Evaluation of older Chinese people's macronutrient intake: Results from the China Health and Nutrition Survey

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Keywords:

Macronutrient intake, Dietary Reference Intakes (DRIs), Older Chinese people, Socioeconomic regions

Running title:

Older Chinese people's macronutrient intake

Abstract: Little is known about the macronutrient intake status of older Chinese people. The present study describes macronutrient intake, examines whether older Chinese people (aged≥60) are meeting Dietary Reference Intakes (DRIs), and explores associations between macronutrient intake and age groups, gender, education levels, work status, BMI, urbanicity, and four Chinese socioeconomic regions (Northeast, East Coast, Central and West). Dietary data from the Longitudinal China Health and Nutrition Survey (2009 wave) have been analysed in four diverse regions, for 2,746 older Chinese with completed dietary data. Dietary data were obtained by interviews using 24 hour-recalls over three consecutive days. Monounsaturated and saturated fatty acids ratio (MUFA/SFA) were calculated based on the China Food Composition Table. We found less than one third of the older people met the adequate intake (AI) for carbohydrate and fat-energy intake; less than one fifth met the recommended nutrient intake (RNI) for protein-energy intake; and more than half of older people had a higher fat-energy intake than DRIs. There were strong associations between three macronutrient-energy intakes and education levels, urbanicity level, and four socioeconomic regions, with older people living in East Coast having different patterns of macronutrient-energy intake compared to the other three regions. Macronutrient intake across different urbanicity levels in the four regions suggests considerable geographical variations in dietary patterns, which will impact on risk factors for Non-Communicable Diseases (NCDs). Clinical interventions and public health policies should recognise these regional differences in diet.

Introduction

China's population is ageing rapidly. In the 2011 census, people aged over 60 accounted for 13.3% of the population, up nearly 3% since 2000. China already has about 102 million people aged 60 years or over, more than one-fifth of the world's older population. The proportion of the population in these older age groups is estimated to increase quickly during the period 2000- 2035, with a predicted one in four people aged 60 years and over in 2035 [1]. Changes to the age structure in China may have many and various impacts, one of which is increasing prevalence of Non-Communicable Diseases (NCDs) [1, 2] .

Diet plays an important role in preventing NCDs, including cardiovascular disease, type 2 diabetes, metabolic syndrome and cancer [2-5], and the associations between macronutrient (carbohydrate, protein, and fat) intake and NCDs have been well documented [6-11]. For example, evidence has shown carbohydrate intake can influence the development of type 2 diabetes through the effect on blood glucose and insulin concentration [6, 7]. In addition, compared with a low-fat diet (10-15% of total calories), a low carbohydrate diet (limited to 30-130 g/daily) can improve glucose control, insulin response, atherogenic dyslipidaemia, and reduce other cardiovascular risk factors [6, 10]. Systematic review and meta-analysis of data from 111 articles reporting on 74 randomised controlled trials shows that a higher-protein diet (>30% of energy input) can potentially improve adiposity, blood pressure and triglyceride, compared with a low-protein meal (<15% energy) [8]. A low-fat diet, particularly low in saturated fat, has been shown to have a positive role in preventing cardiovascular diseases [9, 11] although reduction in saturated fat intake must be evaluated in the context of replacement by other macronutrients [12].

In China, the nutrition and epidemiologic transitions have begun and are proceeding at an extremely accelerated rate. Nutrition changes are linked with epidemiological transitions and the increased burden of NCDs, including rapid increase in overweight, obesity and NCDs [13]. While the importance of macronutrient intake for NCDs risk is well established, population surveys of diet and nutrition often do not include people aged 60 or over [14, 15], and so few studies evaluate macronutrient intake among older Chinese people. Therefore, it is important to evaluate the current macronutrient intake for older Chinese people. It is also important to evaluate differences in intake by region, urbanicity and sociodemographic characteristics, as health outcomes such as NCDs (e.g. obesity) may be influenced by living in different urbanicity levels, and socioeconomic differences between regions [16-18]. More detailed contextual evidence may help to inform regional health policies and planning. The present study aimed to compare macronutrient intake against the DRIs [19] for older Chinese, and to evaluate the associations between macronutrient intake for men and women, in two age groups (60-69, 70 or over), with BMI, education levels, work status, urbanicity and four socioeconomic regions (Northeast, East Coast, Central and West).

Methods

Study design

The China Health and Nutrition Survey (CHNS) is an ongoing open cohort survey. It is an international collaborative project between the Carolina Population Centre at the University of North Carolina at Chapel Hill and the National Institute of Nutrition and Food Safety at the Chinese Center for Disease Control and Prevention [20]. Survey protocols, instruments, and the process for obtaining informed consent for CHNS were approved by the institutional review committees of the University of North Carolina at Chapel Hill and the National Institute of Nutrition and Food Safety, China Centre for Disease Control and Prevention. All participants have given their written informed consent [14]. Also, using CHNS data has been approved by the University of Newcastle, Australia (Approval Number: H-2013-0360).

The first round of the CHNS, including household, community, and health/family planning facility data, was collected in 1989. Seven additional surveys or rounds were collected in 1991, 1993, 1997, 2000, 2004, 2006 and 2009 [20]. In the present study, we utilised data from the CHNS 2009 survey. The total number of participants was 2,746 persons aged 60 years or over with completed dietary data. The survey has been described in detail elsewhere [21, 22] , and has been used to describe the nutrition transformation[14, 23], chronic health conditions[24], and the trends in prevalence and incidence of chronic conditions [25, 26]. A brief description of sample procedures and measures is provided below.

Sample procedure and four regions division

The survey uses a multistage, random cluster process to draw a sample of about 4400 households, with a total of 26,000 individuals in nine provinces. These nine provinces vary substantially in geography, economic development and health indicators. A multistage random-cluster sampling process was used to select the sample surveyed in each of the provinces. Counties in the nine provinces were stratified by different income levels (low, middle and high), and a weighted sampling scheme was used to randomly select four counties in each province. The provincial capital (or big city) and a lower income city were selected. Two urban neighborhoods and two suburban neighborhoods within the cities, and one county capital town and three villages within the counties were subsequently randomly selected. Finally, twenty households were randomly selected within each neighborhood. All individuals in each household were interviewed in CHNS [20] .

