Family Income and Health: Evidence from Food Consumption in China

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Abstract:

With the substantial increase in family income, the prevalence of overweight has risen and become a serious threat to individual health and major health challenges in many developing countries. From the perspective of food consumption, this study attempts to shed light on the effect of family income on adults' health outcomes of BMI and being overweight through three potential channels of nutrition intakes, dietary knowledge, and health insurance. Using data from the China Health and Nutrition Survey (CHNS), the empirical estimations show adults' BMI and the propensity of being overweight tend to increase with rising income in China. After identifying significant correlations between family income and potential channels considered, we conclude that approximately 34.14% and 33.75% of income effect on BMI and overweight could be explained by these three channels, especially, nutrition intakes taking the largest proportion is responsible for 26.96% and 28.08% of income effect on BMI and overweight, respectively. Additionally, we observe that there exists a significant heterogeneity in income-BMI gradients across various income quantiles and sub-samples, showing that income has higher effect on adults' health for male and urban samples but it is not responsible for female sample.

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Keywords: family income, health, food consumption, BMI, overweight

1. Introduction

Along the path of economic transformation, China's remarkable progress has important implications for the income growth over the past four decades (Brandt et al., 2008). Rising income would bestow many benefits on the household in China, for instance, evidence showing that higher income will facilitate poverty alleviation (Zhang and Donaldson, 2008). When incomes rise steadily and significantly, large segments of the population will enjoy higher welfare (Tafreschi, 2015), individuals with higher incomes can also afford better social service including improved health and education on health (Goode et al., 2014).

However, this economic transformation has not been without cost. Signs are emerging that there are already measurable negative effects. Specifically, it has been reported that increasingly high shares of adults in China have been estimated to be overweight (Zhou et al., 2017). Such trends, of course, pose serious threats to individual health as it increases the risk of non-communicable disease (Shimokawa, 2013; Tafreschi, 2015). Being overweight and its accompanying health consequences also have naturally lead to higher health costs not only for the households but also for the whole nation. In the developed countries, it has been well documented that the high propensity of individuals to be overweight has become major a challenge for public health (Cutler et al., 2003; Bleich et al., 2008), especially, it stresses health care system and increase the states expenditures to a large extent (Tafreschi, 2015). The situation is not optimistic in the transition economy of China. As estimated by (Popkin et al., 2006), the future health cost of the overweight epidemic (and direct consequences thereof) is approaching 9% of China's GDP by 2025.

Although the literature has shown that the rise of income is associated with some negative health outcomes (like higher rates of being overweight), what is much less studied is the exact set of channels through which income affects individual's BMI and being overweight. The understanding of these channels is profound not only for individuals to improve their health but also for the policymakers to boost the public health in China, as reducing incomes is not an option to the rising rate of being overweight. It is also important to identify which channel is the most important one in transforming rise of income into being overweight so policymakers can focus on the one that can be changed by policy in an effort to allow nations to enjoy both higher living standards and better health.

The international literature has identified several channels that may be associated with both rising income and health outcome including BMI and increased rates of being overweight. One of the most important effects of income growth is to raise the level of the quantity of food that is consumed—henceforth called *nutrition intakes*. Nutrition intakes are measured by assessing the consumption of three macronutrients of carbohydrate, fat and protein (Mendez et al., 2005). Since rising income has been shown to raise of nutrition intakes of protein and fat but decrease carbohydrate (Huang and Gale, 2009), this needs to be considered in any analysis of the channels that turn income rises into the increasing BMI and the propensity of being overweight.

Dietary knowledge is another channel considered to transform rising income into increasing BMI and prevalence of overweight. We expect a strong link between the family income and dietary knowledge because rising income gives individuals higher possibilities to obtain more sources of information regarding nutrition and health, such as dietary knowledge. Specifically, individuals that have higher incomes will more likely have access to internet, podcasts, classes, as well as mobile phone which has been investigated to significantly improve people's access to information and dietary quality (Sekabira and Qaim, 2017). Internationally, improving dietary knowledge has been shown to help people adjust their eating habits and exercise behaviour in ways that keep them from becoming overweight (Wagner et al. 2016; Nayga, 2000). As far as we can tell, there is no specific study to investigate how income affects individual's dietary knowledge, which, in turn, could affect individuals' health.

Finally, a third channel through which income might affect individual's BMI and the propensity of being overweight is the access to health insurance. On the one hand, to a large extent, health insurance could be regarded as a part of health consciousness (Goode et al., 2014), a state of awareness, that would affect choices been made, especially, in case of food consumption. The international literature is clear that rising incomes produce higher levels of individual's consciousness about their health (Binkley, 2010). Thus, they are less likely to choose unhealthy food consumption. When a person is more conscious of their health, it can affect a wide variety of actions that might lead to lower rates of being overweight. For example, a person with a higher level of consciousness will read labels more carefully, spend time identifying which food outlet have a higher quality of foods, etc. (Viola et al., 2016). On the other hand, with the budget constraint, income is suspected to be one of the main determinates of individuals' decision-making in purchasing health insurance. Thus, rising income might also be transferred into the availability to access the various health insurance, and then has an influence on individual's health outcomes of BMI and being overweight accordingly.

The overall goal of this study attempts to understand the relationship between rising income in China and health outcomes of growth BMI and prevalence of overweight to help policymakers formulate policies to dampen this rising public health concern. To achieve this overall goal, we have three specific objectives. First, we examine the relationship between incomes and health outcomes of BMI and being overweight. Second, we seek to understand which of the various channels—nutrition intakes, dietary knowledge, health insurance—are associated with rising incomes. Finally, we illustrate how and to which extent the family income affects individuals' health through the potential channels considered by gradually decomposing the overall income effect on BMI and being overweight.

This paper indicates a significant positive adult health and family income gradient for the overall sample of adults. Even after controlling for all three channels, the family income still has a significant independent effect on adults' health outcomes, but the magnitude of the coefficient for income changes substantially. Overall, all of these three channels could explain approximately 34% of the overall income effect on BMI and being overweight. Precisely, adults' nutrition intake is one of the most important factors among the three channels directly and indirectly through dietary knowledge under the decomposing analysis framework. Inclusions of dietary knowledge suggest that this channel could explain approximately 4.75% the effect of family income on BMI. After controlling for nutrient intakes and dietary knowledge, health insurance contributes to approximately 3.4% the effect of income on BMI.

This paper also highlights the heterogeneous association between family income and adult's health through the use of unconditional quantile regression (Firpo et al., 2009). The existing literature of adult's health, mainly relying on the subjective measure of health by using binary or ordered categorical variables fail to meet the request of heterogeneous income gradients. As BMI is continuous in nature, this study applies the recently developed unconditional quantile regression to examine the possibility of heterogeneous income gradients at different parts of the health distribution of adults for gender and *hukou* registration status. This type of econometric analysis helps identify which subgroups of the adult are likely to improve or worsen the health when family income increase or decrease.

The results from quantile regression show that, in general, the income effect on health tends to increase from lower quantile to higher quantile, and the results also demonstrate that family income has a significant contribution to BMI and overweight for male, urban, and rural sub-sample, but it is insignificant for female sample. Moreover, income has a higher effect on urban residents than that on rural residents.

In the next section, we introduce the theoretical framework of our study. Section 3 gives a brief presentation of the data. Section 4 lays out our econometric modelling approach in more detail. Section 5 discusses our empirical results on accounting for the distribution of health. The last section concludes.

