

Ren, Yanjun; Castro Campos, Bente; Loy, Jens-Peter; Brosig, Stephan

Article — Published Version

Low-income and overweight in China: Evidence from a life-course utility model

Journal of Integrative Agriculture

Provided in Cooperation with:

Leibniz Institute of Agricultural Development in Transition Economies (IAMO), Halle (Saale)

Suggested Citation: Ren, Yanjun; Castro Campos, Bente; Loy, Jens-Peter; Brosig, Stephan (2019) : Low-income and overweight in China: Evidence from a life-course utility model, Journal of Integrative Agriculture, ISSN 2095-3119, Elsevier, Beijing, Vol. 18, Iss. 8, pp. 1753-1767, [https://doi.org/10.1016/S2095-3119\(19\)62691-2](https://doi.org/10.1016/S2095-3119(19)62691-2)

This Version is available at:

<https://hdl.handle.net/10419/202528>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by-nc-nd/4.0/>



Available online at www.sciencedirect.com

ScienceDirect



RESEARCH ARTICLE

Low-income and overweight in China: Evidence from a life-course utility model



REN Yan-jun^{1,2}, Bente Castro Campos¹, Jens-Peter Loy¹, Stephan Brosig²

¹ Institute of Agricultural Economics, University of Kiel, Kiel 24118, Germany

² Leibniz Institute of Agricultural Development in Transition Economies, Halle (Saale) 06120, Germany

Abstract

Previous literature has demonstrated that low-income people are more likely to settle for poor health choices in developed countries. By using income as a budget constraint and signal for future wellbeing in a life-course utility model, we examine the association amongst income and overweight. The data used for this study are from the China Health and Nutrition Survey (CHNS). Estimations are conducted for overweight initiation, cessation, and participation mirroring a decision to begin and a past decision to not terminate. Our findings propose that body weight and the likelihood of overweight commencement rise with additional income but at a diminishing degree, representing a concave relation; while the likelihood of overweight discontinuance declines with additional income but at an accelerating degree, suggesting a convex relation. We presume that, as opposed to developed countries, low-income people are less inclined to be overweight in China, a country in transition. This could be explained by an income constraint for unhealthy foodstuff. Nevertheless, it will switch when income surpasses the critical threshold of the concave or inverted U-shape curve indicating that low-income people appear to receive not as much utility from future health. Specifically, this adjustment seems to occur earlier for females and inhabitants of urban areas.

Keywords: low-income, overweight, life-course utility, China

1. Introduction

In recent decades, a growing number of studies have investigated the effect of income on individuals' health, and policymakers are increasingly concerned about the

relationship between low-income and health worldwide. In developed countries, it has been well documented that the overall health risk behaviors are more prevalent for low-income individuals compared with other socioeconomic groups (see Lantz *et al.* 1998). Income generally has a positive association with “good” health-related behaviors (Benzeval *et al.* 2000; Binkley 2010; Jolliffe 2011). Lower-income people tend to make less healthy consumption choices. Consequently, they are more likely to suffer from nutrition-related health problems such as overweight and obesity (Sobal and Stunkard 1989; Ball and Crawford 2005).

From an economic perspective, the budget constraint plays an important role in determining poor food consumption behaviors among low-income individuals (see Binkley 2010). In the nutrition-related literature, notably, many researchers

Received 25 July, 2018 Accepted 24 April, 2019
REN Yan-jun, E-mail: yren@ae.uni-kiel.de; Correspondence
Bente Castro Campos, E-mail: bcastro@ae.uni-kiel.de

© 2019 CAAS. Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).
doi: 10.1016/S2095-3119(19)62691-2

argue that low-income people cannot afford to purchase healthy foodstuff, as healthy foodstuff is comparatively more expensive (Drewnowski and Darmon 2005; Drewnowski and Eichelsdoerfer 2010). Notwithstanding, Stewart *et al.* (2003) indicate that low-income households would not purchase more fruits and vegetables with additional income; even though most vegetables and fruits are fairly priced (Kuchler and Stewart 2008). This evidence implies that income as a role of the budget constraint may not be the most crucial determinant for interpreting differences in unhealthy food consumption or health outcomes among individuals situated at different income levels in developed countries. Based upon a life-course utility model, Binkley (2010) puts forward another hypothesis: Low-income people have a comparatively higher direct utility from present consumption but a less intense desire for longevity in the future utility; thus, they have a higher likelihood to consume unhealthy food or to have poor consumption habits.

However, the opposite is true for developing countries. For instance, many studies show that overweight is relatively more widespread among high-income individuals (Popkin 1999; Monteiro *et al.* 2004a; Fernald 2007). With the development of the economy and increasing incomes, total calories consumed has been enhanced accordingly (Ogundari and Abdulai 2013). As a result, overweight and obesity have risen and become a major health challenge in many developing countries (Popkin 1999; Popkin and Ng 2007). In China, dietary preference has changed dramatically from high-carbohydrate food towards high-energy food (Du *et al.* 2004; Batis *et al.* 2014), which increases the risk of overweight. One recent study by Tafreschi (2015) indicates that approximately 30% of individuals are overweight or obese in contemporary China.

In a transitional economy like China, the relation between unhealthy food consumption and income might be a situation that lies in-between developing and developed societies. The income effect on body weight might change from a positive sign to negative with economic development and rising income. However, to the best of our knowledge, very few studies have examined this transition (Pampel *et al.* 2012; Hruschka and Brewis 2013; Deuchert *et al.* 2014), and most of them use cross-sectional data from developing countries and reveal substantial evidence for the reversal hypothesis. Tafreschi (2015), using the data from the China Health Nutrition Survey (CHNS), provides further evidence to support the reversal of the income gradient in China, but without taking an individuals' life-course utility as suggested by Binkley (2010) into consideration. To the best of our knowledge, our study is the first attempt to apply and extend the life-course utility model in the analysis of the reverse relation between income and nutrition-related health issues in a transitional economy like China.

The body mass index (BMI) as an outcome of food consumption is a complicated health measure because it is related to a number of diseases (Jolliffe 2011); and it is often used to determine whether an individual is overweight or obese. According to the NHLBI (1998), being overweight or obese may yield some potential health consequences, e.g., being at increased risk of morbidity from hypertension, type 2 diabetes, stroke, osteoarthritis, respiratory problems, and breast, colon, and prostate cancers. Furthermore, overweight and obesity are also found to be associated with increases in medical expenditure (Konopka *et al.* 2011; Mora *et al.* 2015). Thus, we use overweight to examine individuals' unhealthy food consumption behaviors in this study.

Based on the life-course utility model proposed by Binkley (2010) for unhealthy food consumption, the main contribution of this study is to shed light on the relationship between income and overweight in the transitional economy of China through estimating overweight initiation, cessation, and participation. Using the data from the CHNS, we find that body weight and the likelihood of overweight initiation rise with additional income but at a diminishing degree, representing a concave relation; while the likelihood of overweight cessation declines with additional income but at an accelerating degree, suggesting a convex relation. Thus, we conclude that as opposed to developed countries, low-income people are less inclined to be overweight in China, a country in transition.

The remainder of the paper is organized as follows. The theoretical framework regarding Binkley's (2010) life-course utility model, the empirical model, and the data used are presented in Section 2. Estimation results are discussed in Section 3, and the last section concludes.

2. Methods and data

2.1. Theoretical framework

In neoclassical demand analysis, the base of a rational consumer's decision on what to consume is the utility function. In this study, we apply and extend Binkley's life-course utility model to better understand the reverse relation between income and health. Binkley (2010) proposed a life-course utility model to account for the fact that the effect of unhealthy consumption is of a dynamic nature. Our study applies Binkley's model to unhealthy behavior regarding food consumption. As an extension we account for an income constraint restricting food consumption decisions.

The basic model has the following form:

$$U_L = U_1(X(M), Y(M)) + \theta(t)P(X(M))U_2(g(M)) \quad (1)$$

U_L denotes the expected "lifetime" utility in two periods; the symbols for utility in period 1 (present) and period 2 (future)

are U_1 and U_2 , respectively. X represents the quantity of unhealthy food consumed at present. It affects future utility negatively. Y denotes the amount of all remaining foods consumed in the present. Expenditure on X and Y is limited by a budget constraint given in period 1 by available income M . Utility at present increases monotonically with increasing X or Y . The discount rate at time t within period 1, denoted $\theta(t)$ with $0 < \theta(t) < 1$, is assumed to be the same for all consumers. $P(X(M))$ denotes the probability to survive until period 2 when any positive quantity X of unhealthy food is consumed during period 1. Consuming an unhealthy food item decreases this probability of survival, implying that $P(X(M)) < P(0)$ for any $X > 0$, with $P(0)$ denoting the probability of survival with no unhealthy food consumed. U_2 denotes expected utility in period 2. Our study focuses on the present consumption choice; hence, an assumption of U_2 depending simply on the expected future income $g(M)$ is justifiable. We assume generally that higher current income leads to higher expected future income; hence, $\frac{\partial g(M)}{\partial M} > 0$. The model further maintains the assumption that preferences and prices are constant.

