# Income Effects on the Nutritional Intake of Urban Residents in China

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Nutrition is the basis of population health and social human capital, which is of great significance to social and economic development. Based on the data from the Chinese Health and Nutrition Survey (CHNS) in 2011, this study investigates the effect of household income on the nutritional intake of urban residents. Quantile regression analysis was applied to reveal the diverse effects across the distribution of nutritional intake. The results showed significant differences in calorie intake among urban residents. The effect of household income on calorie intake is greater for lower quantiles than for higher ones. Household demographic characteristics and market variables also have significant effects on the calorie intake of urban residents. It is suggested that nutrition intervention should be tailored to different groups. The effectiveness of dietary guidance should be reinforced to improve the nutritional status of the urban residents in China.

Keywords: Calorie intake; Household income; Quantile regression; Urban residents
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## 1. Introduction

Nutritional value is a crucial indicator of food utilization and population quality, constituting one of the four pillars of food security (Russell et al., 2018). A well-balanced nutritional diet is important for proper bodily functioning and maintaining good health. It should encompass various nutrients, such as vitamins and minerals, to ensure sufficient intake. Otherwise, malnutrition, a diet which has not enough or too much nutrition, could cause health problems. Even though the current global health gap has been narrowed between countries in the past decades, malnutrition remains a persistent challenge to achieving optimal nutritional status (WHO, 2015). A total of 80.5 million people are experiencing undernourishment, and about 79.1 million of them reside in developing countries, accounting for 98% of total undernourished people (FAO, 2014). However, the nutritional status in developed countries is far from satisfactory as well. Many people suffer from diseases related to overnutrition, such as obesity. For example, the obesity rates in America and Europe stand at 61% and 55%, respectively, significantly higher than the rest of the world (FAO, 2015). The underlying causes of global malnutrition include poverty, increasing food prices, unhealthy dietary practices, and more, which make malnutrition an actual social problem in many countries (Musaiger et al., 2016; Vilar-Compte et al., 2021; Headey & Ruel, 2023).

Household income impacts food expenditure, and thus might affect nutritional and dietary structure. Household income directly affects residents' capacity to afford nutritious food (Drewnowski & Darmon, 2005). Income and nutritional intake are highly related (Tiffin & Dawson, 2022). These mixed results were concluded to identify the relationship between income and nutritional intake (Abdulai & Aubert, 2004; Zhao et al., 2022). Many studies have found positive effects of income on total nutritional intake (Salois et al., 2012; Ren et al., 2019; Shabnam et al., 2021), while some studies have found a negative effect (Huang & Gale, 2009). A nonlinear relationship between income and calorie intake has also been found in some studies (Tian & Yu, 2015; Shabnam, 2022; Jumrani, 2023). There are also some studies which have found little or even no correlation between them (Bishop et al., 2010). The mixed results may be related to the caloric availability of the residents (Ali et al., 2018). Therefore, a variation in calorie intake is introduced into our study to find out the various effects of income on different calorie groups.

With the rapid development of China's economy, residents' income levels have gradually increased, and the proportion of malnourished people has also dropped significantly. Nutritional status has improved over the last few decades due to a decrease in morbidity, improvements in food distribution, increased availability of potable water, and better healthcare facilities (Cai et al., 2022). However, an increase in income does not necessarily lead to a balanced nutritional intake (Yin et al., 2023), especially for urban residents. Urban diets typically include more meats, eggs, and oils, which are rich in calories,

fats, and proteins (Zhao et al., 2022). Changes in dietary practice (e.g., eating fewer vegetables) contribute to nutrition-related chronic diseases, such as being overweight, hypertension, diabetes, and heart problems (Neuhouser, 2019). As a result, compared to rural residents, urban residents have a higher rate of chronic diseases. In 2013, urban residents had diabetes and hypertension rates of 4.8% and 16.2%, respectively, which were 2.3 times and 1.3 times higher than those of rural residents in China. Many studies have investigated the relationship between income and calories among the rural residents in China (Shimokawa, 2010; Wang et al., 2020; Zeng et al., 2022). Few studies have focused on the relevant issue in urban areas.

To address the nutritional intake challenges, the Chinese government has implemented a series of guidelines aimed at standardizing dietary habits to reduce malnutrition and chronic diseases. The General Office of the State Council issued the "Report on food and Nutrition Development in China 2014-2020" in 2014 and outlined the targets for daily calorie intake per capita of 2,200-2,300 kilocalories (Kcal) by 2020. The report also includes detailed objectives for food production and consumption, food industry development, and nutrition-related disease control. Moreover, the "Chinese Diet Guidelines 2016" formulated by the National Population and Family Planning Commission emphasize the importance of balanced dietary practice and balanced nutritional intake. However, significant provincial variations exist in the total nutritional intake in China (CHNS, 2015). Therefore, a universal dietary guide cannot solve the malnutritional problems among different calorie groups (Yin et al., 2023). Further investigation into this issue is necessary to provide calorie intake references tailored to different calorie groups.

The study used data from the 2011 Chinese Residents Health and Nutrition Survey (CHNS) to analyze the nutritional intake and distribution characteristics of urban residents in China. Both Ordinary Least Squares (OLS) and Generalized Method of Moments (GMM) were applied to investigate the effect of income on urban residents' nutritional intake. And quantile regression analysis was applied to investigate the income effects across different calorie groups. The results showed that the nutritional intake for urban residents remained at a low level, with significant heterogeneity across income levels. Lower-income households have lower nutritional intake due to limited food accessibility, while higher-income households encounter issues of overnutrition. The effects of income on nutritional intake vary across different calorie groups, with only low-calorie-intake households experiencing discernible changes due to income fluctuations.