2. Theoretical framework

The theoretical and empirical analysis of the determinants of overweight and obesity is derived from the well-known household production model proposed by Becker (1991). It has been employed by Nayga (2000) to examine the effect of schooling and health knowledge on obesity, and by Abdulai (2010) to investigate the impact of income on overweight. The basic idea behind this framework is that households allocate time and goods to produce "commodities," such as the health of family members, to maximize a joint utility function (Grossman, 1972). It is assumed that the maximization of household utility depends on the consumption of food (F_i), a composite good (C_i), and individual health (H). As with Nayga (2000), the production function of an individual household member's health can be described by

$$H = H(F_i, I_i, \mu) \tag{2.1}$$

Generally, F_i includes two main groups: staple foods and luxury foods. According to Chinese dietary tradition, we expect that luxury foods are likely to contain more fat than staple foods (Shimokawa, 2013). I_i donates the health inputs, which consist of health knowledge and health practices (Abdulai, 2010; Nayga, 2000; Shimokawa, 2013), implying that health inputs might be a real good or a service. The emphasis of health inputs is on dietary knowledge and health insurance (Strauss and Thomas, 1995). Here, dietary knowledge is determined by the income constraint of acquiring knowledge. Health insurance, the sum of money used for an individual's consumption of health practices, is expected to have both direct and indirect effects on individual health. Unlike health insurance, better dietary knowledge may make people more conscious of the costs of diet-related diseases and motivate them to pay more attention to consuming less-fatty foods. Doing so might determine their health accordingly. μ denotes family-specific health endowments known to, but not controllable by, the family, such as genetic traits or environmental factors (Rosenzweig and Schultz, 1983), as well as other unobservable determinants of H.

Altogether, the utility function is presented as follows:

$$U = U(F_i, C_i, H(F_i, I_i, \mu)) \tag{2.2}$$

The household budget constraint regarding the purchase of goods and services is

$$P_{Fi}F_i + P_{Ci}C_i + P_{Ii}I_i = M \tag{2.3}$$

where M is exogenous money income, and P_{Fi}, P_{Ci}, and P_{Ii} are exogenous prices for food, other commodities, and health inputs, respectively. According to the FOCs of utility maximization from Lagrange equation of $L(F_i, C_i, \lambda) = U(F_i, C_i, H(F_i, I_i)) - \lambda(M - P_{Fi}F_i - P_{Ci}C_i - P_{Ii}I_i)$, the reduced forms of the demands for foods, other commodities, and health inputs are

$$I_i^* = f(P_{Fi}, P_{Ci}, P_{Ii}, M, \mu) \tag{2.4}$$

$$F_i^* = f(I_i^*, P_{Fi}, P_{Ci}, P_{Ii}, M, \mu) \tag{2.5}$$

$$C_i^* = c(I_i^*, P_{Fi}, P_{Ci}, P_{Ii}, M, \mu) \tag{2.6}$$

Thus, I_i*, the health inputs of dietary knowledge and health insurance, is a function of family income and prices considered. F_i*, food consumption, is a function of family income, the health inputs of dietary knowledge and health insurance, and the prices considered. The reduced form of the demand function for a health outcome H may be expressed as:

$$H^* = H(F_i^*, I_i^*, \mu) = h(P_{Fi}, P_{Ci}, P_{Ii}, M, \mu) \tag{2.7}$$

Therefore, marginal effect of income on health is derived by taking the first deviation of equation (2.7):

$$\frac{\partial H^*}{\partial M} = \frac{\partial H}{\partial F_i^*}\frac{\partial F_i^*}{\partial M} + \frac{\partial H}{\partial I_i^*}\frac{\partial I_i^*}{\partial M} \tag{2.8}$$

Income seemingly has no direct effect on health, and its effect is mainly through food consumption and health inputs. Keeping the nutrition transfer rate unchanged, this study focuses on examining how income affects health through influencing macro nutrition intakes of carbohydrates, protein, and fat. It also examines the health inputs of dietary knowledge and health insurance, since both of them change substantially with increasing income (Shimokawa, 2013; Zhao, 2006). More specifically, this study decomposes the income effect on health into the marginal effect of income on each composite of good or service, multiplying the marginal effect of each composite of good or service. This includes nutrition intakes and the health inputs of dietary knowledge and health insurance. It should be noted that income might also have an independent effect on health through other channels unobserved in our model as a sort of unexplained income effect.

3. Empirical estimation

3.1 Benchmark model for the relationship between adult health and family income

To investigate the relationship between adult health and family income, we start with two benchmark models. As aforementioned, BMI is one of the most important indicators of an individual's health. It is estimated using the OLS estimation strategy by Goode et al. (2014) as follows:

$$BMI_i = \alpha_0 + \beta_0 \log M + \gamma X_i + \varepsilon_i \tag{3.1}$$

where M is the family income at the 2011 level. Most of the control variables are taken from existing studies on health and income (Goode et al., 2014; Tafreschi, 2015), including gender, *hukou*, age, age squared, working status, education, marital status, as well as family size. We also introduce the market prices at the 2011 level of four main food commodities to control for the food market effect: pork, chicken, vegetables, and cereals (Shimokawa 2013). Year and provincial dummies are used to control for time and regional fixed effects.

We employ an additional estimation for being overweight, since its harmful effects have been widely documented. The regression follows a Probit model,

$$\Pr(Overweight_i = 1 \mid \log M_i, X_i) = G(\beta_0 + \beta_1 \log M_i + \delta X_i) \tag{3.2}$$

where the dependent variable indicates whether an individual is overweight. All control variables are the same as in model (3.1).

3.2 Decomposing the possible channels

The main goal of this study is to understand the channels through which income affects adult health. Based on the existing literature, three potential channels regarding health and nutrition aspects exist (Goode et al., 2014). We can then further measure to which extent these channels are associated with family income. The models are given as following,

$$NI_i = \lambda_{1i} + \varphi_{1i} \log M + \eta_{1i} X_i + \varepsilon_{1i} \tag{3.3}$$

$$DK_i = \lambda_{2i} + \varphi_2 \log M + \eta_{2i} X_i + \varepsilon_{2i} \tag{3.4}$$

$$HI_i = \lambda_{3i} + \varphi_3 \log M + \eta_{3i} X_i + \varepsilon_{3i} \tag{3.5}$$

where NI_i, DK_i, and HI_i denote nutrition intakes, dietary knowledge, and health insurance. Specifically, nutrition intakes consist of the three main components of carbohydrates (φ_{11}), fat (φ_{12}), and protein (φ_{13}). Dietary knowledge (φ_2) is measured by a single index, and health insurance is a category variable indicated by access to various types of health insurance: private insurance, basic medical insurance for urban residents, new agricultural cooperative medical insurance, and no insurance. All control variables are identical to those in model (3.1).