Our particular focus is on the decision to consume or not to consume unhealthy food items, hence on a binary choice. Depending on whether unhealthy foods are consumed or not ($X > 0$ or $X = 0$) life-course utility differs by

$$\begin{aligned} D &= [U_1(X(M), Y(M)) + \theta(t)P(X(M))U_2(g(M))] \\ &\quad - [U_1(0, Y(M)) + \theta(t)P(0)U_2(g(M))] \\ &= [U_1(X(M), Y(M)) - U_1(0, Y(M))] \\ &\quad + [\theta(t)P(X(M))U_2(g(M)) - \theta(t)P(0)U_2(g(M))] \end{aligned} \quad (2)$$

Define:

$$D_1 = U_1(X(M), Y(M)) - U_1(0, Y(M)) \quad (3)$$

$$D_2 = \theta(t)[P(X(M)) - P(0)]U_2(g(M)) \quad (4)$$

$$\text{Thus, } D = D_1 + D_2, \quad (5)$$

where D_1 denotes the direct utility difference between consuming goods bundles containing or not containing unhealthy goods in the first period; D_2 indicates how expected health utility due to life-expectancy differs depending on whether X is consumed or not consumed, in the first period. Hence, the total effect $D = D_1 + D_2$. From $U_1(X(M), Y(M)) \geq U_1(0, Y(M))$ follows $D_1 \geq 0$; and $P(X(M)) - P(0) \leq 0$, hence, $D_2 \leq 0$. With positive but decreasing D_1 (unhealthy food assumed to provide decreasing marginal utility) and increasingly negative D_2 (positive marginal utility of income assumed), it can be expected that overall lifetime utility first increases but from a certain level on decreases with rising income. Lifetime utility is maximized when $X = 0$.

The sign of D determines the decision whether to consume unhealthy foods or not. In particular, without any unhealthy consequence, D will be determined only by D_1 , as $D_2 = 0$; then, whether a good is or is not consumed is determined according to the standard theory of utility

maximization. Denoting the marginal utility of unhealthy food as MU_x and λ the marginal utility of income; a nonzero quantity X of unhealthy goods will be consumed when $MU_x / p_x > \lambda$. Since λ declines with income, the probability that the optimal consumption bundle contains a positive quantity X of unhealthy goods increases with income, except if unhealthy goods are to be considered inferior.

The direct utility difference D_1 rises with income $\frac{\partial D_1}{\partial M} > 0$ if two conditions are met. First, healthy and unhealthy foods are normal goods, second consumption of each of the two groups does not impact on the utility derived from consumption of the other good ($\partial U / \partial X(M) / \partial Y(M) \geq 0$ and $\partial U / \partial Y(M) / \partial X(M) \geq 0$).

If consuming unhealthy goods negatively affects individuals' health, the second part in the life-course utility function should be considered.

The first derivative of D_2 with respect to M ,

$$\begin{aligned} \frac{\partial D_2}{\partial M} &= \theta(t)[P(X(M)) - P(0)] \frac{\partial U_2(g(M))}{\partial g(M)} \frac{\partial g(M)}{\partial M} \\ &\quad + \theta(t) \frac{\partial P(X(M))}{\partial X} \frac{\partial g(M)}{\partial M} U_2(g(M)) \end{aligned} \quad (6)$$

As mentioned before, $P(X(M))$ declines with rising consumption of unhealthy foods X and $P(X(M)) - P(0) \leq 0$, hence we obtain $\frac{\partial D_2}{\partial M} < 0$. Consequently, the negative health

utility derived from consumption of unhealthy food X declines with rising income implying that low-income individuals can be assumed to have lower future health utility of longevity.

The total effect that income has on life-course utility D is

$$\frac{\partial D}{\partial M} = \frac{\partial D_1}{\partial M} + \frac{\partial D_2}{\partial M} \quad (7)$$

More pleasure from consuming unhealthy goods X in period 1 (present) will entail a loss of expected health utility in period 2 (future). Rational consumers will, therefore, consider the trade-off between those two effects. It can be concluded from the theoretical framework that the probability to consume unhealthy food upon income increases is lower for low-income individuals, as unhealthy food likely is non-necessity food.

For low-income individuals the quantity of unhealthy food consumed (X) is comparatively low, hence the direct utility derived from consumption of X at present is larger than the negative health utility experienced in the future. This suggests a positive relationship between income and the probability of consuming unhealthy food.

This positive relationship between income and consumption of unhealthy food prevails up to the point where the budget-constraint comes into effect. At this point the loss in future health utility starts to dominate the direct utility from consuming X in life-course utility D . Hence, the probability

to consume X decreases monotonously with income. At this stage, individuals with low incomes start to consume unhealthy goods X . Analogous to Binkley's (2010) argument one could expect that starting to consume unhealthy food X to either become less and less likely throughout the whole relevant income range or that it becomes more likely first but starts to become less likely as income increases. This suggests an inverted U-shape of the relation between income and the probability of unhealthy food consumption.

For a consumer who is actually consuming unhealthy food, the budget constraint is no longer posing a hurdle, meaning that it does not affect consumption of unhealthy goods anymore as long as prices and income do not change. Therefore, the decision to stop unhealthy food consumption depends on D_2 only. Initially it is smaller than D_1 in absolute value but its importance increases. The relationship between income and the probability to stop unhealthy food consumption is U-shaped or increases with increasing slope. In the decreasing part of the U-shaped curve, low-income individuals are more likely to stop consuming X because they have difficulty to continue consuming unhealthy food at their previous level when they are temporarily overcoming the budget constraint. However, as income increases the life-course utility function will eventually be dominated by negative health utility. This implies that high-income individuals are more likely to stop unhealthy consumption than low-income ones. This suggests that at low income levels the probability of "quitting" a state of overweight (the result or "type" of unhealthy consumption which we focus on in this paper) is negatively associated with income but that it is positively associated at high income levels. As continued consumption of a good can be interpreted as the result of an initial decision to start and (potentially several) decisions not to stop (Kenkel et al. 2009) such "participation" in the behavioral pattern of unhealthy food consumption, can be regarded as a consequence of an individuals' previous decisions and analyzed in its association with income.

2.2. Empirical model

To investigate the relation between income and unhealthy food consumption behaviors, the relationship between income and BMI is examined first as it can largely be considered as one representative health outcome from food consumption. The calculation of BMI is described in Section 2.3. Unlike other studies (Ettner 1996; Goode et al. 2014; Fichera and Savage 2015), the focus of this study is not to estimate the causal relationship between income and outcomes of food consumption due to the high attrition rate of panel estimation (Tafreschi 2015) and unavailability of valid instrumental variables for income (Goode et al. 2014). These difficulties are not uncommon in the health

economics literature, especially in estimating the relation between income and health (Reinhold and Jürges 2012; Apouey and Geoffard 2013; Goode et al. 2014). In this research, a non-linear model is employed to detect an expected inverted U-shape relationship between income and BMI simply defined as

$$BMI_{it} = \beta_0 + \beta_1 Income_{it} + \beta_2 (Income_{it})^2 + \sum_k \beta_k D_{kit} + \vartheta_p + \delta_t + \varepsilon_{it} \quad (8)$$

where BMI_{it} refers to i th individual's BMI at time t ; $Income$ presents per capita household income. To detect the non-linear relationship between income and BMI, the squared term of income is used. Based upon our theoretical framework, we anticipate that β_1 and β_2 are positive and negative, respectively. D_{kit} controls for individuals' demographic variables and household characteristics. We also introduce province dummies, ϑ_p , to control for province-specific and time-invariant characteristics, for instance, cultural or geography features that are unchanged over our survey period. δ_t is used to control for any time fixed effects, such as a nation-wide policy or economic shock that could vary over our survey years but have equal influence on each individual across all provinces. To allow for serial and spatial correlation within each community, we cluster the error term ε_{it} by community. The disturbance term ε_{it} is assumed to be normally distributed.