The paper is organized as follows. Section 2 is the literature review. Section 3 presents the methodology, data, and method, followed by the results. Section 4 presents the results. The last section provides the conclusion and implications.

## 2. Literature Review

Nutrition economics has both characteristics of natural science and social science (Finaret & Masters, 2019). It investigates households' nutritional intake, nutrition structure, and dietary behavior under certain budget constraints. Proper food selection and dietary habits will not only help households attain a better health condition and reduce their medical expenditure but also help to reduce the pressure on the public hygiene system (Lenoir-Wijnkoop et al., 2011; Yin et al., 2023). Malnutrition increases the expenditure of the healthcare system and imposes a substantial economic burden (Inciong et al., 2022; Pradelli et al., 2023). Reducing nutritional risk and issuing proper nutritional instructions have large economic benefits (Serra-Majem et al., 2020).

The nutritional intake shows different characteristics during economic development (Wang et al., 2020). Economic development significantly influences households' consumption (Frazao and Allshouse, 2003; Zeng et al., 2022; Kuhlgatz et al., 2022; Bu et al., 2021). In China, as income rises, households may shift from staple-based food to high-fat animal-oriented foods (Bu et al., 2021; Lian et al., 2023). The source of income also plays a role in households' calorie intake. Farming households tend to have higher calorie and protein intake compared to non-farming households (Sun et al., 2021).

The effects of income on nutritional intake are subject to debate. Higher income will increase households' purchasing power but may also lead to more reliance on eating out and fast food, thereby affecting dietary choices (French et al., 2010; Janssen et al., 2018). Salois et al. (2012) found a linear link between income and calorie, fat, and protein intake, with fat intake showing the highest income elasticity. Some previous studies found that income positively influences calorie intake and helps combat malnutrition (Abdulai & Aubert, 2004; Vu, 2008; Yin et al., 2023). Others found that income might not significantly impact nutritional intake, especially if high-income households prioritize food quality and flavor over quantity (Popkin & Ng, 2022). Low-income households may meet calorie needs with lower-cost food options, while higher-income households may not see a proportional rise in nutritional intake despite increased spending (Bocoum et al., 2014). Further research is thus needed to fully understand the relationship between income and nutritional intake.

The total nutritional intake of a household is influenced by various factors, including individual and household income and demographics characteristics. Households with more members

tend to consume more staple foods like rice but may decrease their consumption of fruits and vegetables due to economies of scale in food consumption, leading to reduced food waste (Chang et al., 2018). Research indicates that household size has a negative effect on calorie demand, particularly affecting protein, fat, and carbohydrate intake (Abdulai & Aubert, 2004; Cui et al., 2012). Nutritional intake varies by age in households, with the elderly and children typically responding weakly to calorie intake (Zhou et al., 2018). In addition, the age and gender of the household head play roles in household nutritional intake (Lee & Zhao, 2024). Higher education levels may reduce fat intake and influence food variety, while households led by females tend to have higher food expenditure (Hiza et al., 2013). In addition, the proximity to food markets and access to diverse food options are associated with higher calorie intake, particularly among rural households, while those farther from markets or with limited food variety consume less calories (Headey et al., 2019; Xue et al., 2021). Incorporating these market proximity effects into income analysis can provide a more comprehensive understanding of household nutritional intake.

# 3.Methodology

## 3.1 Economic model

Following Li and Chen (2017), the nutritional intake of urban residents is assumed to be influenced by their income and other social factors, which is presented as:

$$TN=f(E, Z) \tag{1}$$

where $TN$ represents the nutritional intake, $E$ represents the food consumption, and $Z$ is the vector of other factors that influence urban residents' nutritional intake. Let $E=d(F)\times p_F$, where $p_F$ is the food price. As a part of household expenditures, food consumption $E$ is constrained by total income $I$. Under the aim of maximizing utility, the food demand $d(F)$ can be derived from the utility function $U$ as follows:

$$\begin{aligned} &U=z+u(d(F)) \\ &s.t.\ \ z\times p_z+d(F)\times p_F=I \end{aligned} \tag{2}$$

where $z$ represents the demand for numeraire goods and $p_z$ is the price. $p_E$ is the food price and $I$ is the total income. Thus, the food demand function can be transformed as follows:

$$d(F)=g(I, p_F) \tag{3}$$

Assuming that there is no substitutability between different types of food, and that all urban residents face the same food prices in the same period, the food price ($p_F$) is an exogenous constant in the model. By substituting Eq. (3) into Eq. (1), the nutritional demand function can be performed as follows:

$$TN=f(I, Z) \tag{4}$$

where $Z$ is the control variable in the model, which includes the characteristics of the survey population, households, and the accessibility to the traditional market.

## 3.2 Model specification

The specification of urban residents' nutritional intake is assumed to be a function of total income and other factors and can be described as follows:

$$\ln(hhenergypc_i)=\beta_0+\beta_1\ \ln(hhincpc_i)+X_i\gamma+\varepsilon_i \tag{5}$$

where $hhenergypc_i$ represents the nutritional intake of the $i^{th}$ urban household, $hhincpc_i$ is the per capita income of the $i^{th}$ urban household, and $X_i$ is a vector of other variables of individual and household characteristics of the $i^{th}$ urban household.