After identifying a significant correlation between these potential channels and family income, the role of nutrition intakes NI_i can be used as an example to illustrate the extent to which income affects adult health. We introduce nutrition intakes NI_i into our benchmark model, as shown below:

$$BMI_i = \omega_{1i} + \beta_{1i} \log M + \rho_{1i} NI_i + \zeta_{1i} X_i + \mu_{1i} \tag{3.6}$$

When the coefficient of family income in (3.6) is significantly different from the coefficient in benchmark model (3.1), this implies that the overall effect of family income on adult health can be decomposed by the coefficient between family income and nutrition intakes NI_i. This is multiplied by the coefficient between adult health and nutrition intakes NI_i and added to the unexplained income effect which affects adult health but not through the current channel of nutrition intakes.

$$\beta_0 = \beta_{1i} + \rho_{1i} \frac{\mathrm{cov}(\log M, NI_i)}{\mathrm{var}(\log M)} + \frac{\mathrm{cov}(\log M, \mu_{1i})}{\mathrm{var}(\log M)} \tag{3.7}$$

Thus, $\beta_0 - \beta_{1i} = \rho_{1i} * \varphi_{1i} + \frac{\mathrm{cov}(\log M, \mu_{1i})}{\mathrm{var}(\log M)}$. As with the strategy for nutrition intakes NI_i, we decompose the other possible channels by using the estimated coefficients from the models below:

$$BMI_i = \omega_{2i} + \beta_{2i} \log M + \rho_{2i} DK_i + \zeta_{2i} X_i + \mu_{2i} \tag{3.8}$$

$$BMI_i = \omega_{3i} + \beta_{3i} \log M + \rho_{3i} HI_i + \zeta_{3i} X_i + \mu_{3i} \tag{3.9}$$

$$BMI_i = \omega_{4i} + \beta_{4i} \log M + \rho_{4i}' NI_i + \rho_{4i} DK_i + \zeta_{4i} X_i + \mu_{4i} \tag{3.10}$$

Next, we introduce all three channels into model (3.1):

$$BMI_i = \omega + \beta' \log M + \rho_1' NI_i + \rho_2' DK_i + \rho_3' HI_i + \zeta X_i + \mu_i \tag{3.11}$$

The difference in coefficients of income in models (3.1) and (3.11) can be used to identify how, and to which extent, income which passes through these three potential channels affects adult health. β' is the unexplained effect of income on health, which might also pass through other channels but is not observable in this study. As mentioned Section 2, income may have no direct effect on health, and this effect would be expected to equal zero if we could control for all potential channels. From the perspective of the food consumption, increasing income might increase the availability of higher quality food or higher nutrition intake. It also might increase the possibility to obtain dietary knowledge, influence consumption behavior, or even drive higher demand for health insurance. It should be noted that there are still some other important channels through which income may have an influence on adult health, such as through medical treatment, which are beyond the scope of this study.

In accordance with the decomposition methodology for BMI, we conduct similar estimations for overweight to examine how and to what extent income affects the likelihood of an adult being overweight through these three suspected channels.

3.3 Heterogeneity of the correlation between income and health

To the best of our knowledge, existing literature mainly focuses on the mean effect of income on health, but ignores potential heterogeneity in the relationship between adult health and family income. Only one study, by Goode et al. (2014), investigated the relationship between child health and family income. Since BMI is a continuous health measure, the unconditional quantile regression developed by Firpo et al. (2009) is employed to estimate the heterogeneous income effect for adults at various levels of BMI. As stated by Firpo et al. (2009), the unconditional quantile regression can be directly applied to evaluate the economic impact of changing the distribution of independent variables on quantiles of the unconditional distribution of the dependent variable. The estimation of the heterogeneous relationship between family income and adult health can help identify which subgroups of adults are likely to be most sensitive to increases in family income. This group would benefit most from governmental income-support policies such as subsidies.

The influence function from the unconditional quantile regression has been broadly used to check robustness of the estimation. For each quantile, the influence function IF(Y, q_τ) is known to be $(\tau - I(Y_i <= q_\tau))/ f_Y(q_\tau)$, where $\hat{q}_\tau$ is the τ th quantile of Y, I is an indicator function, and f_Y is the density of the marginal distribution of Y. By adding the influence function back into the distributional statistics, the re-centered influence function (*RIF*) is obtained by $q_\tau + IF(Y, q_\tau)$. The *RIF* for quantiles amounts to a linear approximation of the nonlinear quantile function, and it captures the change of quantiles in response to a change in the underlying distribution (Firpo et al. 2009). In our study, the dependent variable is BMI. We model $RIF(BMI_i, q_\tau)$ as a function of family income and covariates:

$$E\left[RIF(BMI_i, q_\tau) \mid \log M_i, X_i\right] = \theta_{0\tau} + \theta_\tau \log M_i + \theta' X_i \tag{3.12}$$

The dependent variable in the regression is $RIF(BMI_i, q_\tau) = q_\tau + \tau - I(BMI_i <= q_\tau)/ f_{BMI}(q_\tau)$, while $RIF(BMI_i, q_\tau)$ is unobservable in practice. Thus, all unknown components are replaced with sample estimators in the following function:

$$\hat{RIF}(BMI_i, \hat{q}_\tau) = \hat{q}_\tau + (\tau - I(BMI_i <= \hat{q}_\tau))\Big/ \hat{f}_{BMI}(\hat{q}_\tau) \tag{3.13}$$

Computation is done by estimating the sample quantile $\hat{q}_\tau$ and estimating the density function $\hat{f}_{BMI}(\hat{q}_\tau)$ at that point of $\hat{q}_\tau$ using kernel methods. From there, a dummy variable $I(BMI_i <= \hat{q}_\tau)$ is generated, which indicates whether the value of BMI is below q_τ. Finally, we can simply estimate the model (3.12) by running an OLS regression of the estimated dependent variable on the covariates. By applying this method, we can readily recover the average partial effect of a small location shift of the log of family income on the unconditional τ-quantile of BMI.

4. Data

The dataset used for this study is from the China Health and Nutrition Survey (CHNS), CHNS is longitudinal, including nine waves in nine provinces, and is comprised of questions for target households, their members, and their communities.[1]

4.1 Samples

The CHNS survey team only started to collect information on dietary knowledge from 2004 onwards. Thus, our analysis only uses data from 2004 and later waves. Second, to make our results comparable to other studies on adult health, we restrict the sample those aged 18-65 at the time of the survey; children and the elderly outside this range are excluded. Third, BMI does not apply to minors and the elderly, pregnant women, and adults suffering from a chronic disease. Therefore, these individuals are excluded. Finally, with full information for each control variable, we use 30,860 observations in the final estimates.

4.2 Variables

Table 1 presents summary statistics of major dependent and independent variables, tabulated by the characteristics of gender and *hukou* registration. In this study, the two dependent variables measuring health are BMI and overweight status. In line with the standard argued for by Zhou (2002) for Chinese adults, the risk of abdominal fat accumulation is proxied as overweight, which is a dummy variable equal to 1 if BMI equals 24 or above, 0 otherwise. The average of BMI and overweight status varied across gender and *hukou* registration. Average BMI is higher for males in urban areas.

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[1] Nine waves include 1989, 1991, 1993, 1997, 2000, 2004, 2006, 2009 and 2011, in 9 provinces of Guangxi, Hunan, Hubei, Henan, Jiangsu, Shandong, Liaoning and Heilongjiang.

Several questions in CHNS focus on food consumption, dietary knowledge, and health insurance. It recorded each individual's consumption, encompassing over 1500 food items consumed at home or elsewhere. The CHNS team used this information, along with information on the nutrition contents of these food items provided by the Chinese Food Nutrition Table (Yang, 2002), to calculate the 3-day average intake of three macronutrients. These include carbohydrates (g), fat (g) and protein (g) consumed at the individual level.[2] The descriptive statistics show that the three components of nutrition intake are comparable with other studies, though their standard deviations are larger (Shimokawa, 2013).

As mentioned, since 2004, respondents finished a twelve-item quiz on basic dietary knowledge (Table A1), which served as a proxy for health consciousness. For each question, the respondents chose 'agree,' 'disagree,' or 'unknown.' Based on the criteria in WHO (1998), we generate an indicator that takes the value of 1 for a correct answer, -1 for an incorrect answer, and 0 for 'unknown,' and construct a summary index of these answers (Shimokawa, 2013). The higher the score, the greater the knowledge assigned concerning nutrition intake. Health insurance, as a channel of income effect on health, is categorized by the variable of participating in health insurance. This variable has the following values, each indicating different levels of health insurance: 3 means the individual has private insurance; 2 means they have basic medical insurance for urban residents; 1 indicates having new agricultural cooperative medical insurance; and 0 means they lack any form of insurance.