With the estimated parameters from the model above, we can calculate the critical value (CV) or threshold value for income after which the reverse effect of income plays the dominant role, using the following formula:

$$CV_{income} = -\beta_1 / 2\beta_2 \quad (9)$$

As suggested in the literature, overweight is mostly related to unhealthy food consumption; thus, three binary choice models are estimated for overweight initiation, cessation, and participation. Our primary concern is how income correlates with the probability of starting and stopping consuming unhealthy food X , which in our study is related to being overweight or not and measured by considering the BMI (Section 2.3). The empirical models are defined as follows for overweight initiation, cessation, and participation:

$$Prob(Y_{it}=1) = \gamma_0 + \gamma_1 Income_{it} + \gamma_2 (Income_{it})^2 + \sum_k \gamma_k D_{kit} + \vartheta_p + \delta_t + \varepsilon_{it} \quad (10)$$

where Y_{it} denotes an individual's status of overweight initiation, cessation, and participation in the survey years considered. A Probit model is estimated for each of the three situations. Precisely, the first model is estimated for the dependent variable *Overweight initiation* defined by a binary indicator, which equals to 1 if an individual was not overweight in the previous survey year but is overweight in the present year, and equals to 0 otherwise. The dependent variable is *Overweight cessation* in the second model, and it is 1 if an individual is overweight in the previous survey year but is not overweight in the present survey year and equals

to 0 otherwise. The entire sample is estimated in the first model of *Overweight initiation*, but the model for *Overweight cessation* is solely restricted to those individuals for whom *Overweight initiation* equals to 1. Additionally, the model for *Overweight participation* is also defined by a binary indicator which equals to 1 if an individual is overweight in the current survey year according to the individual's current BMI value, and equals to 0 otherwise. All control variables are the same as in eq. (8), and the same strategy for calculating the critical value of income is used as in eq. (9). The disturbance term δ_{it} is clustered by community to consider serial and spatial correlation within each community.

2.3. Data

The sample To verify our theoretical model, we use the data from the CHNS. By using a multistage and a random cluster process to draw a sample of approximately 4 400 households with a total of 26 000 individuals, the CHNS is designed to study health and nutrition related issues in China. The CHNS began in 1989 and has been conducted for nine waves until now: 1989, 1991, 1993, 1997, 2000, 2004, 2006, 2009, and 2011, and it is conducted in nine provinces including Guangxi, Guizhou, Heilongjiang, Henan, Hubei, Hunan, Jiangsu, Liaoning, and Shandong, which are substantially varying in geography, economic development, and public resources, as well as in health indicators. In 2011 three additional municipal cities (Beijing, Chongqing, and Shanghai) were included. Since the CHNS data is an unbalanced panel database, we estimate the data as pooled cross-sectional data controlling for province and year fixed effects. The data for the estimation is from 1991 to 2011, as the questionnaires and sampling procedure in the first wave of 1989 are not consistent with those implemented in the following waves (Goode *et al.* 2014; Tafreschi 2015).

Dependent variables In the CHNS, all participants are required to take physical measurements, including height and weight. The BMI can be obtained by dividing weight (in kilogram) by height squared (in meters) using respondents' information on height and weight. According to the conventional standards, an adult is regarded as overweight when his/her BMI is between 25 and 29.9 (WHO 2015)¹. Wu (2006) argues that this classification for overweight from the World Health Organization (WHO) is commonly used for Western people but is not applicable to China. We apply the standard defined by Zhou (2002) in which a BMI ranging from 24.0 to 27.9 is classified as overweight, and a BMI ranging from 28.0 and above as obese (see also Xie

and Mo 2014). Since this standard is only appropriate for adults, we limit our data sample to adults who are 18 years old and above. As shown in Table 1, the mean value of the BMI in our sample is approximately 22.81, and its distribution is shown in Fig. 1. For the entire sample, approximately 32.3% of the individuals are observed to be overweight or obese, and it shows increasing tendency and apparent heterogeneity in BMI among males, females, rural and urban samples over survey years as shown in Fig. 2. The portion of 32.3% is relatively high than that obtained in previous studies (Xie and Mo 2014; Tafreschi 2015). Moreover, our sample shows that approximately 16.4 and 34.2% of the individuals surveyed have started being overweight or have stopped being overweight over time, respectively.

Independent variables The key independent variables in our study are income and income squared to examine the nonlinear relationship between income and unhealthy consumption behaviors. Instead of using individual income, per capita household income is used in the estimation because food consumption and nutrition related decisions are normally made at the household level (Tafreschi 2015). Per capita household income is inflated by the consumer price index taking 2011 as the reference year (Table 1). In the following sections, we refer to per capita household income simply as household income. As shown in Table 1, the average annual household income is approximately 7 430 CNY. The CHNS also includes a range of individual demographic variables which are used as control variables in our estimation, including individual's demographics (gender, age, marital status, education, ethnic status, occupation), household characteristics (household size, residence), and province and year fixed effects. The summary statistics for these control variables are also presented in Table 1.

3. Results and discussion

To verify our theoretical model, the relation between income and BMI is estimated by applying OLS estimation. The relations between income and overweight initiation, cessation, and participation are estimated by applying maximum likelihood estimations for Probit models. Pampel *et al.* (2012) argue that there might exist differences between males and females and in socially constructed body weight norms and ideas. Estimations are, thus, more reliable if different samples are estimated for males and females. Similarly, different samples are used for urban and rural residents to check for potential heterogeneity of the income effect.

¹ It defines four different BMI categories: 1) obese (BMI above 30); 2) overweight (BMI between 25.0 and 29.9); 3) healthy weight (BMI between 18.5 and 24.9); and 4) underweight (BMI below 18.5).

Table 1 Definition and descriptive statistics of key variables¹⁾

Variable	Definition	Mean	Std. Dev.
Dependent variables			
Body mass index (BMI)	Weight/Height ²	22.81	3.393
Start overweight	1 if individual starts being overweight, 0 if otherwise	0.164	0.371
Quit overweight	1 if individual quits being overweight, 0 if otherwise	0.342	0.474
Overweight	1 if individual is overweight, 0 if otherwise	0.323	0.468
Income			
Income	Per capita household income adjusted to 2011 price index (10 000 CNY)	0.743	0.806
Income squared	Squared per capita household income (10 000 CNY)	1.202	3.057
Control variables			
Male	Male=1; Female=0	0.486	0.500
Age 18–29	Age 18–29	0.199	0.399
Age 30–39	Age 30–39	0.179	0.384
Age 40–49	Age 40–49	0.195	0.396
Age 50–59	Age 50–59	0.239	0.427
Age 60+	Age above 60	0.135	0.342
Never married	1 if individual is never married, 0 if otherwise	0.125	0.331
Married	1 if individual is married, 0 if otherwise	0.826	0.379
Widowed	1 if individual is widowed, 0 if otherwise	0.011	0.105
Separated	1 if individual is separated, 0 if otherwise	0.048	0.213
Below primary school	1 if the highest level of education is below primary school, 0 if otherwise	0.247	0.431
Primary school	1 if the highest level of education is primary school, 0 if otherwise	0.203	0.402
Middle school	1 if the highest level of education is middle school, 0 if otherwise	0.499	0.500
College	1 if the highest level of education is college, 0 if otherwise	0.050	0.218
Household size	Household size	3.965	1.578
Ethnic minority	1 if individual is ethnic minority, 0 if not	0.129	0.335
Presently working	1 if individual is presently working, 0 if not	0.681	0.466
Urban	1 if individual lives in urban area, 0 if not	0.340	0.474

¹⁾ Authors' estimations based on the China Health and Nutrition Survey (CHNS) samples.

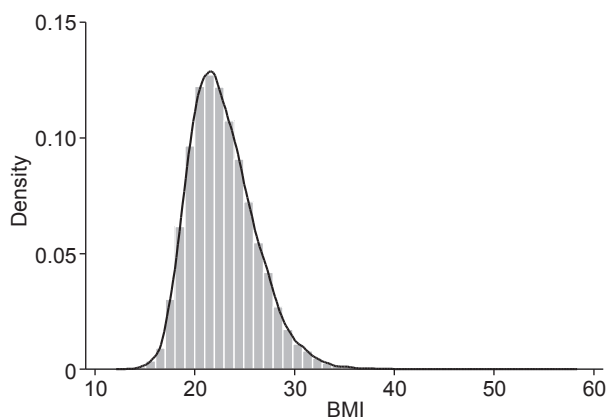


Fig. 1 The distribution of body mass index (BMI) for the pooled China Health and Nutrition Survey (CHNS) sample.