To investigate the income effects across different calorie groups, a quantile regression model was applied in this study.

$$Quant_\theta(hhenergypc_i \mid M_i)=\lambda^\theta \tag{6}$$

where $\theta$ is the quantile of the estimation, and $M_i$ is the explanatory variables in Eq. (5). $Quant_\theta(hhenergypc_i \mid M_i)$ represents the different quantiles ($\theta$, $0<\theta<1$) which are conditional on $M_i$. $\lambda_\theta$ is the coefficient of quantile $\theta$, which minimized the residuals.

$$\lambda^\theta=\arg\min\left\{\sum_{i,hhenergypc_i<M_i\beta}\theta|hhenergypc_i-M_i\beta|+\sum_{i,hhenergypc_i<M_i\beta}(1-\theta)|hhenergypc_i-M_i\beta|\right\} \tag{7}$$

## 3.3 Variable definition

Calorie intake includes the intake of protein, fat, and hydrocarbons, providing a comprehensive reflection of a household's nutritional status. Thus, the household's daily calorie intake serves as the explanatory variable within the model. Moreover, there is less dietary variation by using calories other than nutrition itself. To investigate the income effects on the nutritional intake of households, household income is designated as the primary explanatory variable, while controlling for the characteristics of households and their members, as well as the

distance between their residence and the nearest marketplace. The yearly income per capita is used as the proxy for the household income variable. Food consumption is calculated based on the consumption of all family members, so calorie intake is measured at household level instead of individual level.

Considering that the household head may be an important decision maker regarding household food consumption, their characteristics, such as age, education, and gender, are introduced in the model. These factors can influence the body's metabolic needs, consumption habits, food preferences, and nutritional knowledge, which in turn affect the household's food consumption decisions and caloric intake levels. Additionally, household size is considered, as larger households may have considerable labor income but still face limitations in food consumption due to resource constraints. In addition, there are significant differences in the food consumption and nutritional needs among individuals younger than 6 and those older than 65. Thus, these two special groups are introduced in the model to control for differences in nutritional intake among different age groups. In urban China, residents typically rely on local markets for their daily food needs. Consequently, the development of these markets plays a crucial role in determining the accessibility to kinds of food and food quality and variety, thereby affecting the nutritional intake of urban residents. To account for this, the distance to the nearest traditional market is incorporated as a control variable in the model. The score of the local markets is used as a proxy for the market's development and food accessibility.

### 3.4 Data

The data for this study were from the China Health and Nutrition Survey (CHNS) conducted in 2011. This survey was a joint project between the University of North Carolina at Chapel Hill and Chinese Center for Disease Control and Prevention (CCDC). Using multi-stage random sampling, data from 4,000 households across 12 provinces were collected. In the study, after deleting rural households, the final sample accounted for 1,809 urban households. The data showed that the average daily nutritional intake of urban households in China was 1,781 Kcal, lower that the target range of 2,200-2,300 Kcal outlined in "The National Food and Nutrition Development Outline (2014-2020)." There are regional disparities in nutritional intake. Individuals in the east[1] and middle region have higher average intakes of 1,824 and 1,836 Kcal, respectively, compared to 1,614 Kcal for those in the western region. The per capita income in the western region is only 14,640 yuan per year, which is 59% and 76% of that in the east and central regions, respectively (Table A1).

According to the Dietary Pagoda from the Chinese Nutrition Society (1997), calorie intake is categorized into four groups: low-calorie (less than 1,800 Kcal), medium-low calorie (1,801 to 2,400 Kcal), medium-high calorie (2,401 to 2,800 Kcal), and high-calorie (more than 2,801 Kcal). Calorie intake below 1800 Kcal is considered undernourishment, while above 2,800 Kcal is considered overnutrition; thus, 57.05% of households were experiencing undernourishment and 30.3% of households have a medium-low level of calorie intake on this basis. Only a smaller proportion of households, specifically 8.35% and 4.15%, had medium-high and high levels of calorie intake, respectively. Households at the high-calorie level had an average intake of 3,161 Kcal per capita daily, which was double the amount recommended by dietary guidelines, indicating overnutrition. This large variance in nutritional intake indicates a dual challenge of undernutrition and overnutrition in urban China.

According to the National Bureau of Statistics (NBS) in 2011, household income levels in China were classified as follows: low (less than 8,798 yuan), relatively low (8,790 to 14,499 yuan), medium-low (14,500 to 19,545 yuan), medium-high (19,546 to 26,420 yuan), relatively high (26,421 to 47,021 yuan), and high (over 47,022 yuan). Income varies among different groups. Households with medium-high, and relatively high income accounted for 23%, 20%, and 21% of the total sample, respectively. The average income of high-income households was 66,893 yuan, which was 14 times higher than that of the low-income households.

## 4. Results

### 4.1 Descriptive analysis

Household heads are mainly male and have relatively higher education (Table 1). Male household heads accounted for 70% of the surveyed sample. The average age of household heads was 65 years, with 43% of household heads aged between 50 and 65 years. These household heads typically have completed around 10 years of education, which is higher than the national average in 2021. The household heads in this study exhibited a higher level of education, demonstrating that urban residents are more educated in China.