The independent variable of interest is the log form of household per capita income at the 2011 price level. Furthermore, the CHNS survey also includes information on a wide number of variables, covering individual and family characteristics such as age, marital status, educational attainment, and employment record (Table 1). It also includes equivalent family size constructed from the number of the members who

[2] Because of the correlation of calorie intake (kcal) and its components in nutrition intake, we did not use calorie intake in this study.

consumed food together in the targeted household. Here, the first adult in the family has a weight of 1. Each additional adult aged 14 and over has a weight of 0.5. Each child aged under 14 has a weight of 0.3. Other control variables are the log form of prices at the community level for four food groups, including cereal, pork, chicken, and vegetables.

5. Empirical results

5.1 Adult health and family income gradient

In this section, we estimate the extended model of adult health across socioeconomic groups by gender and *hukou* registration to examine the association between family income and health outcomes. As with Tafreschi (2015), we find a significant relationship between family income and BMI for the whole sample (Table 2). A doubling of family income is associated with an average BMI increase of 0.0905 after controlling for observed variables. This implies that when family income is doubled, average BMI will increase by 2.14 (= 0.0905 * 23.364). Considering that the cutoff for being overweight is a BMI of 24, this means that when family income doubled, a large proportion of adults faces the risk of becoming overweight. The coefficient estimates of family income are also statistically significant for those in urban or rural areas, and this relationship is especially pronounced for males, who see a BMI increase of 2.92 (= 0.1247 * 23.412) when their income doubles.

The Probit estimation results also find a significant association between family income and the probability of being overweight for the whole sample (Table 2). Keeping other variables constant, the marginal effect of 0.0121 of log form of family income suggests that a doubling of family income will increase the probability of being overweight by 1.21 percentage points. The coefficients are statistically significant for subgroup estimations of males and those in urban areas. This indicates that, when income doubles, the probability of being overweight in each of these groups will increase by 1.70 and 1.29 percentage points respectively. However, the coefficients of family income are not statistically significant for females and those in rural areas.

5.2 Decomposition of the possible channels

The first stage of analysis in the decomposition approach requires estimations of the univariate relationships between channel variables and family income (Blanden et al., 2007). Specifically, in this study, the first stage in understanding which channels are likely to affect is to review which of them has a relationship with family income; without this link, they cannot play a role in our explanation.

The first column of Table 3 provides the results from regressions of each variable on family income. They are conditional on other control variables as in the regression of health and family income gradient. With the exception of carbohydrates, all of the other variables in the measures of nutrition intakes are strongly and positively related to family income (see also, Huang and Gale, 2009). Among all channel variables, dietary knowledge has the strongest relationship with family income, with a magnitude of 0.107. Our results show that wealthier adults are more likely to have health insurance. The remainder of Table 3 builds up the sequential health outcome equations. These show how each of the three channels affects health outcomes.

Regarding the health outcome of BMI, the first and second columns of Table 3 compare the predictive power of nutrition intake with that of dietary knowledge. The explanatory power of these two specifications has an R-squared value of about 0.11 for both specifications. As expected, fat and protein are strong predictors of BMI. Each unit increase of fat or protein is associated with a 14.16% and 57.84% increase in BMI, respectively. The dietary knowledge index has a statistically significant impact on BMI, with a 3.94% increase in BMI for each unit increase in dietary knowledge. The results in the third column suggest that, with other factors held constant, those who have insurance are estimated to have a BMI that is 7.71% higher than those without insurance.

The fourth column of Table 3 also shows how the measure of dietary knowledge affects health outcomes through nutrition intake. Introducing the three components of nutrition intakes reduces the strength of the coefficients for dietary knowledge; this suggests that dietary knowledge is partially affecting BMI through its influence on nutrition intakes. The fifth column includes all channels. These variables account for a large proportion of the variation in BMI, with coefficients being both statistically significant and large in magnitude. Interestingly, BMI is still strongly related to nutrition intake and the dietary knowledge index, as there is still change in the coefficients on these variables when the health insurance variable is introduced.

When looking at the estimates, all potential channels are highly correlated with being overweight, as shown in columns (6)-(10) in Table 3. When solely introducing the nutrition intakes in column (6), fat and protein are significant and likely to increase the probability to be overweight. However, carbohydrates tend to decrease the likelihood of being overweight. This may suggest that a shift of the Chinese diet from cereals to animal products gave rise to the prevalence of overweight in China (Batis et al., 2014;).

Surprisingly, as shown in column (7), dietary knowledge has a significantly positive relationship with overweight, indicating a one-unit increase in the index of the dietary knowledge results in about a 12% higher probability of being overweight. After controlling for both nutrition intake and dietary knowledge in column (9), we find that the coefficients of these variables change slightly, but the significance levels remain unchanged. As mentioned before, for BMI, these changes might be due to the effect of dietary knowledge on consumption behaviors for final nutrition intake, as a result of the correlation between dietary knowledge and nutrition intake. Unlike the other two channels, there is no evidence that health insurance has an effect on the probability of being overweight, as shown in Column (8), even when controlling for all channels in Column (10). The coefficients of two other channels remain nearly unchanged in magnitude and significance level.

Table 3 shows that the three channels of nutrition intake, dietary knowledge, and health insurance have significant relationships with family income. These channels also have an important relationship with an adult's health outcome, either directly or via dietary knowledge. Table 4 decomposes BMI and propensity for being overweight into the contribution of each factor by multiplying each channel coefficient in the health outcome equation by its relationship with family income (Table 3, column 1). We summarize this for groups of variables to show BMI and propensity for being overweight when accounted for by the different transmission mechanisms. Even after all channels have been controlled for, family income still has an independent effect on health outcomes, possibly through other channels not observed in our data, described as the unexplained component in Table 4.

Specification (1) and (2) show that nutrition intake and dietary knowledge can explain 0.0244 points (26.96%) and 0.0043 points (4.75%) of the coefficient for income in the BMI estimation. When both nutrition intakes and dietary knowledge are included together in specification (4), the total amount accounts for an increase of 30.72%. Similar to dietary knowledge, health insurance account for 4.19% of BMI. Overall, when all transmission variables are included, more than 34.14% of the income effect on BMI can be explained. However, nutrition intake is responsible for approximately 26.18% of BMI given dietary knowledge and health insurance status.

Regarding the estimation for overweight, it shows that nutrition intake and dietary knowledge may explain 0.0089 points (28.08%) and 0.0012 points (3.79%) of the coefficient for income respectively. With the inclusion of nutrition intake and dietary knowledge in column (9), the total amount accounts for an increase of 31.23%. Health insurance has the lowest explanation of the income effect, accounting for only 3.15% of the income effect in the estimation for overweight. When including all transmission variables, approximately 33.75% of the income effect on overweight could be explained through the possible channels studied.