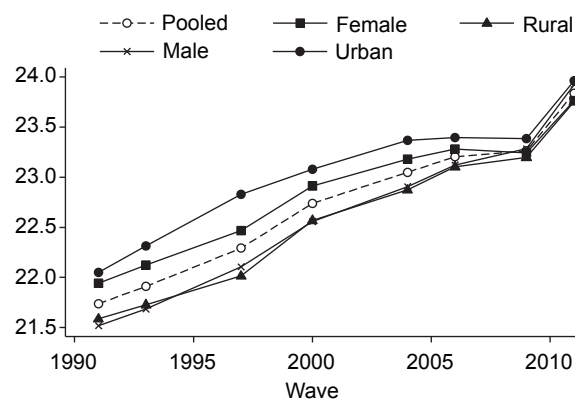


Fig. 2 Average body mass index (BMI) over survey years by gender and by residence.

3.1. The relationship between income and BMI

As shown in Table 2, the relationship between income and BMI, following eq. 8, is estimated using OLS estimation. The positive coefficient of income and the negative coefficient of income squared are both statistically significant at the 1% level in all sample specifications, suggesting that

household income tends to increase individuals' BMI but at a decreasing rate; this finding is in accordance with previous studies (Philipson and Posner 2003; Lakdawalla and Philipson 2009). More specifically, the critical point of the BMI-income quadratic curve is approximately 26 627 CNY, while approximately 95.8% of the individuals in our sample are below this threshold, as shown in Fig. 3. This result indicates that the household income of most observations

considered in our sample is situated in the upper part of the inverted U-shape curve, where consumers' life-course utility is dominated by the direct utility from consumption. Additionally, when other variables are controlled for at the mean values, the marginal effect of income on individual BMI is approximately 0.483, indicating that on average a 10 000 CNY increase in household income will give rise to an individual's BMI of approximately 0.483.

The estimation results for the male and female

subsamples, as well as for the urban and rural subsamples are also presented in Table 2. Generally, the coefficients of income and income squared, are consistent with the estimation results for the pooled sample. Interestingly, the critical value of the BMI-income quadratic curve for females (approximately 24 709 CNY) is relatively lower than the value of 28 659 CNY for males; this suggests that females tend to reduce their BMI at a relatively lower income level compared with males. Looking at the urban and rural samples, we find

Table 2 OLS estimation of the relationship between income and body mass index (BMI)

Variable ¹⁾	Dependent variable: BMI					Marginal effect
	Male (1)	Female (2)	Rural (3)	Urban (4)	Pooled (5)	
Income	0.791*** (0.12)	0.509*** (0.13)	0.625*** (0.13)	0.573*** (0.16)	0.671*** (0.10)	0.483*** (0.06)
Income squared	-0.138*** (0.03)	-0.103*** (0.04)	-0.092** (0.04)	-0.110** (0.04)	-0.126*** (0.03)	
Male			-0.270*** (0.07)	0.073 (0.09)	-0.140** (0.06)	-0.140** (0.06)
Age 30–39	0.521*** (0.07)	0.378*** (0.07)	0.442*** (0.06)	0.484*** (0.09)	0.456*** (0.05)	0.456*** (0.05)
Age 40–49	0.685*** (0.07)	1.114*** (0.07)	0.875*** (0.07)	1.067*** (0.09)	0.933*** (0.05)	0.933*** (0.05)
Age 50–59	0.504*** (0.09)	1.122*** (0.10)	0.738*** (0.08)	1.075*** (0.12)	0.829*** (0.07)	0.829*** (0.07)
Age 60+	0.127 (0.11)	0.555*** (0.13)	0.151 (0.12)	0.611*** (0.13)	0.291*** (0.09)	0.291*** (0.09)
Married	0.948*** (0.09)	0.999*** (0.09)	0.827*** (0.08)	1.133*** (0.11)	0.971*** (0.07)	0.971*** (0.07)
Widowed	0.538** (0.22)	0.690** (0.29)	0.695*** (0.22)	0.512* (0.28)	0.591*** (0.18)	0.591*** (0.18)
Separated	0.172 (0.16)	0.169 (0.16)	0.095 (0.14)	0.575*** (0.20)	0.289** (0.12)	0.289** (0.12)
Primary school	0.249** (0.10)	0.247*** (0.09)	0.121 (0.08)	0.041 (0.15)	0.092 (0.07)	0.092 (0.07)
Middle school	0.552*** (0.10)	-0.226** (0.10)	0.164* (0.09)	-0.268** (0.12)	0.034 (0.07)	0.034 (0.07)
College	0.694*** (0.16)	-1.184*** (0.20)	0.067 (0.19)	-0.500*** (0.18)	-0.274** (0.13)	-0.274** (0.13)
Household size	-0.042** (0.02)	-0.044* (0.02)	-0.054*** (0.02)	-0.031 (0.03)	-0.043** (0.02)	-0.043** (0.02)
Ethnic minority	-0.168 (0.13)	-0.089 (0.16)	-0.365** (0.14)	0.487** (0.19)	-0.126 (0.13)	-0.126 (0.13)
Presently working	-0.353*** (0.07)	-0.573*** (0.07)	-0.480*** (0.08)	-0.426*** (0.09)	-0.501*** (0.06)	-0.501*** (0.06)
Urban	0.271** (0.11)	0.256** (0.11)			0.253*** (0.09)	0.253*** (0.09)
Year dummies	Yes	Yes	Yes	Yes	Yes	
Regional dummies	Yes	Yes	Yes	Yes	Yes	
Constant	20.866*** (0.23)	21.854*** (0.25)	21.884*** (0.25)	21.569*** (0.29)	21.599*** (0.20)	
N	23378	25670	32066	16982	49048	49048
R ²	0.169	0.124	0.140	0.127	0.126	

¹⁾ Time controls include year dummies for 1991, 1993, 1997, 2000, 2004, 2006, 2009, and 2011. Regional controls include dummies for Chongqing, Beijing, Liaoning, Heilongjiang, Shanghai, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi, and Guizhou. Source: authors' estimations based on the China Health and Nutrition Survey (CHNS) samples. Robust standard errors (clustered by community id) are in parentheses. *, $P < 0.10$; **, $P < 0.05$; ***, $P < 0.01$.

that the critical value for the urban sample is approximately 26 045 CNY and approximately 33 967 CNY for the rural sample. The results also suggest that urban residents are more likely to reduce their BMI at a lower income level than are rural residents.

3.2. The relationship between income and overweight initiation

The estimations for the relation between income and overweight initiation are presented in Table 3. We find that the positive coefficient of income and the negative coefficient of income squared are both statistically significant at the conventional levels for all sample specifications except for the female subsample. The results demonstrate existence of an inverted U-shape relationship between overweight initiation and household income. This suggests that the likelihood of ‘starting’ overweight increases with household income at low-income levels and then shows a decreasing trend after the critical point at high levels of household income. As shown in Fig. 4, there exists an inverted U-relationship between income and predicted probability of overweight initiation. Precisely, adults will be less likely to being overweight once their income exceeds the critical point of 20 417 CNY. However, almost 91.5% of the adults considered in our pooled sample are still beneath this threshold, implying that a majority of the adults studied might still be at higher risk of becoming overweight. The marginal effect of income indicates that the likelihood of starting to be overweight would increase by approximately 2.3% points

given a growth in income by 10 000 CNY, holding all other control variables at mean values.

The results for the various subsamples are mostly consistent with the results obtained from the pooled sample as shown in Table 3. For the female subsample, the insignificant coefficient of income and the negatively significant coefficient of income squared, however, suggest that high-income females are unlikely to start being overweight. A similar study by Deuchert *et al.* (2014), using the data from 52 countries, also detects a significantly negative relation between overweight and per capita GDP for females. Moreover, we also find that individuals living in urban areas tend to have a lower threshold value (20 400 CNY), after which adults are less likely to be overweight with growing income.