[1] According to the National Statistics Bureau's geographic division, the eastern region includes Beijing, Jiangsu, Liaoning, Shandong, and Shanghai, the Middle region includes Heilongjiang, Henan, Hubei, and Hunan, and the Western region includes Chongqing, Guangxi, and Guizhou in the sample.

Table 1 Statistical description of the sample (N=1809)

| Variables | Mean | Variance | Min | Max |
|---|---|---|---|---|
| Household income (Yuan per capita) | 21286 | 16555 | 300 | 99061 |
| Household calorie intake (Kcal/day per capita) | 1781 | 534 | 809 | 3543 |
| Household head age (year) | 56 | 13 | 17 | 94 |
| Household head gender (1=male; 0=female) | 0.7 | 0.5 | 0 | 1 |
| Household head education (years) | 10 | 4 | 0 | 18 |
| Household size (number of people) | 3 | 1 | 1 | 9 |
| Age under 6 (1=Yes; 0=No) | 0.1 | 0.3 | 0 | 1 |
| Age above 65 (1=Yes; 0=No) | 0.3 | 0.5 | 0 | 1 |
| Traditional market (score) | 6 | 3 | 0 | 10 |

The average household income is 21,286 yuan, with a wide range from 300 yuan to over 90,000 yuan (Table 1). This indicates a broad socio-economic diversity within the urban population. Most households consist of three members. Households with members older than 65 are more common than those with members younger than 6, which indicates an aging trend among these urban households in China. This may have implications for healthcare and social support systems in urban China.

Households with higher-level incomes tend to have higher-level calorie intakes (Table 2). The group with low income and low-calorie intake comprised the largest proportion of the total sample. As calorie intake levels rose, the number of households decreased accordingly. Among the households with low calorie intake, 41% came from the relatively low-income bracket, and 54% belonged to the medium-low income category. In contrast, among households with high calorie intake, 31% were from the medium-low income group, and 41% were from the relatively low-income group. Within the high calorie intake group, households from the medium-high and relatively high-income brackets both accounted for 24% each. High-income households made up 11% of this group, which was 1.7 times higher than that of low-calorie and medium-low-calorie-intake households and 3.2 times higher than that of medium-high-calorie-intake households.

As household income increased, the average calorie intake increased for those in low-calorie groups but decreased for those in high-calorie groups (Table 2). For the low-calorie households, calorie intake rose with increasing income. Among these households, high-income households consumed an additional 66 Kcal compared to relatively low-income households. However, for medium- and high-calorie groups, a higher income led to decreased calorie intake. Specifically, among high-calorie households, the calorie intake of high-income households was 173 Kcal less than that of relatively low-income households. In addition, the calorie intake among medium-low income households was lower than both higher- and lower-income households. For the medium-high-calorie group, the income effects were almost the same among different levels of household income.

Table 2 Urban household nutritional intake under different income of 2011

| Income level | Low calorie | | Medium calorie | | Medium-high calorie | | High calorie | |
|---|---|---|---|---|---|---|---|---|
| | No. of Obs. | Calorie (Kcal/day/capita) | No. of Obs. | Calorie (Kcal/day/capita) | No. of Obs. | Calorie (Kcal/day/capita) | No. of Obs. | Calorie (Kcal/day/capita) |
| Low | 256 | 1401 | 115 | 2077 | 26 | 2580 | 12 | 3226 |
| Relative-low | 170 | 1401 | 88 | 2075 | 32 | 2547 | 11 | 3202 |
| Medium-low | 133 | 1396 | 81 | 2072 | 23 | 2621 | 8 | 3240 |
| Medium-high | 209 | 1404 | 103 | 2050 | 27 | 2597 | 18 | 3217 |
| Relative-high | 198 | 1438 | 133 | 2081 | 38 | 2556 | 18 | 3051 |
| High | 66 | 1467 | 31 | 1995 | 5 | 2553 | 8 | 3053 |

Households at the low-calorie level were more likely to have a less educated and older household head compared to other households (Table 3). For household demographic characteristics, households with more members tend to have less calorie intake. Among low-calorie households, those with younger and elderly household members have less calorie intake. Overall, for market development, the construction of urban traditional markets has not been well developed, remaining at a medium level. The overall traditional markets need to be improved to increase the availability and variety of food. It is evident that the access to food for low-calorie-intake households is limited, indicating that markets surrounding these households are not well developed. For the medium- and high-calorie households, high-level markets accounted for 40% and 41%, respectively, which were higher than the low and low-medium households of 33% and 32%. However, only low-income households had positive effects due to the better construction of markets.

Table 3 Household head, demographic characteristics and market development and calorie intake