China is a developing country with a vast territory. Different regions have different geographical, economic, cultural and social circumstances. Based on level of economic development, China can be divided into four major regions (East Coast, Central China, Northeast China, and Western China). The purpose for dividing China into four regions is to improve regional coordination and interaction mechanisms so as to form a proper regional development pattern [27]. In the CHNS, nine provinces (Figure 1) are distributed in these four regions, i.e. Northeast China (Heilongjiang, Liaoning); East Coast (Shandong, Jiangsu); Central China (Hennan, Hubei, Hunan); West China (Gunagxi, Guizhou). Thus, the survey covers all levels of socioeconomic development in China (Figure 1). As socioeconomic factors have a potential impact on the nutritional status, dietary patterns and prevalence of NCDs [15, 28, 29], this present study divided China into the four major regions for further analysis.

Dietary data collection

In the CHNS, dietary assessment is a combination of three consecutive 24 hour-recalls at the individual level and a food inventory at the household level carried out over the same three day period [30]. Household food consumption was determined using a weighing technique. All foods (including edible oils) remaining after the last meal before initiation of the survey were weighed and recorded. During the three survey days, whenever food were brought into the household unit, they were weighed. When weighing was not possible, preparation waste was estimated. All remaining foods were weighed and recorded again at the end of this survey [20].

Individual dietary recall data from every household member was collected over three consecutive days that were randomly allocated. Individual dietary intake data were collected by asking each household member (expect children aged younger than 12) to report all food consumed whether at home or away from home, over the previous 24 hours. Using food models and picture aids, trained field interviewers recorded the types and amounts of foods, type of meal and place of consumption of all food items during the previous day [20]. The amount of each dish was estimated from the household inventory and the proportion of each dish consumed was reported by each person interviewed [31].

The quality of the data collection was checked by comparing individual dietary intake based on 24 hour recall data and an individual's average daily dietary intake calculated from the household survey. If there were significant differences, the household and individual questions were revisited, and their food consumption questioned further to resolve these discrepancies. Overall, over 99% of the sample was available for the full three days of data collection; only in a few cases did participants miss a day because of absence. Moreover, data quality control was ensured by a high standard of training of the field interviewers, who were trained for at least three days in the collection of dietary data [20]. Initial data cleaning have been done by CHNS, which include deletion of duplicate records, deletion of blank recodes and recoding out-range value to missing status [20].

Calculation from the Chinese Food Composition Table (FCT)

The mean daily energy intake (kcal), carbohydrate intake (g), fat intake (g) and protein intake (g) were provided by the dietary data in CHNS, which were calculated from the China Food Composition Table [32]. The energy value of a food is the sum of all energy-producing nutrients, i.e., carbohydrate, protein and fat (not including alcohol), multiplied by the corresponding energy conversion factor (1 gram= 4 kcal for carbohydrates; 1 gram = 4 kcal for protein and 1g 9 kcal for fat). As kilojoules (kJ) is more common used in the nutrition researches, we conversed kcal to kJ for further calculation (1 kcal= 4.18 kJ) [32].

We also calculated the monounsaturated fatty acids (MUFA) to saturated fatty acids (SFA) ratio based on the China Food Composition Table (FCT). MUFA and SFA value from each food is available in the FCT [32]. Individual daily intake value for each food item was provided by the dietary data [33]. Average daily monounsaturated and saturated fat intakes for each individual have been calculated using 24 hour recall data in conjunction with China FCT. Previous evidence has shown that the Mediterranean diet can reduce the risk of NCDs and certain cancers [34, 35], with MUFA/SFA >1.6 being one component of adherence to Mediterranean diet. We therefore used MUFA/SFA >1.6 as the cut-off point to evaluate whether people had a high MUFA/SFA ratio.

Chinese DRIs standard

Chinese DRIs have been used as a standard to provide the dietary recommended intake for Chinese people [19]. According to the DRIs for Chinese residents, the Adequate Intake (AI) of carbohydrate should account for 55% to 65% of total energy (carbohydrate-energy percentage); Recommended Nutrient Intake (RNI) of protein should account for 15% of total energy (protein-energy percentage); and Adequate Intake (AI) of fat should account for 20% to 30% of total energy (fat-energy percentage). To estimate whether people meet with macronutrient intake recommendations, we used the DRIs cut point method (AI for carbohydrate and fat, RNI for protein intake).

Other variables

Height and weight were measured directly, based on a standard protocol recommended by the WHO, by trained health workers. Weight in lightweight clothing was measured to the nearest 0.01 kg on a calibrated beam scale and height was measured to the nearest 0.1 cm without shoes with a portable stadiometer [20]. BMI were calculated by using formula [36]: the weight in kilograms/(the height in meters)^2, and divided into four categorical levels based on the WHO suggestion for Chinese, which are underweight: BMI<18.5 kg m^{-2}; normal: BMI:18.5-23.9 kg m^{-2}; overweight: BMI 24.0–27.9 kg m^{-2}; general obesity: BMI ≥ 28.0 kg m^{-2} [36]. Education level was recoded into four categories based on six education categories in the questionnaire: illiteracy; low: primary school; medium: lower middle school; and high: upper middle school, technical school and college/university. Work status was divided into two levels by the answer to the question ‘Are you presently working?’ We used the urbanicity index instead of urban/rural measurement, because that urban/rural measurement is only based on an absolute threshold of population and/or population density [37]. Urbanicity is defined by a multidimensional 12-component urbanization index, which captures population density, physical, social, cultural and economic environment, which has been explained in previous studies [37, 38]. Tertiles of the urbanization index were used to define low, medium and high urbanicity in the present study.

Statistical analysis

The statistical/data analysis package STATA/SE 13.1 (STATA, StataCorp, USA) was used for data analysis. Mean and standard deviation (SD) were used to evaluate average total macronutrient intake, with SD used to evaluate the data distribution. Margin plots were used to show macronutrient-energy intake in three levels of urbanicity across four Chinese regions. Chi-square was used to assess the association between different levels (below, meeting and above recommendations) of DRIs for macronutrient intake by age groups, gender, education levels, work status, BMI, urbanicity levels and by four Chinese regions. ANOVAs were used to assess whether any difference existed between relative macronutrient intakes and these predictor factors. Univariate and multivariable linear regression models were used to explore the association between macronutrients and these predictor factors.