3.3. The relationship between income and overweight cessation

The estimation results for the relation between income and overweight cessation are shown in Table 4. As expected, the negative coefficient of income and positive coefficient of income squared are both statistically significant, indicating the likelihood of ‘quitting’ overweight would reduce with increasing income but at a decreasing rate. As shown in Fig. 5, there exists a U-shape relation between income and overweight cessation and the critical point is approximately 22 308 CNY. However, almost 91% of the adults considered in our pooled sample are beneath this threshold. Furthermore, the evidence from the marginal

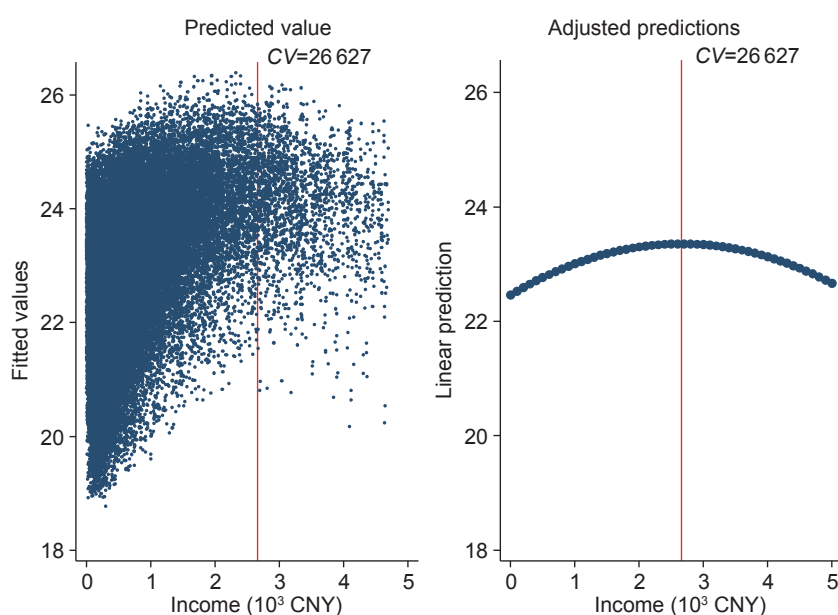


Fig. 3 The relationship between income and predicated body mass index (BMI).

Table 3 Probit estimation results for overweight initiation

Variable ¹⁾	Dependent variable: Overweight initiation					Marginal effect
	Male (1)	Female (2)	Rural (3)	Urban (4)	Pooled (5)	
Income	0.221*** (0.05)	0.061 (0.05)	0.163*** (0.05)	0.102* (0.06)	0.147*** (0.04)	0.023*** (0.01)
Income squared	-0.041*** (0.01)	-0.028* (0.01)	-0.033** (0.01)	-0.025* (0.01)	-0.036*** (0.01)	
Male			-0.057** (0.03)	-0.002 (0.04)	-0.036* (0.02)	-0.009* (0.01)
Age 30–39	0.186*** (0.04)	0.079** (0.04)	0.139*** (0.04)	0.107** (0.05)	0.131*** (0.03)	0.033*** (0.01)
Age 40–49	0.228*** (0.04)	0.312*** (0.04)	0.270*** (0.04)	0.279*** (0.06)	0.274*** (0.03)	0.068*** (0.01)
Age 50–59	0.126** (0.05)	0.247*** (0.05)	0.171*** (0.05)	0.198*** (0.06)	0.183*** (0.04)	0.045*** (0.01)
Age 60+	0.031 (0.05)	0.117** (0.05)	0.015 (0.05)	0.138** (0.07)	0.064* (0.04)	0.016* (0.01)
Married	0.360*** (0.05)	0.368*** (0.05)	0.294*** (0.05)	0.442*** (0.07)	0.357*** (0.04)	0.088*** (0.01)
Widowed	0.317*** (0.11)	0.258** (0.12)	0.241** (0.12)	0.338*** (0.12)	0.281*** (0.09)	0.070*** (0.02)
Separated	0.186* (0.10)	0.150** (0.07)	0.149** (0.07)	0.213** (0.10)	0.184*** (0.06)	0.046*** (0.01)
Primary school	0.047 (0.05)	0.095** (0.04)	0.035 (0.03)	-0.016 (0.06)	0.025 (0.03)	0.006 (0.01)
Middle school	0.190*** (0.04)	-0.027 (0.04)	0.057 (0.04)	-0.011 (0.05)	0.043 (0.03)	0.011 (0.01)
College	0.218*** (0.07)	-0.330*** (0.08)	-0.040 (0.08)	-0.062 (0.07)	-0.048 (0.05)	-0.012 (0.01)
Household size	-0.018* (0.01)	-0.010 (0.01)	-0.013* (0.01)	-0.014 (0.01)	-0.013** (0.01)	-0.003** (0.00)
Ethnic minority	-0.080 (0.05)	0.028 (0.05)	-0.056 (0.05)	0.093 (0.06)	-0.020 (0.04)	-0.005 (0.01)
Presently working	-0.163*** (0.03)	-0.160*** (0.03)	-0.164*** (0.03)	-0.141*** (0.04)	-0.160*** (0.02)	-0.040*** (0.01)
Urban	0.111*** (0.04)	0.174*** (0.04)			0.140*** (0.03)	0.035*** (0.01)
Year dummies	Yes	Yes	Yes	Yes	Yes	
Province dummies	Yes	Yes	Yes	Yes	Yes	
Constant	-1.351*** (0.10)	-1.031*** (0.09)	-1.118*** (0.10)	-0.930*** (0.12)	-1.119*** (0.08)	
N	16343	16743	22365	10721	33086	33086
Chi ²	864	797	1044	663	1285	
Pseudo R-squared	0.083	0.053	0.055	0.064	0.059	

¹⁾ Time controls include year dummies for 1991, 1993, 1997, 2000, 2004, 2006, 2009, and 2011. Regional controls include dummies for Chongqing, Beijing, Liaoning, Heilongjiang, Shanghai, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi, and Guizhou.

Source: authors' estimations based on the China Health and Nutrition Survey (CHNS) samples. Robust standard errors (clustered by community id) are in parentheses. *, $P < 0.10$; **, $P < 0.05$; ***, $P < 0.01$.

effect of household income on overweight cessation shows that a 10 000 CNY growth in household income would cause a decrease in the likelihood of overweight cessation by roughly 4.7% when controlling all other independent variables at the mean values. The likelihood of ceasing overweight would consistently increase once the household income is larger than the critical point of 22 307 CNY, while there are no more than 10% of adults whose household

incomes are higher than this threshold.

Similar to the pooled sample, the likelihood of overweight cessation first declines and then increases with income after reaching a bottom value. The results also suggest that females and urbanite have smaller critical values of 20 952 CNY and 23 000 CNY, respectively, indicating that females and urbanite are more likely to 'quit' overweight at relatively lower income levels.

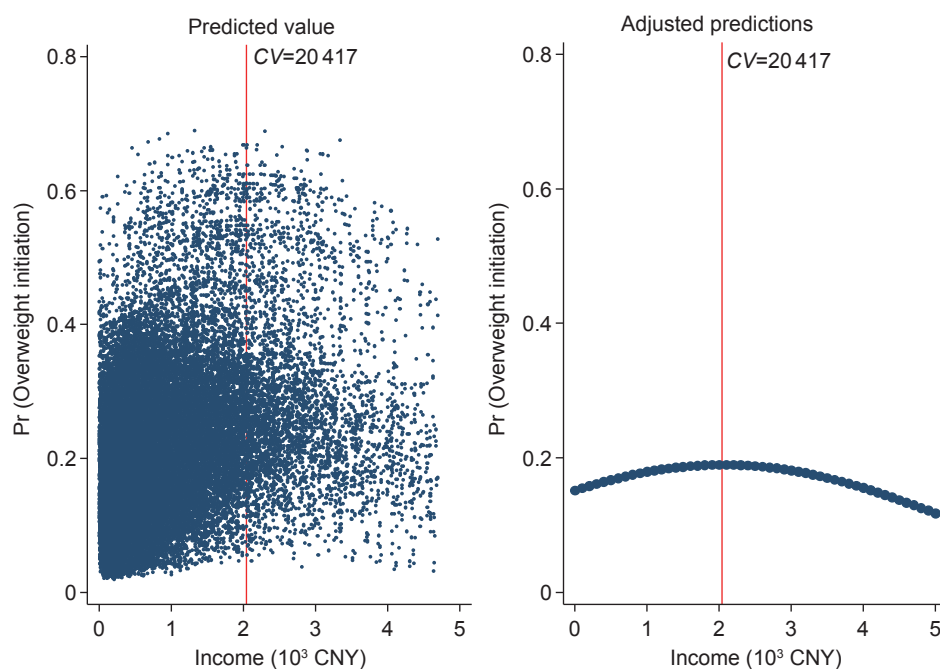


Fig. 4 The relationship between income and predicted probability of overweight initiation.