| | Low level | | Medium-low level | | Medium-high level | | High level | |
|---|---|---|---|---|---|---|---|---|
| | No. of Obs. | Calorie (Kcal/day/capita) | No. of Obs. | Calorie (Kcal/day/capita) | No. of Obs. | Calorie (Kcal/day/capita) | No. of Obs. | Calorie (Kcal/day/capita) |
| **Household head characteristics** | | | | | | | | |
| Age | | | | | | | | |
| ≤35 | 57 | 1444 | 31 | 1998 | 11 | 2581 | 11 | 3275 |
| 35-50 | 269 | 1436 | 152 | 2071 | 42 | 2587 | 18 | 3206 |
| 50-65 | 437 | 1413 | 239 | 2076 | 73 | 2562 | 31 | 3143 |
| ＞65 | 269 | 1381 | 129 | 2063 | 25 | 2591 | 15 | 3064 |
| Gender | | | | | | | | |
| Male | 701 | 1412 | 378 | 2068 | 104 | 2575 | 50 | 3161 |
| Female | 331 | 1412 | 173 | 2066 | 47 | 2576 | 25 | 3161 |
| Education | | | | | | | | |
| Below primary school | 238 | 1366 | 94 | 2083 | 21 | 2573 | 10 | 3133 |
| Secondary school | 608 | 1428 | 356 | 2062 | 105 | 2566 | 50 | 3142 |
| Above college | 186 | 1422 | 101 | 2070 | 25 | 2617 | 15 | 3245 |
| **Household demographic characteristics** | | | | | | | | |
| Household size | | | | | | | | |
| 1 | 47 | 1415 | 33 | 2007 | 12 | 2568 | 7 | 2992 |
| 2-3 | 744 | 1340 | 410 | 2106 | 114 | 2562 | 57 | 2915 |
| 4-5 | 216 | 1309 | 92 | 2098 | 23 | 2590 | 9 | 3292 |
| Above 6 | 25 | 1389 | 16 | 2071 | 2 | 2529 | 2 | 3040 |
| Under 6 | | | | | | | | |
| No | 907 | 1421 | 519 | 2071 | 145 | 2575 | 74 | 3161 |
| Yes | 125 | 1351 | 32 | 2006 | 6 | 2590 | 1 | 3208 |
| Above 65 | | | | | | | | |
| No | 705 | 1430 | 392 | 2072 | 120 | 2572 | 59 | 3180 |
| Yes | 327 | 1373 | 159 | 2055 | 31 | 2589 | 16 | 3094 |
| **Market development characteristics** | | | | | | | | |
| Low level | 61 | 1358 | 28 | 2116 | 7 | 2674 | 2 | 3459 |
| Medium level | 626 | 1412 | 345 | 2058 | 83 | 2584 | 42 | 3196 |
| High level | 345 | 1423 | 178 | 2077 | 61 | 2552 | 31 | 3095 |

### 4.2 The effect of household income on calorie intake

The effect of household income on calorie intake was significantly positive; that is, an increase of household income increased nutritional intake (Table 4). The total income elasticity for urban residents in China is 0.021. This indicates that as households become more affluent, they may have increased ability to afford a nutritionally diverse diet, and thus are likely to spend more on the quantity and quality of food (Gao et al., 2020). Meanwhile, the increased demand for high-calorie foods such as fast food will also increase their calorie intake (Fryar et al., 2018).

Table 4 The determinants of household calorie intake

| Variables | Household calorie intake | |
|---|---|---|
| | OLS | GMM |
| ln(Household income per capita) | 0.021*** | 0.066** |
| | (0.007) | (0.029) |
| Age of household head | -0.001 | -0.002 |
| | (0.001) | (0.001) |
| Education of household head | 0.004** | 0.002 |
| | (0.002) | (0.002) |
| Household size | -0.011 | -0.005 |
| | (0.007) | (0.008) |
| Under 6 (1=yes; 0=no) | -0.178*** | -0.179*** |
| | (0.024) | (0.024) |
| Above 65 (1=yes; 0=no) | -0.049** | -0.050** |
| | (0.023) | (0.023) |
| Traditional market score | 0.006** | 0.007** |
| | (0.003) | (0.003) |
| constant | 7.297*** | 6.874*** |
| | (0.102) | (0.300) |
| No. of Obs. | 1809 | 1809 |

*Note*: Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

The education of household heads has a significant positive effect on calorie intake, while households with either younger or older members have a negative effect. The positive coefficient of household head education indicates that households with a more educated household head tend to intake more calories. Household heads serve as decision makers on household consumption. Household heads with higher education levels might have better knowledge of nutrition and a healthy diet. But the effect was not found to be significant using IV-GMM method. In addition, the coefficients of dummy variables for households with either younger or older members were significantly negative. This indicates that these households have lower calorie intake than others. This may be because younger and older people have low calorie demand (DeSilva, 2021). Younger children and older adults typically have lower basal metabolic rates and therefore require fewer calories. This highlights the importance of age-adapted dietary recommendations to prevent undernutrition in these sensitive age groups.

The availability of better traditional markets has a positive effect on the household's calorie intake. Improved access to food markets often means a greater variety of available foods and possibly lower prices due to competition. This improved availability makes it easier for households with better market access to meet their caloric and nutritional needs. Thus, households' calorie intake would be higher if various food were easier to be accessed. This is in line with the views of Bashira and Schilizzia (2013).

To eliminate the endogeneity between income and urban nutritional intake, both OLS and IV-GMM were applied in this study. Two dummy variables representing households in the eastern region and those of the Han ethnicity were used as instrumental variables in the IV-GMM model. The first-stage regression results of the IV-GMM model confirmed a significant positive correlation between these instrumental variables and household income. Furthermore, Hansen's J statistic and the Durbin–Wu–Hausman (DWH) test were used to assess overidentification and the exogeneity of instrumental variables. The Hansen's J statistic value was 10.62 with a p-value of 0.16, indicating that the instrumental variables were exogenous within the model context. Both OLS and IV-GMM analyses demonstrated a significant positive impact of household income on calorie intake.