Results

The CHNS (2009) data contained information for 2,746 (men n= 1300; women = 1446) participants aged 60 years or over. Of these participants, 57% (n = 1564) of participants were aged 60-69 and 43% (n = 1182) were aged 70 or above. The total number of participants in the Northeast, East Central, Central and West regions were 485 (17.7%), 674 (24.5%), 862 (31.4%) and 725 (26.4%), respectively.

Table 1 presents the Mean and Standard Deviation (SD) for total energy, macronutrient intake (carbohydrate, protein and fat), energy from macronutrient (%), and MUFA/SFA ratio for the participants, classified by age groups, gender, urbanicity levels, BMI levels, education levels, work status and four regions.

Total energy, carbohydrate, protein, fat intake, and MUFA/SFA ratio

In general, older people who were aged 60-69, had a higher total energy and macronutrient intake than those in the 70 or above age group. Males had a higher total energy and macronutrient intake than women (Table 1).

As shown in Table 1, for total energy and carbohydrate intakes, people living in low urbanicity areas had higher total energy and carbohydrate intakes than those in high and medium urbanicity areas. People in the East Coast region had the highest energy intake, while people in the West China region had the lowest total energy and carbohydrate intake. People with higher BMI level, had lower total carbohydrate intakes. People with low and medium education had higher carbohydrate intake than those with illiteracy and high education level. Older people with a job had higher total carbohydrate and protein intake, but did not have higher total fat intake (Table 1).

Compared with energy and carbohydrate intakes, there was an inconsistent picture for total protein and fat intakes. Older people in high urbanicity areas had higher total protein and fat intake than people in low and medium urbanicity areas. Lowest total protein and fat intake levels were found in West China, while highest protein and fat intake levels were found in the East Coast region. People with higher BMI levels, had higher total fat intakes. Highest total protein and fat intakes were found for older people with medium education level (Table 1).

MUFA/SFA ratios tend to be stable across four regions, with the range from 1.3 to 1.5 (Northeast: 1.4; East Coast: 1.4, Central: 1.3, and West: 1.5, respectively). As we used MUFA/SFA >1.6 as a standard, the average MUFA/SFA ratios were lower than our standard. Only one fifth of older people had a higher monounsaturated and saturated fat ratio (>1.6) across four Chinese regions.

Energy from carbohydrate, protein and fat (relative carbohydrate, protein and fat, %)

As shown in Table 1, among older Chinese people, there are large variations in relative carbohydrate, protein and fat intakes across different urbanicity levels, and across the four regions.

For relative carbohydrate intake, people in low urbanicity areas had a higher intake than people in medium and high urbanicity areas; people in West China had the highest intake, and people in the East Coast region had the lowest intake. Compared with relative carbohydrate intake, there was an opposite effect for relative protein and fat intake. In medium and high urbanicity areas, people had a higher percentage of fat intake compared to people in low urbanicity areas; the highest relative protein and fat intake was in the East Coast, while lowest fat intake was in the West China region (Table1).

As there exists large variation for relative macronutrient intake across urbanicity levels, and across the four regions of China, it was useful to assess the difference in relative macronutrient intake between three levels of urbanicity within the four regions (Figure 2). After conducting margin plots (with 95% CI), we found that in high urbanicity areas of the East Coast, people had the lowest relative carbohydrate intake (47%, n=297); while older Chinese in low urbanicity areas of West China had the highest relative carbohydrate intake (62%, n=532). Of the high urbanicity areas in the four regions, the Northeast had the highest relative carbohydrate intake (55%, n=210).

The average relative protein intake was less than 15% across the urbanicity levels across China (Table 1). There was not much difference for relative protein intake between different urbanicity levels across China's four regions, with intakes ranging from 11%-13%. As for relative fat intake, people in high urbanicity areas had much higher intakes than those in low and medium urbanicity areas across three regions (East Coast, Central and West), but not in the Northeast of China. The biggest difference between different urbanicity levels was in West China, and the smallest difference was in the Northeast of China (Figure 2).

The percentage of older people meeting DRIs

Figure 3 shows the percentage of older people who met, were below, and were above the DRIs for relative macronutrients, classified by age groups, gender, BMI, education levels, work status, urbanicity levels and four regions.

Less than one-third of older Chinese included in the study met the DRIs for relative carbohydrate and fat intake, and less than one-fifth for relative protein intake. In the four regions, more than four-fifths of older people had lower relative protein intake, and no older people had higher relative protein intake. Moreover, more than 50% of older people had higher relative fat intake (Figure 3).

There were no significant differences between the percentage of older Chinese who met, were below, or were above the DRIs for relative macronutrients intake with respect to different age groups (carbohydrate: p=0.6; protein: p=0.65; fat: p=0.41); and gender (carbohydrate: p=0.88; protein: p=0.66; fat: p=0.08). However, there were significant differences in the levels meeting the macronutrients percentage (from DRIs) for older Chinese in different urbanicity levels, regions, BMI, education levels, and work status (p<0.005).

Linear Regression Models

Since differences exist in the relative macronutrient intake across the urbanicity levels, regions, BMI groups, education levels, and work status, we assessed the association between relative macronutrients and these predictor factors using linear regression models. Both univariate and multivariate models analysis have been conducted, and results are presented in Table 2. As previously shown in Figure 4, total carbohydrate-energy, protein-energy and fat-energy by gender were normally distributed. As MUFA/SFA ratios tended to be stable by different predictor variables (Table 1), they were not included for further analysis.

For relative carbohydrate intake, there were no statistically significant differences between age groups (p=0.28, 95% CI:-1.51, 0.44), and gender (p=0.81, 95% CI: -0.84, 1.09) in the univariate model. The final multivariable regression model showed the strong relationships that have been found between relative carbohydrate intake and work status (p<0.001, 95% CI: 2.16, 4.38), education level (p<0.01), urbanicity levels (p<0.001), and four regions (p<0.001). Compared to older Chinese who were not working, people undertaking paid work had a 3.3% higher relative carbohydrate intake (p<0.001, 95% CI: 2.16, 4.38). Compared with people with illiteracy, people with low, medium and high education levels had a lower relative carbohydrate intake (p<0.01). Older Chinese people in low urbanicity areas had an 8.1% higher relative carbohydrate intake than older people in high urbanicity areas, which was statistically significant (p<0.001). Compared to older Chinese in the East Coast, people in Northeast, Central and West China had higher relative carbohydrate intake (4.7%, 3.3% and 5.4% higher, respectively).