Table 4 Probit estimation results for overweight cessation

Variable ¹⁾	Dependent variable: Overweight cessation					Marginal effect
	Male (1)	Female (2)	Rural (3)	Urban (4)	Pooled (5)	
Income	-0.276*** (0.07)	-0.176*** (0.06)	-0.241*** (0.07)	-0.161*** (0.05)	-0.232*** (0.04)	-0.047*** (0.01)
Income squared	0.060*** (0.02)	0.042*** (0.02)	0.050** (0.02)	0.035** (0.01)	0.052*** (0.01)	
Male			0.014 (0.04)	-0.134*** (0.04)	-0.046 (0.03)	-0.015 (0.01)
Age 30–39	-0.366*** (0.06)	-0.286*** (0.05)	-0.358*** (0.05)	-0.290*** (0.06)	-0.324*** (0.04)	-0.105*** (0.01)
Age 40–49	-0.382*** (0.05)	-0.610*** (0.04)	-0.583*** (0.04)	-0.430*** (0.06)	-0.519*** (0.03)	-0.168*** (0.01)
Age 50–59	-0.433*** (0.05)	-0.633*** (0.05)	-0.566*** (0.05)	-0.554*** (0.06)	-0.550*** (0.04)	-0.179*** (0.01)
Age 60+	-0.287*** (0.07)	-0.418*** (0.06)	-0.369*** (0.06)	-0.322*** (0.07)	-0.340*** (0.04)	-0.110*** (0.01)
Married	-0.463*** (0.07)	-0.485*** (0.07)	-0.467*** (0.06)	-0.464*** (0.08)	-0.468*** (0.05)	-0.152*** (0.02)
Widowed	-0.269* (0.16)	-0.389** (0.15)	-0.169 (0.15)	-0.553*** (0.16)	-0.328*** (0.11)	-0.107*** (0.04)
Separated	-0.118 (0.11)	-0.346*** (0.09)	-0.331*** (0.09)	-0.320*** (0.11)	-0.317*** (0.07)	-0.103*** (0.02)
Primary school	0.002 (0.07)	-0.016 (0.05)	0.055 (0.05)	0.006 (0.06)	0.054 (0.04)	0.017 (0.01)
Middle school	-0.064 (0.06)	0.254*** (0.05)	0.110** (0.04)	0.221*** (0.06)	0.160*** (0.04)	0.052*** (0.01)
College	-0.065 (0.09)	0.625*** (0.09)	0.232** (0.09)	0.327*** (0.07)	0.293*** (0.06)	0.095*** (0.02)
Household size	0.022 (0.01)	-0.007 (0.01)	0.017 (0.01)	-0.014 (0.02)	0.005 (0.01)	0.002 (0.00)

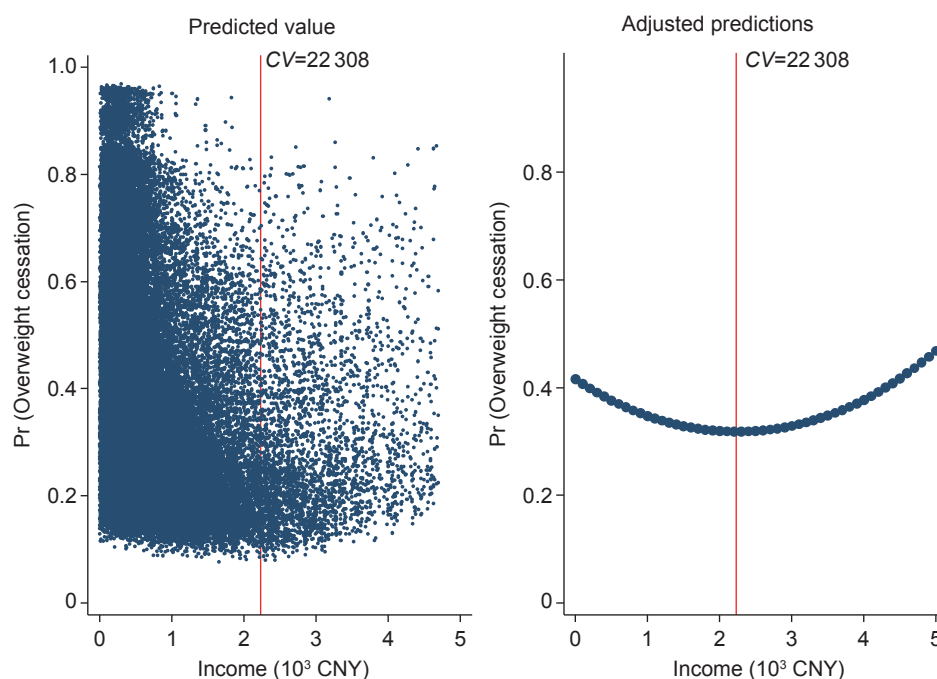
(Continued on next page)

Table 4 (Continued from preceding page)

Variable ¹⁾	Dependent variable: Overweight cessation					Marginal effect
	Male (1)	Female (2)	Rural (3)	Urban (4)	Pooled (5)	
Ethnic minority	-0.060 (0.08)	0.042 (0.06)	0.092 (0.06)	-0.203** (0.09)	-0.007 (0.05)	-0.002 (0.02)
Presently working	0.034 (0.05)	0.129*** (0.04)	0.080** (0.04)	0.108** (0.05)	0.095*** (0.03)	0.031*** (0.01)
Urban	-0.009 (0.05)	0.035 (0.04)			0.017 (0.03)	0.006 (0.01)
Year dummies	Yes	Yes	Yes	Yes	Yes	
Province dummies	Yes	Yes	Yes	Yes	Yes	
Constant	1.506*** (0.14)	1.023*** (0.12)	1.176*** (0.12)	1.237*** (0.11)	1.214*** (0.09)	
N	7041	8919	9698	6262	15960	15960
Chi ²	1063	1289	1600	968	2012	
Pseudo R-squared	0.155	0.138	0.160	0.112	0.135	

¹⁾ Time controls include year dummies for 1991, 1993, 1997, 2000, 2004, 2006, 2009, and 2011. Regional controls include dummies for Chongqing, Beijing, Liaoning, Heilongjiang, Shanghai, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi, and Guizhou.

Source: authors' estimations based on the China Health and Nutrition Survey (CHNS) samples. Robust standard errors (clustered by community id) are in parentheses. *, $P < 0.10$; **, $P < 0.05$; ***, $P < 0.01$.

**Fig. 5** The relationship between income and predicted probability of overweight cessation.

3.4. The relationship between income and overweight participation

Table 5 shows the estimation results of overweight participation. The probability of overweight cessation increases with income at high-income levels, while overweight initiation has become more prevalent in China, a transition economy. Therefore, we suspect that the relationship between income and overweight participation

generally may show a similar pattern as overweight initiation (Pampel *et al.* 2012; Hruschka and Brewis 2013; Deuchert *et al.* 2014). Our results support this anticipation that the relation between income and the probability of overweight participation switches from a positive to a negative sign with increasing income, implying there also exists an inverted U-shape relationship between income and overweight participation. As indicated in Fig. 6, the estimation for the pooled sample shows that the peak of this inverted U-shape

curve occurs at the point of income approaching 22727 CNY, while approximately 91.8% of the adults considered in the pooled sample are mainly below this level. In the view of the marginal effect of income on overweight participation, we observe that growth of 10 000 CNY in household income could decrease the likelihood of overweight participation by approximately 5.3% when controlling for all other variables at the mean values.

The estimation results for the subsamples coincide with the pooled sample, as shown in Table 5. The critical point of the inverted U-shape curve between income and overweight participation is lower for females and urbanite than it is for males and rural residents implying that females and urbanite are more likely to decrease the likelihood of being overweight earlier compared to males and residents in rural areas (see also Tafreschi 2015).