### 4.3 The income effect among different calorie intake levels

The coefficient of household income is positive across all quantiles, and only the coefficients in the 10th, 50th, and 90th quantiles were significant (Table 5). This indicates that the positive effect of household income on calorie intake varied according to the amount of calories consumed. The largest income elasticity was in the 10th quantile (0.033), followed by the 90th quantile (0.022) and the 50th quantile (0.019). This indicates that these households with lower calorie intake showed a greater response in calorie intake as income increased. Low-calorie households might face a higher risk of nutritional deficiency. Thus, additional income is likely to be used to meet basic food needs, thereby increasing the calorie intake. This is in line with Zhou and Yu (2014) who reported that larger calorie–income elasticities were found among lower quantiles.

Table 5 Estimation results of urban residents' calorie intake under normal quantile

| Variables | quantile | | | | |
|---|---|---|---|---|---|
| | q=10 | q=25 | q=50 | q=75 | q=90 |
| ln (Household income per capita) | 0.033** | 0.017 | 0.019** | 0.013 | 0.022** |
| | (0.015) | (0.011) | (0.008) | (0.010) | (0.011) |
| Age of household head | -0.001 | -0.000 | -0.001 | -0.000 | -0.002 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.002) |
| Education of household head | 0.007* | 0.005 | 0.003 | 0.000 | 0.004 |
| | (0.004) | (0.003) | (0.003) | (0.003) | (0.003) |
| Household size | -0.011 | -0.005 | -0.015* | -0.017* | -0.017 |
| | (0.015) | (0.008) | (0.008) | (0.010) | (0.011) |
| Under 6 (1=yes; 0=no) | -0.142*** | -0.189*** | -0.154*** | -0.187*** | -0.205*** |
| | (0.042) | (0.038) | (0.029) | (0.030) | (0.043) |
| Above 65 (1=yes; 0=no) | -0.043 | -0.083*** | -0.043 | -0.073** | -0.038 |
| | (0.037) | (0.030) | (0.027) | (0.029) | (0.039) |
| Traditional market score | 0.004 | 0.002 | 0.004 | 0.008** | 0.006 |
| | (0.005) | (0.004) | (0.003) | (0.004) | (0.005) |
| constant | 6.771*** | 7.096*** | 7.325*** | 7.554*** | 7.703*** |
| | (0.167) | (0.136) | (0.112) | (0.123) | (0.160) |
| No. of Obs. | 1809 | 1809 | 1809 | 1809 | 1809 |

*Note*: Estimation is based on the bootstrap for 400 times. Standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

Compared to household size, household demographics has a consistently larger effect on calorie intake, especially those with children under 6 years old (Table 5). The negative effect of household size on calorie intake was significant only in the 50th and 75th quantiles. Households with members under 6 years old retained a significant and negative effect on household calorie intake in each quantile, and those having members aged above 65 years old had a significantly negative effect only in the 25th and 75th quantiles. Households with children may adjust their dietary structure to be more child-friendly, which might also prompt adults to adopt healthier diets and lifestyles, especially for households with higher calorie intake previously.

Table 6 presents the quantile regression results based on the classification criteria of the Dietary Pagoda guidance. Household income had a larger effect on low- and medium-calorie households. The effect of household income on calorie intake was significant among households at low- and medium-calorie intake, with positive elasticities of 0.019 and 0.22, respectively. The significant effect of household income on calorie intake was found between the 10th and 50th quantiles. The effect of income was largest among households below the 20th quantile of calorie intake.

The positive effect of traditional market score on calorie intake was significant only in the quantile of the medium-calorie level (Table 6). The effect, however, is minimal in low- and high-calorie households. It is suggested that access to better traditional markets enhances nutrient intake mainly in medium-calorie households. This could be due to the better availability of diverse food options in traditional markets, which might not be crucial for households already meeting or exceeding their caloric needs.

Figure 1 represents the changes of the coefficients of determinants affecting household calorie intake as intake increases. The coefficient for household income showed a decreasing trend as calorie intake increasing, eventually approaching zero. This trend confirms previous findings,

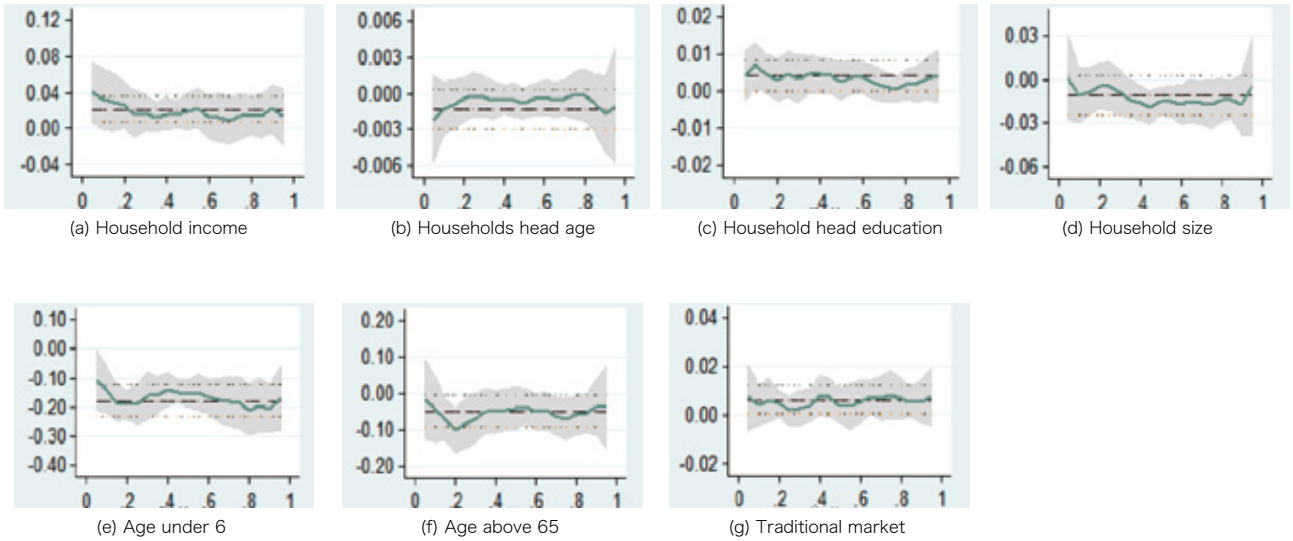
Table 6 Estimation results of urban residents' calorie intake under special quantile