No statistically significant differences were found for relative protein intake between gender, BMI, and age groups (p>0.05). However, there were strong relationships between relative protein intake and urbanicity levels, education levels, work status, as well as the four regions. Older Chinese people living in low and medium urbanicity levels had lower relative protein intake than their high urbanicity counterparts (p<0.001). Compared with people with illiteracy, people with low, medium and high education levels had higher relative protein intake. Compared to older Chinese in the East Coast, older people in Central China or in the Northeast had lower relative protein intake, which were 0.6% and 0.8% lower. There was only a 0.03% higher intake for older Chinese living in West China, which was not statistically significant (p=0.84, 95% CI: -0.29, 0.35).

There were no statistically significant differences for relative fat intake between age groups (p=0.06, 95% CI: -0.04, 1.92). However, associations were found between the relative fat intake and gender, BMI, urbanicity levels, work status, education level and four regions. In the final linear regression model, the relative fat intake of older women was 1.4% higher than that of males (p=0.01, 95% CI: 0.35, 2.35); older people with a job had a lower relative fat intake than those with no job (p<0.001, 95% CI: -4.97,-2.67); compared with older people with illiteracy, those with low, medium and high education had higher relative fat intake (1.5%, 3.3% and 2%, respectively); older people in medium and low urbanicity areas had 6.3% and 3.3% lower relative fat intake than their high counterparts. Compared to the East Coast of China, there were statistically significant differences between relative fat intake of older people in the Northeast, Central and West (p<0.01).

In summary, statistically significant differences have been found between relative intakes for three macronutrients, and education level, urbanicity, and regions. Although BMI had statistically significant differences for relative carbohydrate and fat intake in the univariate model, difference were not statistically significant in the final multivariate linear regression model when other predictor variables were included in the model. Older people with illiteracy in low urbanicity areas had higher relative carbohydrate intakes but lower relative protein and fat intakes. Compared to older people in East Coast, people in Northeast, Central and West China had higher relative carbohydrate intake, but the opposite effect was observed for relative protein and fat intake.

Discussion

Our study shows that few older people met the DRIs for carbohydrate and protein intake, and more than half of the older people in the study exceeded the recommended fat intake. Moreover, there were significant differences in the three relative macronutrient intakes according to education level, urbanicity levels, as well as across the four regions.

Our study demonstrated that the greatest variation of macronutrient intake is seen in the percentage of people who meet the energy recommendation for carbohydrate and fat; while protein intake has less variation. The variation in macronutrient intake by urbanicity levels and across four Chinese socioeconomic regions may be due to economic growth, modernization, urbanization and the globalization of agri-food system. These factors can impact on eating habits, and potentially result in increased prevalence of obesity and NCDs in different Chinese regions [28, 29, 39]. The increasing number of NCDs will no doubt put a further drain on the health systems and economic cost of prevention and treatment of NCDs in China [40, 41].

The most interesting finding from our study is for fat intake. More than 50% of older Chinese people consume a higher relative fat intake than recommended, with women consuming more of their intake from fat than men. Percentage fat intakes were also greater in higher urbanicity areas than low and medium urbanicity areas. The monounsaturated to saturated fat ratio was not high, with only one fifth of older people having a high MUFA/SFA ratio (>1.6). In our study, total fat intake and total fat-energy was high, and MUFA/SFA ratios tended to be low, which implies that older people have a higher risk for overweight and obesity, particularly for women, and also those living in high urbanicity areas. Previous studies have shown that women have a higher prevalence of overweight and obesity than men, and the prevalence of overweight and obesity is higher in urban than rural areas across the whole of China [17, 39]. Also, a recent study from the CHNS, comparing two provinces in Eastern China and two provinces in Western China, of older people (aged 60 or over), showed that older people in the eastern regions and in urban areas were more likely to be overweight or obese, compared with those in western regions and rural areas [16]. Women have a higher life expectancy and increased risk of obesity and NCDs compared to men in China [42]. Therefore, women may need to spend more on health to maintain a better quality of life. In addition, diet and exercise interventions are extremely important in preventing obesity and NCDs [43, 44]. Older women, who are living in high urbanicity areas, may benefit from health education, diet and exercise interventions. Targeted screening for risk factors may also help to reduce the number of NCDs in China.

Although there are some studies that have been conducted to evaluate nutritional status and nutrition transition [14, 15], our study is the first study to assess macronutrient intake for older Chinese people (aged 60 or above) in three levels of urbanicity across four Chinese regions. From CHNS, one study examined the trends in dietary energy, fat, carbohydrate and protein intake among Chinese children and adolescents from 1991 to 2009, which showed that the daily proportion of energy from protein and fat intake has steadily increased. The proportion of energy from protein and fat had increased to 13.1% and 30% respectively in 2009. Also the daily carbohydrate intake and proportion of energy from carbohydrate has steadily declined, with reductions to 254.1 g and 56.8% in 2009 [14]. In the present study, for older people, energy from carbohydrate, energy from protein and energy from fat were 56.1%, 11.9% and 30.6% respectively. We can see that there was quite a similar macronutrient intake among older people and children in China in 2009.

Our study showed that compared with people with illiteracy, people with medium and high education levels had lower relative carbohydrate intake, higher relative protein intake, and higher relative fat intake, which implies that education levels impact on the prevalence of NCDs. Evidence from previous studies have also shown that there are strong relationships between education levels and prevalence of NCDs [45-47]. Whilst macronutrient intake is one of the important factors which impact on the prevalence of NCDs, education levels can potentially also affect macronutrient intake and eating habits.

We used CHNS (2009) Survey data to do cross-sectional analysis. Individual, consecutive food records over three days, in addition to food weighing, were used in the CHNS to assess food and nutrient intake, which provides a more accurate estimate of individual intake than when only using 24 hour food records. This method has also been used in another study in China [48].

