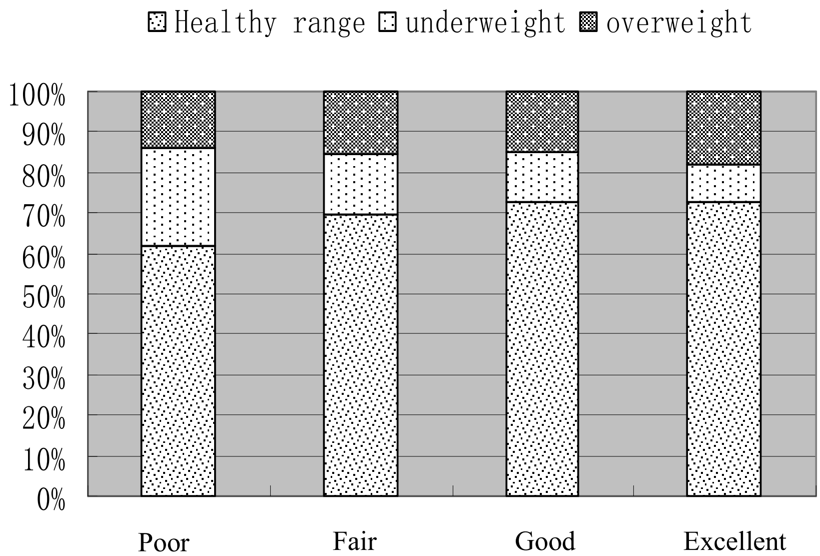
Source: Physical Examination in China Health and Nutrition Survey, various years.

Figure 3 Healthy Weight, Underweight and Overweight by Year



Source: Physical Examination in China health and Nutrition Survey, various years.

Figure 4 Healthy Weight, Underweight and Overweight in Different Health Status



Source: Physical Examination in China health and Nutrition Survey, various years.

Table 4 The Impact of SES on Healthy BMI: (Random-Effects) Tobit Model

Explanatory Var.	**Full Sample**		**Healthy & Overweight**		**Healthy & Underweight**	
	Tobit	RE-Tobit	Tobit	RE-Tobit	Tobit	RE-Tobit
Gender	-0.431***	-0.343***	-0.953***	-0.677***	-0.069**	-0.046*
	(-8.93)	(-7.56)	(-11.10)	(-10.55)	(-1.97)	(-1.91)
Educ	-0.016**	-0.010	-0.032**	-0.019*	-0.002	-0.004
	(-1.99)	(-1.42)	(-2.39)	(-1.89)	(-0.40)	(-0.96)
Age	-0.041***	-0.020**	0.197***	0.164***	-0.126***	-0.090***
	(-3.55)	(-1.97)	(8.78)	(10.36)	(-15.60)	(-16.64)
Agesq	0.0007***	0.0005***	-0.0016***	-0.0013***	0.0015***	0.0011***
	(5.95)	(4.37)	(-6.40)	(-7.74)	(16.69)	(17.54)
Married	-0.110	-0.063	0.459***	0.299***	-0.248***	-0.139***
	(-1.49)	(-1.02)	(3.25)	(3.07)	(-4.92)	(-4.12)
Urban	0.079	0.091*	0.234**	0.205***	-0.050	-0.035
	(1.47)	(1.80)	(2.55)	(3.01)	(-1.22)	(-1.25)
Ladhinc	0.091***	0.068***	0.244***	0.165***	-0.060***	-0.039***
	(2.98)	(2.92)	(4.45)	(4.52)	(-2.72)	(-2.77)
Profes	0.296**	0.151	0.334*	0.200	0.113	0.062
	(2.55)	(1.56)	(1.78)	(1.51)	(1.17)	(0.96)
Adminis	0.497***	0.321***	0.706***	0.441***	-0.148	-0.078
	(4.09)	(3.26)	(3.70)	(3.34)	(-1.31)	(-1.07)
Staff	0.023	0.001	-0.078	-0.049	0.109	0.070
	(0.17)	(0.01)	(-0.36)	(-0.34)	(1.00)	(0.99)
Farmers	-0.609***	-0.415***	-1.656***	-1.066***	0.113**	0.077**
	(-8.49)	(-7.17)	(-13.18)	(-12.35)	(2.10)	(2.20)
Skilled	-0.028	-0.015	-0.039	0.01	0.010	0.002
	(-0.28)	(-0.20)	(-0.23)	(0.09)	(0.13)	(0.05)
Drivers	0.26	-0.019	0.663**	0.28	-0.063	-0.109
	(1.27)	(-0.12)	(1.99)	(1.24)	(-0.37)	(-0.99)
Service	0.180*	0.084	0.337**	0.183	-0.014	-0.025
	(1.73)	(1.04)	(1.98)	(1.59)	-(0.17)	(-0.48)
Reg. Dummies	yes	yes	yes	yes	yes	yes
Year Dummies	yes	yes	yes	yes	yes	yes
Log likelihood	-26970.73	-25240.07	-17027.71	-16236.79	-12117.40	-11754.57
Likelihood-ratio		3461.33		1580.83		725.68
No. of the Obs.	26366	26366	22931	22931	22336	22336

Notes: t statistics in parentheses, *** Significant at 1%; **Significant at 5%; * Significant at 10%. Regressions estimated by Tobit and random-effects Tobit (RE-Tobit).