| Variables | Low-calorie q=57 (1800 Kcal) | Medium-calorie q=88 (2400 Kcal) | High-calorie q=96 (2800 Kcal) |
|---|---|---|---|
| ln (Household income per capita) | 0.019*<br>(0.011) | 0.022**<br>(0.010) | 0.020<br>(0.017) |
| Age of household head | -0.001<br>(0.001) | -0.001<br>(0.001) | -0.001<br>(0.003) |
| Education of household head | 0.003<br>(0.003) | 0.003<br>(0.003) | 0.005<br>(0.004) |
| Household size | -0.016*<br>(0.009) | -0.014<br>(0.009) | -0.002<br>(0.015) |
| Under 6 (1=yes; 0=no) | -0.143***<br>(0.032) | -0.181***<br>(0.043) | -0.166**<br>(0.065) |
| Above 65 (1=yes; 0=no) | -0.034<br>(0.028) | -0.041<br>(0.031) | -0.037<br>(0.066) |
| Traditional market score | 0.003<br>(0.004) | 0.008*<br>(0.004) | 0.005<br>(0.007) |
| constant | 7.374***<br>(0.138) | 7.639***<br>(0.136) | 7.757***<br>(0.268) |
| No. of Obs. | 1809 | 1809 | 1809 |

*Note*: Estimation is based on the bootstrap for 400 times. Standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

suggesting that the effect of income diminishes among households with a calorie intake of more than 2800 Kcal. Household head characteristics had little influence on household calorie intake. For other determinants, the number of household members had a consistent negative effect on nutritional intake, especially for those in the 35$^{th}$ -60$^{th}$ and 80$^{th}$ -90$^{th}$ quantiles. Households with members under 6 years old consumed significantly less calories, as the confidence intervals for these variable coefficients were always below zero. But having a household member aged above 65 years old negatively influenced household calorie intake only in households below the 85$^{th}$ quantile, which indicates that older people only influence low- and medium-low-calorie households. In addition, the traditional markets variable had a positive influence on the nutritional intake, particularly between the 65$^{th}$ and 85$^{th}$ quantiles.

Figure 1 Coefficient variation of daily household calorie intake.




(a) Household income (b) Households head age (c) Household head education (d) Household size

(e) Age under 6 (f) Age above 65 (g) Traditional market

## 5. Discussion and conclusion

Income variation has significant influences on households' nutritional intake, however the existing literature provided mixed results. In this paper, an analysis is conducted on the effect of income affecting nutritional intake of Chinese urban residents, utilizing the CHNS 2011 data as the foundation for the study. The overall nutritional intake for urban residents is not high and malnutrition is a problem. The analysis indicates that overnutrition is a prevalent issue. Notably, the impact of income varies among different calorie-intake groups. To further explore this, a quantile estimation was conducted to assess the income effects on various calorie groups. The results reveal that income significantly influences household nutritional intake. However, the effects differ among distinct calorie-intake categories. Basically, a uniform income increment would not increase the overall calorie intake.

The low-calorie group has low income, whereas the income level of the high-calorie group is high under the large income variation. The household heads of low-calorie households are older than others and have a lower education level. The low-calorie group has older and younger household members, and thus, their nutritional intake per capita is low. Moreover, the results from quantile regression show that the traditional market has little influence on the high-calorie group. The reasons could be that the high-calorie group has a high income, so they can choose a market from other communities or dine out, which indicates that there is a need for the well-being of lower-income households to be thoroughly developed. Therefore, it is necessary to give dietary instructions to different calorie-intake groups while taking the household characteristics into consideration. An income increment and a better social security service are necessary for the low-calorie group. With either old or young members in the low-income households would influence their total nutritional intake. Thus, a dietary subsidy could be an option for low-income households and avoid malnutrition and related diseases. Giving more information about malnutrition to urban residents to improve their overnutrition is recommended. Better education about nutritional intake is necessary to develop healthier dietary habits and reduce the obesity rates and other diseases. It is also necessary to improve the construction of community markets and increase the availability, quality, and variety of food.