5.3 Heterogeneity of the correlation between income and health

To check for heterogeneity of the income gradient on adult health, we run the unconditional quantile regression as specified in the model (3.13) at various percentiles (the 5th, 25th, 45th, 60th, 75th, and 90th percentiles) of the BMI distribution. This allows us to easily examine the income effect on health at various amounts of nutrition[3]. The different sub-sample specifications are also investigated by gender, as well as by urban or rural status. Generally, the results indicate there exists significant heterogeneity in the effect of family income on adult health at various levels in the distribution of BMI. Substantial differences in the income effect on adult health across various sample specifications are also observed. Table 5 presents the OLS estimation and unconditional quantile regression results by gender and residency status. Starting with the estimations for the entire sample, the results from model specification (1), without including the three channel variables, show that the effect of income on adult health tends to increase with each successive income quantile. It varies from 0.0848 to 0.1104 standard deviations of BMI growth from the 25th to 75th percentiles, respectively. This result implies that, keeping height constant, adults with higher BMI will gain more weight with each increase in family income. However, there is no significant relationship between income and BMI at either tail of the distribution. Therefore, any policy intended to improve the health of malnourished adults, those below the 5th percentile, needs to consider increasing their income. Only when family income increases to a certain level do they seem to realize health benefits. After controlling for all three channels in specification (2), the magnitude of the family income estimates become smaller. Most are insignificant, except for the income effect at the 25th percentile, suggesting that family income generally has no independent and significant effect on BMI.

Looking at the income gradient by gender in Table 5, it is statistically significant

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[3] We estimate our sample for stated six quantiles because adults under 5th percentile are malnourished, above 60th percentile are overweight, and above 90th are obese.

for males, indicating that a doubling of family income gives rise to an increase of 0.1247 standard deviations in BMI. It also shows a significant heterogeneous income gradient across income quantiles. Similar to the pooled sample, the income effect on BMI generally increases with higher income quantiles. This effect tends to be weaker and insignificant for most income quantiles, except for the 25th (0.0834) and 90th percentiles when controlling for the nutrient intakes, dietary knowledge and health insurance. In total, these three channels explain approximately 30.95% of the income effect on health for males.

In conclusion, significant heterogeneity across various income quantile and sub-samples is shown in Table 5. The findings suggest that male and urban groups witness higher income effects on their health, while income seemingly does not affect female BMI.

6. Conclusion

With the substantial increase in family income, the prevalence of overweight has risen and become serious threat to individual health and major health challenges in many developing countries. This study attempts to shed light on the effect of family income on adults' health outcomes (BMI, overweight) through the potential channels of nutrition intakes, dietary knowledge, and health insurance. The data is drawn from the China Health and Nutrition Survey (CHNS) covering the period of 2004, 2006, 2009, and 2011.

The estimation results show that family income is highly associated with these potential channels considered. Precisely, an increase of family income improves the nutrition components of protein and fat intakes, while it is negatively correlated with carbohydrate intake. This result is consistent with the findings in other studies that people from higher income families are more likely to have more calories intake through the intake of protein and fat such as meat and milk products, but less carbohydrate from cereal food (Huang and Gale, 2009; Ogundari and Abdulai, 2013). Income also has a significantly positive correlation with dietary knowledge as expected, since adults are more conscious of health and have a higher availability of health information with increasing income (Binkley, 2010; Sekabira and Qaim, 2017). Adults with higher family income are more likely to have various health insurance, indicating they are more conscious of their health and less constrained by the budget as income increases.

To investigate the effect of income on health, we conduct the estimations for BMI, overweight, respectively. There exist significantly positive correlations between adult's BMI, overweight and family income. For further illustration of the channels through which family income might affect adult's health, the possible channels are gradually controlled to examine the changes in the coefficient of family income. Even after controlling for all channels, the family income still has a significant independent effect on adults' health outcome, but the magnitude of the coefficient for income changes substantially. Overall, all of these three channels could explain approximately 34.14% and 33.75% of the overall income effect on BMI and being overweight. Specifically, adults' nutrition intakes are the most important factors among the three channels as the coefficient of family income is changed to the largest extent after controlling for nutrition intakes of carbohydrate, fat, and protein; they contribute to approximately 26.96% and 28.08% of the total income effect on BMI and overweight, respectively. However, it should be noted that unexplained income effect might affect adult's health through other channels not considered in our empirical model due to the data constraint, to some extent, this study provides an first example for the future research on investigating the mechanism of income effect on adult's health through other channels.

To check the heterogeneity of income effect on adults' health, we conduct the unconditional quantile estimations across different sample specifications for gender and *hukou* registration status, as well as for the various income percentiles. The results from quantile regressions for BMI show that the marginal effect of income on health tends to increase from lower quantile to higher quantile, implying that BMI tend to increasing with income growth. For the sub-samples, family income has a significant contribution to BMI for male, urban, and rural subsamples, but it has no significant effect for female sample; meanwhile, urban residents have higher income effect on health than do rural residents. In addition, income has a higher effect on adult's health for urban sample than for rural samples.

According to our estimation results, profound policy implications are drawn in twofold. First, income is still the main factor restricting health and nutrition intakes in transition economy of China. Unlike in developed countries that higher income classes are less likely to have unhealthy food consumption and health related problems (Binkley, 2010), rising family income in China not only tends to increase nutrition intakes of protein and fat intake but also results in the prevalence of health issues from over-nutrition dramatically. Second, family income could promote adult's dietary knowledge significantly, but it might not be an efficient method to address adult's health issue in the short term as health knowledge has a lagging and limited effect on changes in consumer behavior. For instance, Shimokawa (2013) find that the dietary knowledge only largely affect the quantity and quality of food consumed for overweight and non-overweight adults, respectively. As suggested by Nayga (2000), the most effective method of health education might need to highlight the disease element of poor dietary habits and health.

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Table 1. Definition and descriptive statistics of selected key variables.

Variables	Variables Definition	All (1) Mean (S.D.)	Male (2) Mean (S.D.)	Female (3) Mean (S.D.)	Mean Difference (2) - (3)	Urban (4) Mean (S.D.)	Rural (5) Mean (S.D.)	Mean Difference (4) - (5)
Dependent Variables								
BMI	Body mass index	23.364	23.412	23.321	0.091**	23.660	23.145	0.515***
		(3.317)	(3.250)	(3.376)		(3.298)	(3.314)	
Overweight	1=If BMI>24; 0=Otherwise	0.395	0.403	0.388	0.015***	0.436	0.365	0.071***
		(0.488)	(0.491)	(0.487)		(0.496)	(0.482)	
Independent Variables		8.883	8.904	8.863	0.041***	9.241	8.617	0.624***
LogM	Natural logarithm of per capita family income (Yuan) inflated to 2011	(1.084)	(1.074)	(1.091)		(1.029)	(1.046)	
Nutrition Intakes (NI):								
Log(Carbohydrate)	Natural logarithm of 3-Day Ave: Carbohydrate (g)	5.623	5.705	5.549	0.156***	5.511	5.706	-0.195***
		(0.371)	(0.358)	(0.367)		(0.361)	(0.357)	
Log(Fat)	Natural logarithm of 3-Day Ave: Fat (g)	4.157	4.227	4.094	0.133***	4.253	4.086	0.167***
		(0.538)	(0.533)	(0.535)		(0.499)	(0.556)	
Log(Protein)	Natural logarithm of 3-Day Ave: Protein (g)	4.143	4.223	4.070	0.153***	4.176	4.118	0.058***
		(0.331)	(0.316)	(0.327)		(0.326)	(0.332)	
Dietary Knowledge (DK):								
DK	Dietary knowledge index	6.266	6.248	6.282	-0.034	6.904	5.793	1.111***
		(3.623)	(3.615)	(3.632)		(3.505)	(3.638)	
Health Insurance (HI):								
Insurance	3=Business insurance; 2=Basic medical insurance for urban residents; 1=NCMS[a]; 0=No	0.894	0.900	0.888	0.012	1.165	0.693	0.472***
		(0.849)	(0.853)	(0.845)		(1.028)	(0.613)	
Gender	1=Male; 0=Female	0.476				0.485	0.469	0.016***