Table 5 Probit estimation results for overweight participation

Variable ¹⁾	Dependent variable: Overweight participation					Marginal effect
	Male (1)	Female (2)	Rural (3)	Urban (4)	Pooled (5)	
Income	0.325*** (0.05)	0.168*** (0.04)	0.270*** (0.05)	0.168*** (0.05)	0.250*** (0.04)	0.053*** (0.01)
Income squared	-0.063*** (0.01)	-0.044*** (0.01)	-0.051*** (0.01)	-0.036*** (0.01)	-0.055*** (0.01)	
Male			-0.099*** (0.03)	0.003 (0.03)	-0.058*** (0.02)	-0.019*** (0.01)
Age 30–39	0.223*** (0.03)	0.122*** (0.03)	0.179*** (0.03)	0.156*** (0.04)	0.170*** (0.02)	0.056*** (0.01)
Age 40–49	0.290*** (0.03)	0.403*** (0.03)	0.360*** (0.03)	0.356*** (0.04)	0.356*** (0.02)	0.116*** (0.01)
Age 50–59	0.257*** (0.04)	0.428*** (0.04)	0.342*** (0.03)	0.382*** (0.04)	0.347*** (0.03)	0.114*** (0.01)
Age 60+	0.149*** (0.05)	0.232*** (0.04)	0.147*** (0.04)	0.249*** (0.05)	0.175*** (0.03)	0.057*** (0.01)
Married	0.395*** (0.04)	0.429*** (0.05)	0.368*** (0.04)	0.445*** (0.06)	0.407*** (0.03)	0.133*** (0.01)
Widowed	0.316*** (0.10)	0.248*** (0.11)	0.251*** (0.09)	0.321*** (0.11)	0.278*** (0.07)	0.091*** (0.02)
Separated	0.126 (0.08)	0.201*** (0.06)	0.181*** (0.06)	0.246*** (0.08)	0.214*** (0.05)	0.070*** (0.02)
Primary school	0.080 (0.05)	0.068** (0.03)	0.023 (0.03)	-0.005 (0.05)	0.010 (0.03)	0.003 (0.01)
Middle school	0.231*** (0.04)	-0.104*** (0.04)	0.043 (0.04)	-0.069 (0.04)	0.004 (0.03)	0.001 (0.01)
College	0.286*** (0.07)	-0.468*** (0.07)	-0.003 (0.07)	-0.130** (0.06)	-0.088* (0.05)	-0.029* (0.02)
Household size	-0.025*** (0.01)	-0.010 (0.01)	-0.022*** (0.01)	-0.006 (0.01)	-0.016*** (0.01)	-0.005*** (0.00)
Ethnic minority	-0.075 (0.05)	-0.026 (0.05)	-0.117** (0.05)	0.116* (0.07)	-0.045 (0.04)	-0.015 (0.01)
Presently working	-0.169*** (0.03)	-0.216*** (0.03)	-0.202*** (0.03)	-0.175*** (0.03)	-0.199*** (0.02)	-0.065*** (0.01)
Urban	0.098** (0.04)	0.132*** (0.04)			0.111*** (0.03)	0.036*** (0.01)
Year dummies	Yes	Yes	Yes	Yes	Yes	
Province dummies	Yes	Yes	Yes	Yes	Yes	
Constant	-1.363*** (0.10)	-0.929*** (0.09)	-0.980*** (0.10)	-0.981*** (0.10)	-1.041*** (0.07)	
N	23378	25670	32066	16982	49048	49048
Chi ²	1572	1557	1861	1079	2399	
Pseudo R-squared	0.113	0.078	0.093	0.073	0.086	

¹⁾ Time controls include year dummies for 1991, 1993, 1997, 2000, 2004, 2006, 2009, and 2011. Regional controls include dummies for Chongqing, Beijing, Liaoning, Heilongjiang, Shanghai, Jiangsu, Shandong, Henan, Hubei, Hunan, Guangxi, and Guizhou. Source: authors' estimations based on the China Health and Nutrition Survey (CHNS) samples. Robust standard errors (clustered by community id) are in parentheses. *, $P < 0.10$; **, $P < 0.05$; ***, $P < 0.01$.

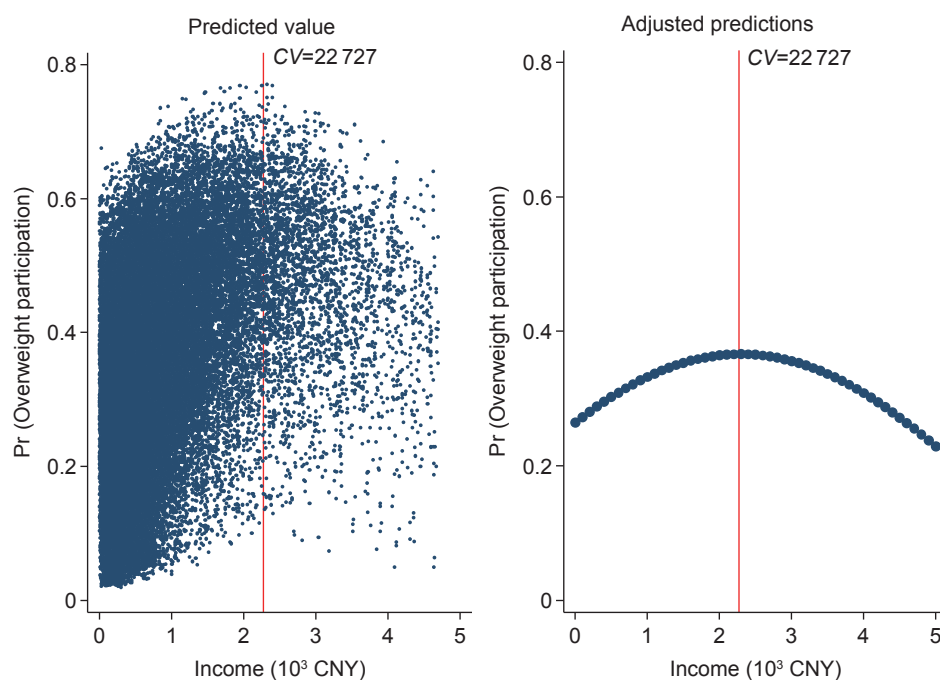


Fig. 6 The relationship between income and predicted probability of overweight participation.

4. Conclusion

From a life-course utility model we derive the hypothesis that individuals with unhealthy food consumption patterns are at a higher risk of having a lower expected future health utility because of lower longevity. In our theoretical model, health utility is a decreasing function of income. Thus, low-income individuals have lower costs of future health utility. These individuals are more likely to consume unhealthy food and show more unhealthy consumption behaviors when their income constraint is overcome. Increased incidences of people with overweight in developed countries serve evidence for this behavior. However, the income constraint still plays a significant role in individuals' food consumption in transition economies such as China. We, therefore, investigate incidences of overweight caused by unhealthy food consumption using the data from the CHNS.

The estimation results indicate that BMI and overweight have an inverted U-shape relationship with household income. This shows that BMI and the probability of overweight initiation increase with income at a decreasing rate. When income increases, overweight individuals are less likely to limit overweight at low levels of income and are more likely to limit overweight at high levels of income. Thus, low-income individuals have a higher probability to limit overweight when their income is at the left side of the inverted U-shaped function. One possible explanation might

be that overweight individuals with low incomes can hardly maintain their previous food consumption and easily lose their weight.

Our findings demonstrate that low-income individuals in China tend to have a healthier diet. The reason for this is not that low-income individuals make more rational and knowledgeable food consumption choices. The reason rather is that the income constraint leads them to consume food with lower calories and nutrition. Low incomes limit excess food consumption and increase physically demanding labor. High incomes increase excess to food and also allow to avoid physically demanding labor (Pampel *et al.* 2012). Furthermore, consumption of unhealthy food items containing high saturated fats and sugars might also be a symbol of status for the “newly rich” showing the ability of abundant consumption just after the income threshold is overcome. Therefore, with increasing income low-income individuals in transition economies such as China may consume unhealthier food. This leads to a higher overweight rate and nutrition-related incidents up to a certain income threshold where the future health utility is considered more important than consuming unhealthy food items.

Urban residents tend to reach the threshold value of the relationship between income and BMI, as well as between income and overweight initiation, cessation, and participation, earlier than do rural residents. It concludes that urban residents are more likely to decrease the likelihood

of being overweight and increase the likelihood of ceasing overweight earlier compared with rural residents. Given the ongoing changes of the relation between income and overweight participation from positive in developing regions to negative in developed regions (Sobal and Stunkard 1989; Monteiro *et al.* 2004b; Tafreschi 2015), urban residents are more likely to reach the threshold value earlier, possibly because urban areas are remarkably more developed than are rural areas in China.

We also find a reverse relationship between income and BMI, overweight initiation, cessation, and participation earlier for females than for males. As females (males) tend to understate (overestimate) their true body weight (Cawley 2004), the results may be biased. However, it could also very well be that overweight females are more likely to follow physician's suggestions to consume less unhealthy food with high calories (Loureiro and Nayga 2006).

Moreover, in future studies it would be fruitful to investigate mechanisms through which income could have impact on nutrition-related health since income can hardly have direct effects on individuals' BMI and being overweight. It has been well documented that income is associated with nutrition improvement and a dramatic dietary change in China (Tian and Yu 2015; Ren *et al.* 2019). For instance, rising income might increase the quantity of food consumption (Huang and Gale 2009; Ren *et al.* 2018), improve the quality of diets such as diet diversity (Doan 2014), shift food preference from high-carbohydrate food towards dense high-energy food (Du *et al.* 2004; Curtis *et al.* 2007; Batis *et al.* 2014), and change lifestyle such as dining out (French *et al.* 2010; Liu *et al.* 2015). Understanding these channels has profound consequences not only for individuals to improve their health but also for policymakers to improve public health in China.