The findings from our study provide important insights into the macronutrient intakes of older Chinese people. Different macronutrient intake across urbanicity levels in the four regions suggests that there are considerable variations in dietary patterns, which may impact on the risk factors for the NCDs. Also, the different intakes across different socioeconomic regions suggest that health prevention and clinical interventions will need to be tailored towards different regional contexts for programs to be effective or successful at reducing risk of NCDs. Although alcohol is one of the macronutrients to provide energy, only one quarter of older Chinese have consumed alcohol in the past year. Thus, alcohol consumption was not included in this study analysis.

The strengths of this study include the use of individual, consecutive three-day recall methods to improve the accuracy of recall and hence analysis and results [48]. Examination of macronutrient intake over four diverse socioeconomic regions of China has allowed a more detailed, contextual analysis to be undertaken for a large sample of older Chinese people, in two age cohorts. Moreover, use of the urbanicity index helps us to capture details of population density, physical, social, cultural and economic environment, rather than only an absolute threshold of population and/or population density based on urban and rural measurement. However, some limitations may apply. The cross-sectional design does not enable analysis of macronutrient intake transitions over time. Also, the CHNS does not present national data, therefore the westernmost region of China is excluded from this study. Although physical activity levels should be considered when comparing DRIs, the CHNS does not measure physical activity levels among these populations. Therefore, we are unable to analyse macronutrient intake based on different physical activity levels. The inclusion of physical activity data in future nutritional surveys would increase the usefulness of research for clinical applications. However, these limitations do not affect the significance of the study. In this study, we have, to a large extent, demonstrated diverse macronutrient intakes among older Chinese people, which provide important information for preventive health strategies for NCDs.

Conclusion

We used CHNS (2009) survey data to do a cross sectional analysis examining macronutrient (carbohydrate, protein and fat) intakes in older Chinese people (>=60 years old) in four regions in China. We found that few people meet the DRIs for carbohydrate, protein and fat intake. Most people had high fat intake, particularly those in high urbanicity areas. Furthermore, there were strong associations between macronutrient intake and living in different urbanicity areas, and four socioeconomic regions. This study provides important evidence that can inform policy makers in making recommendations on DRIs and prevention of NCDs for older Chinese people. In addition, the different macronutrient intake associated with different urbanicity areas across the four regions indicates that there are considerable variations in dietary patterns, which may impact on the incidence and prevalence of NCDs. Therefore, clinical interventions and health policies for older people should recognise and be adapted for regional contexts to maximise success.

Acknowledgements

This research uses data from China Health and Nutrition Survey (CHNS). We thank the National Institute of Nutrition and Food Safety, China Center for Disease Control and Prevention, Carolina Population Center (5 R24 HD050924), the University of North Carolina at Chapel Hill, the NIH (R01-HD30880, DK056350, R24 HD050924, and R01-HD38700) and the Fogarty International Center, NIH for financial support for the CHNS data collection and analysis files from 1989 to 2011 and future surveys, and the China-Japan Friendship Hospital, Ministry of Health for support for CHNS 2009. The authors also thank the University of Newcastle, Australia, for funding Xiaoyue Xu’s scholarship in gender, health and ageing research, and for assistance with this analysis, which is part of the requirement for her PhD studies. This research was supported by infrastructure and staff of the Research Centre for Gender Health and Ageing, who are members of the Hunter Medical Research Institute. Also the authors thank Cassie Curryer, Research Centre for Gender, Health and Ageing, for editing assistance.

The authors’ contributions are as follow: X. Xu conducted the analyses and wrote the manuscript; J. Byles, Z. Shi and J Hall guided the data analysis procedure and reviewed the manuscript. All authors approved the final version of the manuscript. The authors declare that they have no conflicts.

References

1. World Health Organization (2011) Western Pacific country health information profiles WHO. http://www.wpro.who.int/health_information_evidence/documents/CHIPS2011.pdf (accessed Jun 2013).

2. World Health Organization (2003) *Diet, nutrition and the prevention of chronic disease: report of a joint WHO/FAO expert consultation.WHO Technical Report Series* no.916. Geneva: WHO

3. Mente A, Koning L, Shannon SH *et al.* (2009). A systematic review of the evidence supporting a causal link between dietary factors and coronary heart disease. *Arch Intern Med* **169,** 659-669.

4. Sharma S, Vik S, Kolonel LN (2014) Fruit and vegetable consumption, ethnicity and risk of fatal ischemic heart disease. *J Nutr Health Aging* **18**,573-578.

5. Roberts CK, Barnard RJ (2005) Effects of exercise and diet on chronic disease. *J Appl Physiol* **98**, 3-30.

6. Nielsen JV, Joensson EA (2008) Low-carbohydrate diet in type 2 diabetes: stable improvement of bodyweight and glycemic control during 44 months follow-up. *Nurtr Metab* **5**,14.

7. Boling CL, Westman EC, Yancy WS Jr (2009) Carbohydrate-restricted diets for obesity and related diseases: An update. *Curr Atherosclerosis Rep* **11**, 462-469.

8. Santesso N, Akl EA, Bianchi M *et al.* (2012) Effects of higher- versus lower-protein diets on health outcomes: a systematic review and meta-analysis. *Eur J Clin Nutr* **66**,780-788.

9. Woodside JV, McKinley MC, Young IS (2008) Saturated and trans fatty acids and coronary heart disease. *Curr Atherosclerosis Rep* **10**, 460-466.

10. Hite AH, Berkowitz VG, Berkowitz K (2011) Low-carbohydrate diet review: shifting the paradigm. *Nutr Clin Pract* **26**, 300-308.

11. Baş M, Altan T, Dinçer D *et al.* (2005) Determination of dietary habits as a risk factor of cardiovascular heart disease in Turkish adolescents. *Eur J Nutr* **44**, 174-182.

12. Siri-Tarino PW, Sun Q, Hu FB *et al.* (2010) Meta-analysis of prospective cohort studies evaluating the association of saturated fat with cardiovascular disease. *Am J Clin Nutr* **91**, 535-546.

13. Du S, Lu B, Zhai F *et al.* (2002) A new stage of the nutrition transition in China. *Public Health Nutr* **5**, 169-174.