		(0.499)				(0.500)	(0.500)	
Hukou	1=Urban; 0=Rural	0.426	0.434	0.418	0.016***			
		(0.494)	(0.496)	(0.493)				
Age	Years	45.235	45.148	45.313	-0.165	45.419	45.098	0.321**
		(11.735)	(11.960)	(11.531)		(11.739)	(11.731)	
Working status	1=Yes; 0=No	0.683	0.773	0.601	0.172***	0.592	0.750	-0.158***
		(0.465)	(0.419)	(0.490)		(0.491)	(0.433)	
Education	6=Master or above; 5=College or university; 4=Vocational education; 3=High school; 2=Junior high school; 1=Elementary school; 0=Illiterate	2.036	2.251	1.841	0.410***	2.793	1.475	1.318***
		(1.403)	(1.329)	(1.440)		(1.446)	(1.066)	
Marital status	1=Married with companion; 0=Unmarried or married without companion	0.875	0.862	0.886	-0.025***	0.854	0.890	0.038***
		(0.331)	(0.344)	(0.318)		(0.353)	(0.313)	
Family size[b]	Household members	2.579	2.573	2.585	-0.012	2.326	2.767	-0.441***
		(0.823)	(0.811)	(0.833)		(0.701)	(0.856)	
Chicken	Price of chicken at community level (Yuan/Jin[c])	19.264	19.275	19.254	0.021	18.707	19.677	-0.970***
		(6.925)	(6.922)	(6.927)		(6.435)	(7.239)	
Pork	Price of pork at community level (Yuan/Jin[c])	24.303	24.265	24.339	-0.074	23.905	24.598	-0.693***
		(6.430)	(6.401)	(6.456)		(6.195)	(6.584)	
Vegetables	Price of vegetables at community level (Yuan/Jin[c])	2.687	2.678	2.695	-0.017	2.744	2.644	0.100***
		(0.962)	(0.955)	(0.967)		(0.985)	(0.942)	
Cereals	Price of cereals at community level (Yuan/Jin[c])	4.543	4.544	4.542	0.002	4.552	4.536	0.016
		(1.164)	(1.162)	(1.166)		(1.182)	(1.150)	
No. of obs.		30860	14681	16179		13129	17731	

Note: a. New agricultural cooperative medical insurance. b. The first adult in the household has a weight of 1. Each additional adult aged 14 and over has a weight of 0.5. Each child aged under 14 has a weight of 0.3. c. 1 Jin=0.5kg.

Source: Author's calculation using the CHNS data (2004-2011).

Table 2. Per capita family income and health.

Dependent Variable	BMI[a]					Overweight[b]				
	All	Male	Female	Urban	Rural	All	Male	Female	Urban	Rural
LogM	0.0905**	0.1247**	0.0233	0.0849*	0.0735*	0.0121**	0.0170**	0.0028	0.0129**	0.0093
	(0.04)	(0.05)	(0.04)	(0.05)	(0.04)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Gender	0.2595***			0.7541***	-0.1984**	0.0363***			0.1104***	-0.0289**
	(0.08)			(0.09)	(0.10)	(0.01)			(0.01)	(0.01)
Hukou	0.4126***	0.6395***	0.1929*			0.0569***	0.0859***	0.0296*		
	(0.08)	(0.10)	(0.11)			(0.01)	(0.02)	(0.02)		
Age	0.2963***	0.2349***	0.3288***	0.2493***	0.3267***	0.0389***	0.0317***	0.0450***	0.0354***	0.0408***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Age^2	-0.0030***	-0.0026***	-0.0032***	-0.0023***	-0.0034***	-0.0004***	-0.0003***	-0.0004***	-0.0003***	-0.0004***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Working status	-0.4138***	-0.1566**	-0.5130***	-0.1082	-0.4438***	-0.0558***	-0.0242*	-0.0702***	-0.0204*	-0.0627***
	(0.05)	(0.08)	(0.08)	(0.08)	(0.07)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Education	-0.1157***	0.1454***	-0.2827***	-0.1734***	0.0181	-0.0122**	0.0269***	-0.0400***	-0.0196***	0.0049
	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
Marital status	0.3769***	0.6527***	0.3181***	0.2518**	0.3214**	0.0418***	0.0776***	0.0402**	0.0261	0.0372**
	(0.09)	(0.13)	(0.11)	(0.12)	(0.12)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Family size	0.0830*	0.0409	0.1106*	0.1497*	0.0800	0.0085	0.0035	0.0113	0.0144	0.0092
	(0.05)	(0.06)	(0.06)	(0.08)	(0.06)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Chicken	-0.0152**	-0.0251***	-0.0087	-0.0169*	-0.0105	-0.0023**	-0.0041***	-0.0012	-0.0023	-0.0020*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Pork	0.0014	0.0038	-0.0017	0.0148	-0.0137	-0.0001	0.0000	-0.0002	0.0007	-0.0011
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Vegetables	-0.0010	-0.0033	-0.0005	-0.0680	0.0513	-0.0052	-0.0044	-0.0067	-0.0116	-0.0013
	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Cereals	0.0201	0.0996**	-0.0409	0.0298	0.0449	0.0049	0.0225***	-0.0092	0.0101	0.0059
	(0.04)	(0.04)	(0.05)	(0.06)	(0.04)	(0.00)	(0.01)	(0.01)	(0.01)	(0.00)

Year dummies	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Provincial dummies	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
R^2	0.109	0.127	0.138	0.119	0.115					
Log-pseudolikelihood						-19477.795	-9205.671	-9941.729	-8427.436	-10901.292
N	30860	14681	16179	13129	17731	30860	14681	16179	13129	17731

Note: a. Coefficients are presented from the OLS regression for BMI. b. Marginal effects are presented from the Probit regression for Overweight. Standard errors are given in parentheses.

Source: Author's estimation using the CHNS data (2004-2011).

* p<0.10, ** p<0.05, *** p<0.010

Table 3. Relationship between potential channels and per capita family income.

Dependent Variable	LogM	BMI					Overweight				
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Nutrition Intakes (NI):											
Log(Carbohydrate)	-0.0042	-0.2383**			-0.2224**	-0.2196**	-0.0938**			-0.0890**	-0.0884**
	(0.00)	(0.11)			(0.11)	(0.11)	(0.04)			(0.04)	(0.04)
Log(Fat)	0.0434***	0.1416***			0.1362***	0.1359***	0.0528***			0.0512***	0.0512***
	(0.01)	(0.05)			(0.05)	(0.05)	(0.02)			(0.02)	(0.02)
Log(Protein)	0.0298***	0.5784***			0.5699***	0.5667***	0.2114***			0.2089***	0.2081***
	(0.00)	(0.12)			(0.12)	(0.12)	(0.05)			(0.05)	(0.05)
Dietary Knowledge (DK):											
DK	0.1069***		0.0394***		0.0373***	0.0369***		0.0118***		0.0110***	0.0109***
	(0.03)		(0.01)		(0.01)	(0.01)		(0.00)		(0.00)	(0.00)
Health Insurance (HI):											
Insurance	0.0489***			0.0771**		0.0662*			0.0207		0.0172
	(0.01)			(0.04)		(0.04)			(0.01)		(0.01)
Other control variables	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year dummies	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Provincial dummies	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
R^2		0.113	0.110	0.110	0.114	0.114					
Log-pseudolikelihood							-19434.781	-19468.613	-19476.278	-19426.823	-19425.779
N	30860	30860	30860	30860	30860	30860	30860	30860	30860	30860	30860

Note: Standard errors are given in parentheses.