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## <Appendix>

Table A1 Urban residents' calorie intake under different quantile（N=1809）

| Region | Calorie intake（Kcal/day/person） | Household income（Yuan/person） | No. of Obs. | Proportion（%） |
|---|---|---|---|---|
| Eastern Region | 1824 | 24725 | 999 | 55.22 |
| Central Region | 1836 | 19301 | 418 | 23.11 |
| Western Region | 1614 | 14640 | 392 | 21.67 |
| Total | 1781 | 21286 | 1809 | 100 |

Table A2 Urban residents' calorie intake under different quantile（N=1809）

| Variable | Quantile | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | q=5 | q=10 | q=15 | q=20 | q=25 | q=30 | q=35 | q=40 | q=45 | q=50 |
| ln（Household income per capita） | 0.040** | 0.033** | 0.029** | 0.026** | 0.017 | 0.018** | 0.013* | 0.016** | 0.016** | 0.019** |
| | (0.017) | (0.015) | (0.015) | (0.012) | (0.011) | (0.009) | (0.007) | (0.008) | (0.007) | (0.008) |
| Age of household head | -0.002 | -0.001 | -0.001 | 0.000 | 0.000 | 0.000 | -0.001 | -0.001 | -0.001 | -0.001 |
| | (0.002) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Education of household head | 0.004 | 0.007* | 0.005 | 0.003 | 0.005 | 0.003 | 0.005 | 0.005* | 0.004 | 0.003 |
| | (0.004) | (0.004) | (0.004) | (0.003) | (0.003) | (0.004) | (0.003) | (0.002) | (0.003) | (0.003) |
| Household size | 0.001 | -0.011 | -0.008 | -0.004 | -0.005 | -0.009 | -0.014* | -0.016** | -0.019** | -0.015* |
| | (0.016) | (0.015) | (0.012) | (0.009) | (0.008) | (0.008) | (0.007) | (0.007) | (0.008) | (0.008) |
| Under 6（1=yes; 0=no） | -0.107** | -0.142*** | -0.185*** | -0.192*** | -0.189*** | -0.159*** | -0.161*** | -0.138*** | -0.147*** | -0.154*** |
| | (0.050) | (0.037) | (0.028) | (0.031) | (0.036) | (0.042) | (0.038) | (0.030) | (0.028) | (0.029) |
| Above 65（1=yes; 0=no） | -0.018 | -0.0429 | -0.072** | -0.102*** | -0.083*** | -0.070** | -0.049 | -0.052* | -0.045 | -0.043 |
| | (0.055) | (0.037) | (0.030) | (0.028) | (0.031) | (0.032) | (0.031) | (0.027) | (0.028) | (0.028) |
| Traditional market score | 0.007 | 0.004 | 0.006 | 0.005 | 0.002 | 0.003 | 0.004 | 0.008** | 0.007** | 0.004 |
| | (0.007) | (0.005) | (0.005) | (0.004) | (0.004) | (0.004) | (0.004) | (0.003) | (0.004) | (0.003) |
| constant | 6.594*** | 6.771*** | 6.888*** | 6.973*** | 7.096*** | 7.148*** | 7.232*** | 7.225*** | 7.282*** | 7.325*** |
| | (0.228) | (0.163) | (0.156) | (0.138) | (0.145) | (0.129) | (0.120) | (0.113) | (0.115) | (0.116) |

*Note*: Estimation is based on the bootstrap for 400 times. Standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.

(continued)

| Variables | Quantile | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | q=55 | q=60 | q=65 | q=70 | q=75 | q=80 | q=85 | q=90 | q=95 |
| ln（Household income per capita） | 0.022** (0.011) | 0.013 (0.011) | 0.012 (0.011) | 0.009 (0.010) | 0.013 (0.010) | 0.015 (0.009) | 0.014 (0.009) | 0.0219** (0.011) | 0.014 (0.015) |
| Age of household head | 0.000 (0.001) | 0.000 (0.001) | -0.001 (0.001) | 0.000 (0.001) | 0.000 (0.001) | 0.000 (0.001) | -0.001 (0.001) | -0.002 (0.002) | -0.001 (0.002) |
| Education of household head | 0.004 (0.003) | 0.004 (0.003) | 0.002 (0.003) | 0.001 (0.003) | 0.000 (0.003) | 0.002 (0.003) | 0.002 (0.003) | 0.004 (0.003) | 0.004 (0.004) |
| Household size | -0.015* (0.009) | -0.017* (0.009) | -0.015 (0.009) | -0.016 (0.010) | -0.017 (0.011) | -0.014* (0.008) | -0.014* (0.007) | -0.017* (0.010) | -0.00467 (0.013) |
| Under 6 （1=yes; 0=no） | -0.148*** (0.032) | -0.163*** (0.030) | -0.176*** (0.030) | -0.180*** (0.030) | -0.187*** (0.029) | -0.209*** (0.031) | -0.193*** (0.041) | -0.205*** (0.043) | -0.170*** (0.059) |
| Above 65 （1=yes; 0=no） | -0.036 (0.027) | -0.050* (0.027) | -0.048 (0.030) | -0.064** (0.027) | -0.073*** (0.027) | -0.060** (0.028) | -0.054* (0.029) | -0.038 (0.035) | -0.038 (0.051) |
| Traditional market score | 0.003 (0.004) | 0.005 (0.004) | 0.007* (0.004) | 0.007* (0.004) | 0.008* (0.004) | 0.007** (0.003) | 0.006* (0.003) | 0.006 (0.005) | 0.007 (0.006) |
| constant | 7.295*** (0.132) | 7.425*** (0.140) | 7.473*** (0.141) | 7.560*** (0.129) | 7.554*** (0.120) | 7.586*** (0.109) | 7.675*** (0.107) | 7.703*** (0.154) | 7.785*** (0.214) |

*Note*: Estimation is based on the bootstrap for 400 times. Standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.