14. Cui Z, Dibley MJ (2012) Trends in dietary energy, fat, carbohydrate and protein intake in Chinese children and adolescents from 1991 to 2009. *Brit J of Nutr* **108**,1292-1299.

15. Liu H, Fang H, Zhao Z (2012) Urban–rural disparities of child health and nutritional status in China from 1989 to 2006. *Economics Hum Biol* **11**, 294-309.

16. Kun P, Liu Y, Pei X *et al.* (2013) Regional and urban-rural disparities in prevalence of over-weight among old people in China: evidence from four Chinese provinces. *J Nutr Health Aging* **17**, 859-864.

17. Yu Z, Lin X, Haas JD *et al.* (2009) Obesity related metabolic abnormalities: Distribution and geographic differences among middle-aged and older Chinese populations. *Prev Med* **48**,272-278.

18. Zimmer Z, Kwong J (2004) Socioeconomic status and health among older adults in rural and urban China. *J Aging and Health* **14**,44-67.

19. The Chinese Nutrition Society (2013) *Chinese Dietary Reference Intake*. China: China Light Industry Press.

20. Carolina Population Center (2011) China Health and Nutrition Survey. http://www.cpc.unc.edu/projects/china (accessed Oct 2013).

21. Popkin BM, Du S, Zhai F *et al.* (2009) Cohort Profile: The China Health and Nutrition Survey—monitoring and understanding socio-economic and health change in China, 1989–2011. *Int J Epidemiol* **39**,1435-1440.

22. Zhang B, Zhai F, DU S *et al.* (2013) The China Health and Nutrition Survey, 1989–2011. *Obes Rev* **15**,Suppl. S1,2-7.

23. Li Y, Li D, Ma C *et al.* (2012) Consumption of, and factors influencing consumption of, fruit and vegetables among elderly Chinese people. *Nutr Health* **28**,504-508.

24. Hu YH, Reilly KH, Liang YJ *et al.* (2011) Increase in body mass index, waist circumference and waist-to-height ratio is associated with high blood pressure in children and adolescents in China. *J Int Med Res* **39**,23-32.

25. Xi B, Liang Y, He T *et al.* (2012) Secular trends in the prevalence of general and abdominal obesity among Chinese adults, 1993–2009. *Obes Rev* **13**,287-296.

26. Liang YJ, Xi B, Hu YH *et al.* (2011) Trends in blood pressure and hypertension among Chinese children and adolescents: China Health and Nutrition Surveys 1991 – 2004. *Blood pressure* **20**,45-53.

27. Liu F (2009) New trends in China's regional economic development. *In regional economic development in China.* pp.9-14 [Swee-Hock Saw, Wong J, editors].Singapore: Institute of Southeast Asian Studies.

28. Mukhopadhyay K, Thomassin PJ (2012) Economic impact of adopting a healthy diet in Canada. *J Public Health* **20**,639-652.

29. Dai J, Sriboonchitta S, Zi C *et al.* (2014) A study on whether economic development and urbanization of areas are associated with prevalence of obesity in Chinese adults: Findings from 2009 China Health and Nutrition Surveys. *Modeling Dependence in Econometrics* **251**,289-305.

30. Batisa C, Sotres-Alvareza D, Gordon-Larsen P *et al.* (2014) Longitudinal analysis of dietary patterns in Chinese adults from 1991 to 2009. *Brit J Nutr* **111**,1441-1451.

31. Zhai FY, Du S, Wang Z *et al.* (2014) Dynamics of the Chinese diet and the role of urbanicity, 1991–2011. *Obes Rev* **15**,Suppl.1,16-26.

32. Yang Y, He M, Pan X (2002) *China Food Composition Table.* China Institute of Nutriton and Food Safety, China CDC.

33. H J Wang, Z H Wang, J G Zhang, *et al.* (2014) Trends in dietary fiber intake in Chinese aged 45 years and above, 1991–2011. *Eur J Clin Nutr* **68**,619-622.

34. Esposito K, Maiorino MI, Di Palo C *et al.* (2009) Adherence to a Mediterranean diet and glycaemic control in Type 2 diabetes mellitus. *Diabet Med* **26**, 900-907.

35. Mitrou PN, Kipnis V, Thiébaut AC *et al.* (2007) Mediterranean dietary pattern and prediction of all-cause mortality in a US population: results from the NIH-AARP Diet and Health Study. *Arch Intern Med* **167**, 2461-2468.

36. Chen C, Lu FC (2004) The guidelines for prevention and control of overweight and obesity in Chinese adults. *Biomed Environ Sci* **17**,1-36.

37. Yan S, Li J, Li S, Zhang B *et al.* (2012) The expanding burden of cardiometabolic risk in China: the China Health and Nutrition Survey. *Obes Rev* **13**,810-821.

38. Jones-Smith JC, Popkin BM (2010) Understanding community context and adult health changes in China: Development of an urbanicity scale. *Soc Sci Med* **71**,1436-4146.

39. Reynolds K, Gu D, Whelton PK *et al.* (2007) Prevalence and risk factors of overweight and obesity in China. *Obesity* **15**,10-18.

40. Zhao W, Zhai Y, Hu J (2008) Economic burden of obesity-related chronic diseases in Mainland China. *Obes Rev* **9**, Suppl. 1, 62-67.

41. Popkin MB, Kim S, Rusev RE *et al.* (2006) Measuring the full economic costs of diet, physical activity and obesity-related chronic diseases. *Obes Rev* **7**,271–293.

42. World Health Organization (2014) China. http://www.who.int/countries/chn/en/ (accessed Jan 2014).

43. Wyness L. (2009) Understanding the role of diet in type 2 diabetes prevention. *Br J Community Nurs* **14**,374-378.

44. Lambers S, Laetghem VC, Acker VK *et al.* (2007) Influence of combined exercise training on indices of obesity, diabetes and cardiovascular risk in type 2 diabetes patients. *Clin Rehabil* **22**, 483-492.

45. Dalstra JA, Kunst AE , Borrell C *et al.* (2005) Socioeconomic differences in the prevalence of common chronic diseases: an overview of eight European countries. *IntJ Epidemiol* **34**,316-326.