Source: Author's estimation using the CHNS data (2004-2011).

* p<0.10, ** p<0.05, *** p<0.010

Table 4. Accounting for the Channels through which family income affects health and overweight.

Dependent Variable	BMI					Overweight				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Log(Carbohydrate)	0.0010			0.0010	0.0009	0.0004			0.0003	0.0004
Log(Fat)	0.0062			0.0059	0.0059	0.0023			0.0022	0.0022
Log(Protein)	0.0172			0.0169	0.0169	0.0062			0.0062	0.0061
Sum of Nutrition Intakes (NI):	*0.0244*			*0.0238*	*0.0237*	*0.0089*			*0.0087*	*0.0087*
DK		0.0043		0.0040	0.0040		0.0012		0.0012	0.0012
Sum of Dietary Knowledge (DK):		*0.0043*		*0.0040*	*0.0040*		*0.0012*		*0.0012*	*0.0012*
Sum of Nutrition Intakes (NI) & Dietary Knowledge (DK):				*0.0278*	*0.0277*				*0.0099*	*0.0099*
Insurance			0.0038		0.0032			0.0010		0.0008
Sum of Health Insurance (HI):			*0.0038*		*0.0032*			*0.0010*		*0.0008*
Explained	0.0244	0.0043	0.0038	0.0278	0.0309	0.0089	0.0012	0.0010	0.0099	0.0107
Unexplained	0.0661	0.0862	0.0867	0.0627	0.0596	0.0228	0.0305	0.0307	0.0218	0.0210
Total	0.0905	0.0905	0.0905	0.0905	0.0905	0.0317	0.0317	0.0317	0.0317	0.0317

Notes. The columns provide the decompositions that are derived from the income and channels relationships in Table 3, as described in the text. The contributions of the variables that account for missing values are included in the "Unexplained" component.

Source: Author's calculation using the CHNS data (2004-2011).

Table 5. Unconditional quantile regressions for the relation between income and BMI.

		OLS	Q5	Q25	Q45	Q60	Q75	Q90
All	(1)	0.0905**	0.0489	0.0848**	0.0915**	0.1045**	0.1104**	0.0705
		(0.04)	(0.04)	(0.03)	(0.04)	(0.05)	(0.05)	(0.06)
	(2)	0.0596*	0.0284	0.0565*	0.0529	0.0683	0.0811	0.0416
		(0.03)	(0.03)	(0.03)	(0.04)	(0.04)	(0.05)	(0.06)
Male	(1)	0.1247**	-0.0111	0.1152**	0.1300**	0.1446**	0.1285*	0.1498**
		(0.05)	(0.05)	(0.05)	(0.06)	(0.06)	(0.07)	(0.07)
	(2)	0.0861*	-0.0362	0.0834*	0.0835	0.1005	0.0845	0.1192*
		(0.05)	(0.05)	(0.04)	(0.06)	(0.06)	(0.07)	(0.07)
Female	(1)	0.0233	0.0417	0.0233	0.0072	0.0381	0.0537	-0.0610
		(0.04)	(0.05)	(0.04)	(0.04)	(0.05)	(0.06)	(0.08)
	(2)	0.0004	0.0253	-0.0020	-0.0242	0.0099	0.0381	-0.0867
		(0.04)	(0.05)	(0.04)	(0.04)	(0.05)	(0.06)	(0.08)
Urban	(1)	0.0849*	0.1280**	0.1375***	0.1060**	0.1045**	0.0888	-0.0495
		(0.05)	(0.06)	(0.05)	(0.05)	(0.05)	(0.07)	(0.09)
	(2)	0.0607	0.1055*	0.1143**	0.0785	0.0820	0.0708	-0.0689
		(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.07)	(0.09)
Rural	(1)	0.0735*	-0.0152	0.0500	0.0670	0.0937	0.0816	0.1198
		(0.04)	(0.04)	(0.04)	(0.05)	(0.06)	(0.07)	(0.07)
	(2)	0.0362	-0.0315	0.0175	0.0237	0.0459	0.0391	0.0822
		(0.04)	(0.04)	(0.03)	(0.05)	(0.05)	(0.06)	(0.07)

Notes: a. Row (1) includes the control variables from Table 2; Row (2) includes all channel variables and control variables in Table A2. b. Observations under q5 are malnourished, above q60 are overweight, and above q90 are obese, respectively.

Source: Author's estimation using the CHNS data (2004-2011).

* p<0.10, ** p<0.05, *** p<0.010

Table A1. Questions concerning dietary knowledge in the CHNS.

Dietary knowledge: Do you strongly agree, somewhat agree, neutral, somewhat disagree or strongly disagree with this statement?	True/False
**Please note that the question is not asking about your actual habits.*	
Q1: Choosing a diet with a lot of fresh fruit and vegetables is good for one's health	T
Q2: Eating a lot of sugar is good for one's health	F
Q3: Eating a variety of foods is good for one's health	T
Q4: Choosing a diet high in fat is good for one's health	F
Q5: Choosing a diet with a lot of staple foods (rice and rice products and wheat and wheat products) is not good for one's health	T
Q6: Consuming a lot of animal products daily (fish, poultry, egg and lean meat) is good for one's health	F
Q7: Reducing the amount of fatty meat and animal fat in the diet is good for one's health	T
Q8: Consuming milk and dairy products is good for one's health	T
Q9: Consuming beans and bean products is good for one's health	T
Q10: Physical activities are good for one's health	T
Q11: Sweaty sports or other intense physical activities are not good for one's health	T
Q12: The heavier one's body is, the healthier he or she is	F
Index rules: "1" point was given for a correct answer, "-1" point for a incorrect answer, and "0" points for the other answers.	

Source: The dietary knowledge questionnaire is from the official website of China Health and Nutrition Survey. (http://www.cpc.unc.edu/projects/china)

Table A2. Per capita family income and health controlling for all channel variables.