Acknowledgements

This research uses data from the China Health and Nutrition Survey (CHNS). We thank the National Institute of Nutrition and Food Safety, China Center for Disease Control and Prevention, Carolina Population Center (5 R24 HD050924), the University of North Carolina at Chapel Hill, the NIH (R01-HD30880, DK056350, R24 HD050924, and R01-HD38700) and the Fogarty International Center, NIH for financial support for the CHNS data collection and analysis files from 1989 to 2011 and future surveys, and the China-Japan Friendship Hospital, Ministry of Health for support for CHNS 2009. The authors also acknowledge the financial support from the China Scholarship Council for conducting this research.

References

- Apouey B, Geoffard P Y. 2013. Family income and child health in the UK. *Journal of Health Economics*, **32**, 715–727.
- Ball K, Crawford D. 2005. Socioeconomic status and weight change in adults: A review. *Social Science & Medicine*, **60**, 1987–2010.
- Batis C, Sotres-Alvarez D, Gordon-Larsen P, Mendez M A, Adair L, Popkin B. 2014. Longitudinal analysis of dietary patterns in Chinese adults from 1991 to 2009. *British Journal of Nutrition*, **111**, 1441–1451.
- Benzeval M, Taylor J, Judge K. 2000. Evidence on the relationship between low income and poor health: Is the government doing enough? *Fiscal Studies*, **21**, 375–399.
- Binkley J. 2010. Low income and poor health choices: The example of smoking. *American Journal of Agricultural Economics*, **92**, 972–984.
- Cawley J. 2004. The impact of obesity on wages. *Journal of Human Resources*, **39**, 451–474.
- Curtis K R, McCluskey J J, Wahl T I. 2007. Consumer preferences for western-style convenience foods in China. *China Economic Review*, **18**, 1–14.
- Deuchert E, Cabus S, Tafreschi D. 2014. A short note on economic development and socioeconomic inequality in female body weight. *Health Economics*, **23**, 861–869.
- Doan D. 2014. Does income growth improve diet diversity in China? In: *Selected Paper Prepared for Presentation at the 58th AARES Annual Conference, Port Macquarie, New South Wales*. pp. 4–7.
- Drewnowski A, Darmon N. 2005. Food choices and diet costs: An economic analysis. *The Journal of Nutrition*, **135**, 900–904.
- Drewnowski A, Eichelsdoerfer P. 2010. Can low-income Americans afford a healthy diet? *Nutrition Today*, **44**, 246–249.
- Du S, Mroz T A, Zhai F, Popkin B M. 2004. Rapid income growth adversely affects diet quality in China — particularly for the poor! *Social Science & Medicine*, **59**, 1505–1515.
- Ettner S L. 1996. New evidence on the relationship between income and health. *Journal of Health Economics*, **15**, 67–85.
- Fernald L C H. 2007. Socio-economic status and body mass index in low-income Mexican adults. *Social Science & Medicine*, **64**, 2030–2042.
- Fichera E, Savage D. 2015. Income and health in Tanzania. An instrumental variable approach. *World Development*, **66**, 500–515.
- French S A, Wall M, Mitchell N R. 2010. Household income differences in food sources and food items purchased. *The International Journal of Behavioral Nutrition and Physical Activity*, **7**, 77.
- Goode A, Mavromaras K, Zhu R. 2014. Family income and child health in China. *China Economic Review*, **29**, 152–165.
- Hruschka D J, Brewis A A. 2013. Absolute wealth and world region strongly predict overweight among women (ages 18–49) in 360 populations across 36 developing countries. *Economics & Human Biology*, **11**, 337–444.

- Huang K S, Gale F. 2009. Food demand in China: Income, quality, and nutrient effects. *China Agricultural Economic Review*, **1**, 395–409.
- Jolliffe D. 2011. Overweight and poor? On the relationship between income and the body mass index. *Economics & Human Biology*, **9**, 342–355.
- Kenkel D, Lillard D R, Liu F. 2009. An analysis of life-course smoking behavior in China. *Health Economics*, **18**, S147–S156.
- Konnopka A, Bødemann M, König H H. 2011. Health burden and costs of obesity and overweight in Germany. *The European Journal of Health Economics*, **12**, 345–352.
- Kuchler F, Stewart H. 2008. *Price Trends Are Similar for Fruits, Vegetables, and Snack Foods. Economic Research Report No. 55*. Economic Research Service, USDA. [2018-2-10]. <http://www.ers.usda.gov/media/224301/err55.pdf>. Accessed 6 August 2015
- Lakdawalla D, Philipson T. 2009. The growth of obesity and technological change. *Economics & Human Biology*, **7**, 283–293.
- Lantz P M, House J S, Lepkowski J M, Williams D R, Mero R P, Chen J. 1998. Socioeconomic factors, health behaviors, and mortality: Results from a nationally representative prospective study of US adults. *The Journal of the American Medical Association*, **279**, 1703–1708.
- Liu H, Wahl T I, Seale J L, Bai J. 2015. Household composition, income, and food-away-from-home expenditure in urban China. *Food Policy*, **51**, 97–103.
- Loureiro M L, Nayga Jr R M. 2006. Obesity, weight loss, and physician's advice. *Social Science & Medicine*, **62**, 2458–2468.
- Monteiro C A, Conde W L, Lu B, Popkin B M. 2004a. Obesity and inequities in health in the developing world. *International Journal of Obesity*, **28**, 1181–1186.
- Monteiro C A, Moura E C, Conde W L, Popkin B M. 2004b. Socioeconomic status and obesity in adult populations of developing countries: A review. *Bulletin of the World Health Organization*, **82**, 940–946.
- Mora T, Gil J, Sicras-Mainar A. 2015. The influence of obesity and overweight on medical costs: A panel data perspective. *The European Journal of Health Economics*, **16**, 161–173.
- NHLBI (National Heart, Lung, and Blood Institute). 1998. *Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults*. National Heart, Lung, and Blood Institute, United States.
- Ogundari K, Abdulai A. 2013. Examining the heterogeneity in calorie–income elasticities: A meta-analysis. *Food Policy*, **40**, 119–128.
- Pampel F C, Denney J T, Krueger P M. 2012. Obesity, SES, and economic development: A test of the reversal hypothesis. *Social Science & Medicine*, **74**, 1073–1081.
- Philipson T J, Posner R A. 2003. The long-run growth in obesity as a function of technological change. *Perspectives in Biology and Medicine*, **46**, S87–S107.
- Popkin B. 1999. Urbanization, lifestyle changes and the nutrition transition. *World Development*, **27**, 1905–1916.
- Popkin B, Ng S W. 2007. The nutrition transition in high- and low-income countries: What are the policy lessons? *Agricultural Economics*, **37**, 199–211.
- Reinhold S, Jürges H. 2012. Parental income and child health in Germany. *Health Economics*, **21**, 562–579.
- Ren Y, Li H, Wang X. 2019. Family income and nutrition-related health: Evidence from food consumption in China. *Social Science & Medicine*, **232**, 58–76.
- Ren Y, Zhang Y, Loy J P, Glauben T. 2018. Food consumption among income classes and its response to changes in income distribution in rural China. *China Agricultural Economic Review*, **10**, 406–424.
- Sobal J, Stunkard A J. 1989. Socioeconomic status and obesity: A review of the literature. *Psychological Bulletin*, **105**, 260.
- Stewart H, Blisard N, Jolliffe D. 2003. Do income constraints inhibit spending on fruits and vegetables among low-income households? *Journal of Agricultural and Resource Economics*, **28**, 465–480.
- Tafreschi D. 2015. The income body weight gradients in the developing economy of China. *Economics & Human Biology*, **16**, 115–134.
- Tian X, Yu X. 2015. Using semiparametric models to study nutrition improvement and dietary change with different indices: The case of China. *Food Policy*, **53**, 67–81.
- WHO (World Health Organization). 2015. Obesity and overweight. [2015-09-14]. <http://www.who.int/mediacentre/factsheets/fs311/en/>
- Wu Y. 2006. Overweight and obesity in China. *British Medical Journal*, **333**, 362–364.
- Xie S, Mo T. 2014. The impact of education on health in China. *China Economic Review*, **29**, 1–18.
- Zhou B F. 2002. Effect of body mass index on all-cause mortality and incidence of cardiovascular diseases — report for meta-analysis of prospective studies open optimal cut-off points of body mass index in Chinese adults. *Biomedical and Environmental Sciences*, **15**, 245–252.

Executive Editor-in-Chief HUANG Ji-kun
 Managing editor WENG Ling-yun