46. Ahmed SM, Hadi A, Razzaque A *et al.*(2009) Clustering of chronic non-communicable disease risk factors among selected Asian populations: levels and determinants. *Glob Health Action,* issue 2, http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2785214/ (accessed Feb 2014).

47. Marengoni A, Anglemana S, Melisa R, *et al.* (2011) Aging with multimorbidity: A systematic review of the literature. *Ageing Res Rev* **10**,430-439.

48. Shi Z, Hu X, Yuan B, *et al.* (2008) Vegetable-rich food pattern is related to obesity in China. *Int J Obesity* **32**,975-984.

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Table 1. Mean and Standard Deviation (SD) for total macronutrient, energy from macronutrient (%) and MUFA/SFA ratio of participants

	N (%)	Energy (kJ)	Carbohydrate (g)	Protein (g)	Fat (g)	MUFA/SFA	Energy from Carbohydrate (%)	Energy from protein (%)	Energy from fat (%)
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Age groups									
60-69	1564 (57.0)	9131.5 (5274.1)	293.5 (107.2)	64.4 (24.6)	80.7 (121.9)	1.4 (0.5)	56.0 (12.7)	12.3 (3.0)	30.8 (12.7)
70 or above	1182 (43.0)	7847.9 (5567.6)	246.7 (102.3)	54.2 (21.6)	73.3 (135.0)	1.4 (0.4)	55.4 (13.2)	12.2 (3.2)	31.8 (13.4)
Gender									
Male	1300 (47.3)	9356.2 (5760.7)	297.9 (112.4)	65.5 (24.7)	82.7 (135.7)	1.4 (0.5)	55.7 (12.8)	12.2 (3.0)	30.6 (12.7)
Female	1446 (52.7)	7880.3 (5032.4)	251.3 (98.1)	55.2 (22.0)	72.8 (120.0)	1.4 (0.4)	55.8 (12.9)	12.2 (3.1)	31.8 (13.2)
Urbanicity									
Low	932 (34.0)	8915.2 (4885.8)	311.7 (116.2)	57.8 (22.0)	70.9 (107.5)	1.4 (0.4)	61.3 (12.6)	11.4 (2.6)	26.7 (13.3)
Medium	901 (32.8)	8329.0 (3182.2)	268.1 (100.1)	60.1 (25.1)	72.0 (54.0)	1.5 (0.4)	55.3 (12.2)	12.3 (3.0)	31.4 (12.1)
High	913 (33.3)	8482.5 (7381.2)	239.5 (92.5)	62.3 (24.3)	89.7 (184.9)	1.4 (0.6)	50.5 (11.5)	13.1 (3.4)	35.8 (12.0)
Regions									
Northeast	485 (17.7)	8399.0 (2845.7)	276.5 (97.6)	60.3 (24.1)	70.0 (39.1)	1.4 (0.3)	56.1 (10.6)	12.2 (3.1)	30.6 (10.4)
East Coast	674 (24.5)	9271.6 (6794.4)	272.1 (113.7)	66.9 (27.2)	92.8 (170.8)	1.4 (0.6)	51.7 (12.4)	12.7 (3.1)	34.6 (12.8)
Central	862 (31.4)	8917.4 (6732.1)	280.9 (111.1)	58.5 (22.0)	84.5 (161.1)	1.3 (0.4)	56.1 (13.0)	11.8 (3.1)	31.6 (13.4)
West	725 (26.4)	7653.3 (2908.7)	263.5 (103.4)	55.4 (21.0)	59.9 (46.8)	1.5 (0.2)	58.9 (13.6)	12.4 (3.0)	28.1 (13.4)
BMI									
Underweight	222 (8.5)	7429.2 (2863.2)	254.2 (95.9)	50.8 (18.0)	60.2 (43.6)	1.4 (0.4)	58.5 (13.3)	11.8 (2.9)	29.1 (13.1)
Normal	1341 (51.4)	8664.8 (5537.4)	280.4 (114.3)	60.1 (24.7)	76.6 (128.4)	1.4 (0.5)	56.4 (12.9)	12.1 (3.0)	30.7 (13.0)
Overweight	798 (30.6)	8918.1 (6278.0)	275.2 (101.1)	62.8 (23.0)	84.2 (154.8)	1.4 (0.5)	54.5 (12.2)	12.5 (3.1)	32.2 (12.6)
General Obesity	249 (9.5)	8727.6 (4291.7)	264.9 (96.1)	62.7 (25.8)	84.7 (97.8)	1.4 (0.5)	53.0 (12.7)	12.4 (3.3	34.0 (13.1)
Education level									
Illiteracy	818 (30.5)	7801.2 (5321.0)	257.9 (110.0)	52.5 (22.0)	68.5 (125.7)	1.4 (0.5)	58.1 (13.3)	11.9 (2.9)	29.6 (13.8)
Low	1113 (40.9)	8606.6 (3252.5)	285.0 (112.0)	60.5 (22.7)	72.7 (55.7)	1.4 (0.5)	56.4 (12.7)	12.1 (2.9)	30.7 (12.7)
Medium	422 (15.5)	10013.2 (10016.8)	280.0 (101.3)	67.4 (26.4)	107.2 (254.7)	1.4 (0.5)	52.4 (12.8)	12.6 (3.5)	33.6 (13.3)
High	369 (13.6)	8647.3 (2602.5)	265.9 (91.5)	67.1 (23.6)	79.4 (38.7)	1.4 (0.3)	51.9 (10.7)	13.1 (3.2)	34.1 (10.5)
Work Status									
No	2011 (73.6)	8260.6 (5603.2)	254.0 (97.8)	58.4 (23.1)	79.1 (135.1)	1.4 (0.5)	54.2 (12.6)	12.4 (3.2)	32.9 (12.8)
Yes	721 (26.4)	9475.2 (4882.5)	327.6 (115.2)	64.7 (25.4)	73.3 (105.3)	1.4 (0.6)	60.3 (12.5)	11.8 (2.7)	26.6 (12.5)

Table 2. Linear regression models for the relative contribution of macronutrient, classified by predictor factors