Dependent Variable	BMI[a]					Overweight[b]				
	All	Male	Female	Urban	Rural	All	Male	Female	Urban	Rural
LogM	0.0596*	0.0861*	0.0004	0.0607	0.0362	0.0080	0.0117	-0.0003	0.0101	0.0041
	(0.03)	(0.05)	(0.04)	(0.05)	(0.04)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
<u>*Nutrition Intakes (NI):*</u>										
Log(Carbohydrate)	-0.2196**	-0.3001***	-0.2499*	0.2274	-0.5274***	-0.0338**	-0.0363**	-0.0454**	0.0262	-0.0760***
	(0.11)	(0.11)	(0.14)	(0.16)	(0.12)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Log(Fat)	0.1359***	0.1332**	0.1204**	0.1075	0.0998	0.0196***	0.0282***	0.0100	0.0105	0.0176**
	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Log(Protein)	0.5667***	0.7035***	0.4395***	0.3006*	0.8265***	0.0796***	0.0895***	0.0734***	0.0369*	0.1208***
	(0.12)	(0.14)	(0.16)	(0.16)	(0.13)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
<u>*Dietary Knowledge (DK):*</u>										
DK	0.0369***	0.0483***	0.0305***	0.0377***	0.0284***	0.0042***	0.0053***	0.0037***	0.0039*	0.0035***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
<u>*Health Insurance (HI):*</u>										
Insurance	0.0662*	0.0918	0.0221	0.0519	0.1738***	0.0066	0.0125	-0.0019	0.0075	0.0163*
	(0.04)	(0.06)	(0.04)	(0.04)	(0.06)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Gender	0.1982**			0.6687***	-0.2516**	0.0279**			0.1008***	-0.0379***
	(0.08)			(0.10)	(0.10)	(0.01)			(0.01)	(0.01)
Hukou	0.3345***	0.5427***	0.1272			0.0469***	0.0734***	0.0212		
	(0.08)	(0.10)	(0.12)			(0.01)	(0.01)	(0.02)		
Age	0.2924***	0.2325***	0.3257***	0.2490***	0.3222***	0.0383***	0.0313***	0.0447***	0.0354***	0.0402***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Age^2	-0.0030***	-0.0025***	-0.0031***	-0.0023***	-0.0034***	-0.0004***	-0.0003***	-0.0004***	-0.0003***	-0.0004***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Working status	-0.4128***	-0.1653**	-0.5015***	-0.1304*	-0.4164***	-0.0556***	-0.0258*	-0.0682***	-0.0231*	-0.0589***
	(0.05)	(0.08)	(0.08)	(0.08)	(0.07)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Education	-0.1403***	0.1152***	-0.3035***	-0.1853***	-0.0161	-0.0153***	0.0232***	-0.0426***	-0.0210***	0.0004
	(0.03)	(0.04)	(0.04)	(0.04)	(0.04)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
Marital status	0.3445***	0.6026***	0.2989***	0.2234*	0.2793**	0.0378***	0.0718***	0.0374**	0.0231	0.0314*

	(0.09)	(0.12)	(0.11)	(0.12)	(0.12)	(0.01)	(0.02)	(0.02)	(0.02)	(0.02)
Family size	0.0965*	0.0581	0.1207**	0.1654**	0.0886	0.0104	0.0063	0.0122	0.0161	0.0105
	(0.05)	(0.06)	(0.06)	(0.08)	(0.06)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Chicken	-0.0153**	-0.0251***	-0.0088	-0.0184*	-0.0090	-0.0023***	-0.0042***	-0.0012	-0.0025*	-0.0018*
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Pork	0.0051	0.0094	0.0012	0.0153	-0.0102	0.0005	0.0008	0.0003	0.0007	-0.0005
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Vegetables	-0.0033	-0.0070	-0.0035	-0.0594	0.0395	-0.0057	-0.0049	-0.0073	-0.0106	-0.0032
	(0.04)	(0.05)	(0.05)	(0.05)	(0.05)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Cereals	0.0106	0.0889**	-0.0507	0.0292	0.0264	0.0037	0.0217***	-0.0109	0.0100	0.0035
	(0.04)	(0.04)	(0.05)	(0.06)	(0.04)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)
Year dummies	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Provincial dummies	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
R^2	0.114	0.134	0.141	0.123	0.121					
Log-pseudolikelihood						-19425.779	-9168.255	-9923.932	-8414.069	-10850.806
N	30860	14681	16179	13129	17731	30860	14681	16179	13129	17731

Note: a. Coefficients are presented from the OLS regression for BMI. b. Marginal effects are presented from the Probit regression for Overweight. Standard errors are given in parentheses.

Source: Author's estimation using the CHNS data (2004-2011).

* p<0.10, ** p<0.05, *** p<0.010

Table A3. Extended model of health and overweight.

Dependent Variable	BMI						Overweight					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
LogM	0.0905**	0.0661*	0.0862**	0.0867**	0.0627*	0.0596*	0.0317**	0.0228*	0.0305**	0.0307**	0.0218	0.0210
	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Nutrition Intakes (NI):												
Log(Carbohydrate)		-0.2383**			-0.2224**	-0.2196**		-0.0938**			-0.0890**	-0.0884**
		(0.11)			(0.11)	(0.11)		(0.04)			(0.04)	(0.04)
Log(Fat)		0.1416***			0.1362***	0.1359***		0.0528***			0.0512***	0.0512***
		(0.05)			(0.05)	(0.05)		(0.02)			(0.02)	(0.02)
Log(Protein)		0.5784***			0.5699***	0.5667***		0.2114***			0.2089***	0.2081***
		(0.12)			(0.12)	(0.12)		(0.05)			(0.05)	(0.05)
Dietary Knowledge (DK):												
DK			0.0394***		0.0373***	0.0369***			0.0118***		0.0110***	0.0109***
			(0.01)		(0.01)	(0.01)			(0.00)		(0.00)	(0.00)
Health Insurance (HI):												
Insurance				0.0771**		0.0662*				0.0207		0.0172
				(0.04)		(0.04)				(0.01)		(0.01)
Gender	0.2595***	0.1938**	0.2636***	0.2607***	0.1971**	0.1982**	0.0949***	0.0716**	0.0960***	0.0953***	0.0725**	0.0729**
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Hukou	0.4126***	0.3654***	0.3947***	0.3929***	0.3508***	0.3345***	0.1484***	0.1311***	0.1430***	0.1430***	0.1268***	0.1224***
	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.08)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)
Age	0.2963***	0.2914***	0.2977***	0.2958***	0.2928***	0.2924***	0.1016***	0.1000***	0.1020***	0.1014***	0.1004***	0.1002***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Age^2	-0.0030***	-0.0030***	-0.0030***	-0.0030***	-0.0030***	-0.0030***	-0.0010***	-0.0010***	-0.0010***	-0.0010***	-0.0010***	-0.0010***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Working status	-0.4138***	-0.4120***	-0.4109***	-0.4170***	-0.4100***	-0.4128***	-0.1450***	-0.1442***	-0.1440***	-0.1458***	-0.1436***	-0.1443***
	(0.05)	(0.06)	(0.05)	(0.05)	(0.05)	(0.05)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Education	-0.1157***	-0.1269***	-0.1263***	-0.1205***	-0.1364***	-0.1403***	-0.0318**	-0.0361***	-0.0349***	-0.0331***	-0.0389***	-0.0399***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Marital status	0.3769***	0.3590***	0.3634***	0.3745***	0.3463***	0.3445***	0.1107***	0.1043***	0.1065***	0.1099***	0.1005***	0.0999***

	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.09)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)
Family size	0.0830*	0.0932*	0.0854*	0.0847*	0.0951*	0.0965*	0.0223	0.0260	0.0231	0.0228	0.0267	0.0271
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Chicken	-0.0152**	-0.0153**	-0.0153**	-0.0150**	-0.0154**	-0.0153**	-0.0060**	-0.0061**	-0.0060**	-0.0060**	-0.0061***	-0.0061***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Pork	0.0014	0.0041	0.0026	0.0013	0.0052	0.0051	-0.0002	0.0010	0.0002	-0.0002	0.0013	0.0013
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Vegetables	-0.0010	-0.0048	0.0007	-0.0015	-0.0029	-0.0033	-0.0137	-0.0154	-0.0131	-0.0138	-0.0148	-0.0149
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Cereals	0.0201	0.0145	0.0163	0.0193	0.0112	0.0106	0.0128	0.0108	0.0116	0.0126	0.0097	0.0096
	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.04)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Year dummies	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Provincial dummies	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
R^2	0.109	0.113	0.110	0.110	0.114	0.114						
N	30860	30860	30860	30860	30860	30860	30860	30860	30860	30860	30860	30860

Note: Standard errors are given in parentheses.

Source: Author's estimation using the CHNS data (2004-2011).

* $p<0.10$, ** $p<0.05$, *** $p<0.010$