Table 5 Determinants of BMI Values

Explanatory Variable		**Log(weight)**	
	RE-REG	RE-REG	RE-REG
Gender		-0.039***	-0.036***
		(-13.252)	(-12.392)
Age		0.011***	0.011***
		(35.446)	(30.646)
Agesq		-0.0001***	-0.0001***
		(-27.440)	(-23.485)
Education			0.003***
			(10.646)
Married			-0.0004
			(-0.186)
Urban			0.005**
			(2.223)
Ladhinc			0.002***
			(2.766)
Profes			0.0001
			(0.024)
Admins			0.011***
			(3.627)
Staff			0.002
			(0.708)
Farmer			-0.016***
			(-8.739)
Skilled			0.0004
			(0.193)
Driver			0.009*
			(1.955)
Service			0.009***
			(3.658)
Log(height)	2.094***	2.395***	2.247***
	(94.878)	(83.827)	(76.840)
R-squared	0.40	0.44	0.45
No. of the Obs.	26366	26366	26366

Notes: t statistics in parentheses, *** Significant at 1%; **Significant at 5%; * Significant at 10%. Regressions are estimated based on panel data with random-effects (RE-REG). A constant term, which is not reported, was included in all regressions.

Table 6 The Optimal Calculations for (BMI_0^u, BMI_0^o) and (BMI_a^u, BMI_a^o)

Explanatory Variable	Self-reported Health	
	RE-OP1	RE-OP2
Gender	0.253***	0.224***
	(7.946)	(7.067)
Education	0.024***	0.024***
	(4.737)	(4.741)
Age	-0.043***	-0.025***
	(-5.761)	(-3.363)
Agesq	0.00003	-0.0001*
	(0.339)	(-1.677)
Married	-0.011	-0.004
	(-0.244)	(-0.087)
Urban	-0.385***	-0.385***
	(-10.578)	(-10.582)
Ladhinc	0.109***	0.108***
	(5.945)	(5.925)
Profes	-0.123*	-0.118
	(-1.648)	(-1.581)
Admins	0.186**	0.190**
	(2.398)	(2.449)
Staff	0.148*	0.156*
	(1.792)	(1.884)
Farmer	-0.091**	-0.094**
	(-2.019)	(-2.070)
Skilled	0.171***	0.177***
	(2.725)	(2.811)
Driver	0.292**	0.304**
	(2.128)	(2.223)
Service	0.108	0.108
	(1.582)	(1.574)
BMI_0^u/ BMI_a^u	-0.123***	-0.192***
	(-13.453)	(-13.165)
BMI_0^o / BMI_a^o	-0.103***	-0.119***
	(-4.441)	(-3.476)
Regional dummies	Yes	Yes
Year dummies	Yes	Yes
Log likelihood	-25497.53	-25504.45
Restricted log likelihood†	-25658.92	-25666.20
No. of the Obs.	26366	26366

Notes: t statistics in parentheses, *** Significant at 1%; **Significant at 5%; * Significant at 10%. Regressions are estimated by random-effects ordered probit. † Log-likelihood ratio is calculated by $2(L_{unrestricted} - L_{restricted})$. BMI_0^u and BMI_0^o are defined by equation (10), and BMI_a^u and BMI_a^o are defined by equation (11). The results of first column (RE-OP1) are based on (BMI_0^u, BMI_0^o), i.e. (22-27). The results of second column (RE-OP2) are based on (BMI_a^u, BMI_a^o), i.e. (15-19).

Table 7 The Impact of New BMI together with SES on SRH

Explanatory Var.	Self-reported Health			
	OProbit	RE-OProb	OProbit	RE-OProb
Gender	0.205***	0.223***	0.261***	0.286***
	(7.823)	(7.053)	(7.665)	(7.135)
Education	0.021***	0.024***	0.027***	0.031***
	(4.789)	(4.708)	(5.223)	(5.084)
Age	-0.024***	-0.026***	-0.013*	-0.012
	(-3.811)	(-3.440)	(-1.744)	(-1.368)
Agesq	-0.0001	-0.0001	-0.0002**	-0.0003***
	(-1.512)	(-1.623)	(-2.513)	(-2.752)
Married	0.012	-0.003	0.012	-0.002
	(0.290)	(-0.060)	(0.306)	(-0.042)
Urban	-0.352***	-0.384***	-0.354***	-0.386***
	(-11.818)	(-10.557)	(-11.869)	(-10.604)
Ladhinc	0.109***	0.109***	0.084***	0.084***
	(6.627)	(5.982)	(3.974)	(3.603)
BMINEW	-0.160***	-0.182***	-0.029	0.024
	(-13.101)	(-13.264)	(-0.194)	(0.143)
BMI*gender			-0.062**	-0.070**
			(-2.531)	(-2.535)
BMI*age			-0.013***	-0.016***
			(-2.765)	(-3.071)
BMI*agesq			0.0001**	0.0002***
			(2.495)	(2.820)
BMI*education			-0.008**	-0.008**
			(-2.263)	(-2.106)
BMI*Ladhinc			0.028**	0.028*
			(1.972)	(1.790)
Occupations	Yes	Yes	Yes	Yes
Regional dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
Log likelihood	-25668.41	-25506.37	-25655.74	-25493.98
Restricted log likelihood	-27238.45	-25668.41	-27238.45	-25655.74
No. of the Obs.	26366	26366	26366	26366

Notes: t statistics in parentheses, *** Significant at 1%; ** Significant at 5%; * Significant at 10%. Regressions are estimated by ordered probit (OProbit) and random-effects ordered probit (RE-OProb).