Variables	N (%)	Univariate Model		Final Multivariable Model*	
		Coef. (95% CI)	P-value	Coef. (95% CI)	P-value
		Carbohydrate			
Age groups					
60-69 (Ref)	1564 (57.0)				
70 or above	1182 (43.0)	-0.54 (-1.51,0.44)	0.28		
Gender					
Male (Ref)	1300 (47.3)				
Female	1446 (52.7)	0.12 (-0.84,1.09)	0.81		
BMI					
Normal (Ref)	1341 (51.4)				
Underweight	222 (8.5)	2.03 (0.23, 3.84)	0.03		
Overweight	798 (30.6)	-1.96 (-3.08, -0.85)	0.001		
Obesity	249 (9.5)	-3.40 (-5.12, -1.68)	<0.001		
Work Status					
No (Ref)	2011 (73.6)				
Yes	721 (26.4)	6.25 (5.18,7.32)	<0.001	3.27 (2.16, 4.38)	<0.001
Education level					
Illiteracy (Ref)	818 (30.5)				
Low	1113 (40.9)	-1.65 (-2.79, -0.50)	0.005	-1.48 (-2.56,-0.39)	0.008
Medium	422 (15.5)	-5.72 (-7.21, -4.24)	<0.001	-3.99 (-5.42, -2.56)	<0.001
High	369 (13.6)	-6.14 (-7.70, -4.59)	<0.001	-2.36 (-3.93, -0.78)	0.003
Urbanicity					
High (Ref)	913 (33.3)				
Medium	901 (32.8)	4.76 (3.64, 5.87)	<0.001	3.66 (2.50, 4.81)	<0.001
Low	932 (34.0)	10.8 (9.65, 11.9)	<0.001	8.07 (6.81,9.33)	<0.001
Regions					
East Coast (Ref)	674 (24.5)				
Northeast	485 (17.7)	4.42 (2.95,5.89)	<0.001	4.74 (3.33,6.15)	<0.001
Central	862 (31.4)	4.36 (3.09,5.64)	<0.001	3.27 (2.07,4.48)	<0.001
West	725 (26.4)	7.18 (5.85,8.50)	<0.001	5.36 (4.10,6.63)	<0.001
		Protein			
Age groups					
60-69 (Ref)	1564 (57.0)				
70 or above	1182 (43.0)	-0.04 (-0.27,0.20)	0.75		
Gender					
Male (Ref)	1300 (47.3)				
Female	1446 (52.7)	-0.01 (-0.24,0.23)	0.96		
BMI					
Normal (Ref)	1341 (51.4)				
Underweight	222 (8.5)	-0.26 (-0.69, 0.18)	0.25		
Overweight	798 (30.6)	0.37 (0.10, 0.64)	0.01		
Obesity	249 (9.5)	0.29 (-0.13, 0.71)	0.18		

Work Status					
No (Ref)	2011 (73.6)				
Yes	721 (26.4)	-0.61 (-0.87,-0.35)	<0.001		
Education level					
Illiteracy (Ref)	818 (30.5)				
Low	1113 (40.9)	0.17 (-0.10, 0.45)	0.22	0.10 (-0.17,0.37)	0.46
Medium	422 (15.5)	0.68 (0.32, 1.04)	<0.001	0.38 (0.02,0.74)	0.04
High	369 (13.6)	1.26 (0.88, 1.63)	<0.001	0.69 (0.30,1.09)	0.001
Urbanicity					
High (Ref)	913 (33.3)				
Medium	901 (32.8)	-1.76 (-2.03,-1.48)	<0.001	-1.57 (-1.86,-1.28)	<0.001
Low	932 (34.0)	-0.86 (-1.13,-0.58)	<0.001	-0.77 (-1.05,-0.48)	<0.001
Regions					
East Coast (Ref)	674 (24.5)				
Northeast	485 (17.7)	-0.56 (-0.92,-0.21)	0.002	-0.61 (-0.96,-0.25)	0.001
Central	862 (31.4)	-0.97 (-1.28,-0.66)	<0.001	-0.78 (-1.09,-0.48)	<0.001
West	725 (26.4)	-0.33 (-0.65,-0.01)	0.042	0.03 (-0.29,0.35)	0.84
			Fat		
Age groups					
60-69 (Ref)	1564 (57.0)				
70 or above	1182 (43.0)	0.94 (-0.04,1.92)	0.061		
Gender					
Male (Ref)	1300 (47.3)				
Female	1446 (52.7)	1.18 (0.21,2.16)	0.017	1.35 (0.35,2.35)	0.01
BMI					
Normal (Ref)	1341 (51.4)				
Underweight	222 (8.5)	-1.58 (-3.42, 0.25)	0.09		
Overweight	798 (30.6)	1.54 (0.41, 2.67)	0.01		
Obesity	249 (9.5)	3.33 (1.59, 5.09)	<0.001		
Work Status					
No (Ref)	2011 (73.6)				
Yes	721 (26.4)	-6.37 (-7.45,-5.29)	<0.001	-3.82 (-4.97,-2.67)	<0.001
Education level					
Illiteracy (Ref)	818 (30.5)				
Low	1113 (40.9)	1.02 (-0.14,2.19)	0.09	1.47 (0.30,2.63)	0.01
Medium	422 (15.5)	4.01 (2.49,5.52)	<0.001	3.32 (1.77,4.87)	<0.001
High	369 (13.6)	4.49 (2.90,6.07)	<0.001	2.04 (0.32,3.76)	0.02
Urbanicity					
High (Ref)	913 (33.3)				
Medium	901 (32.8)	4.67 (3.53,5.81)	<0.001	-6.33 (-7.64,-5.03)	<0.001
Low	932 (34.0)	9.10 (7.96,10.2)	<0.001	-3.30 (-4.49,-2.11)	<0.001
Regions					
East Coast (Ref)	674 (24.5)				
Northeast	485 (17.7)	-4.01 (-5.50,-2.51)	<0.001	-4.41 (-5.86,-2.96)	<0.001
Central	862 (31.4)	-2.98 (-4.27,-1.69)	<0.001	-2.13 (-3.37,-0.88)	0.001
West	725 (26.4)	-6.56 (-7.90,-5.22)	<0.001	-5.20 (-6.50,-3.89)	<0.001

**The final multivariable models have been adjusted for age group, gender and BMI for carbohydrate; adjusted for age group, gender, BMI and work status for protein; and adjusted for age group and BMI for fat.*

Figure 1. Selected nine provinces in CHNS*

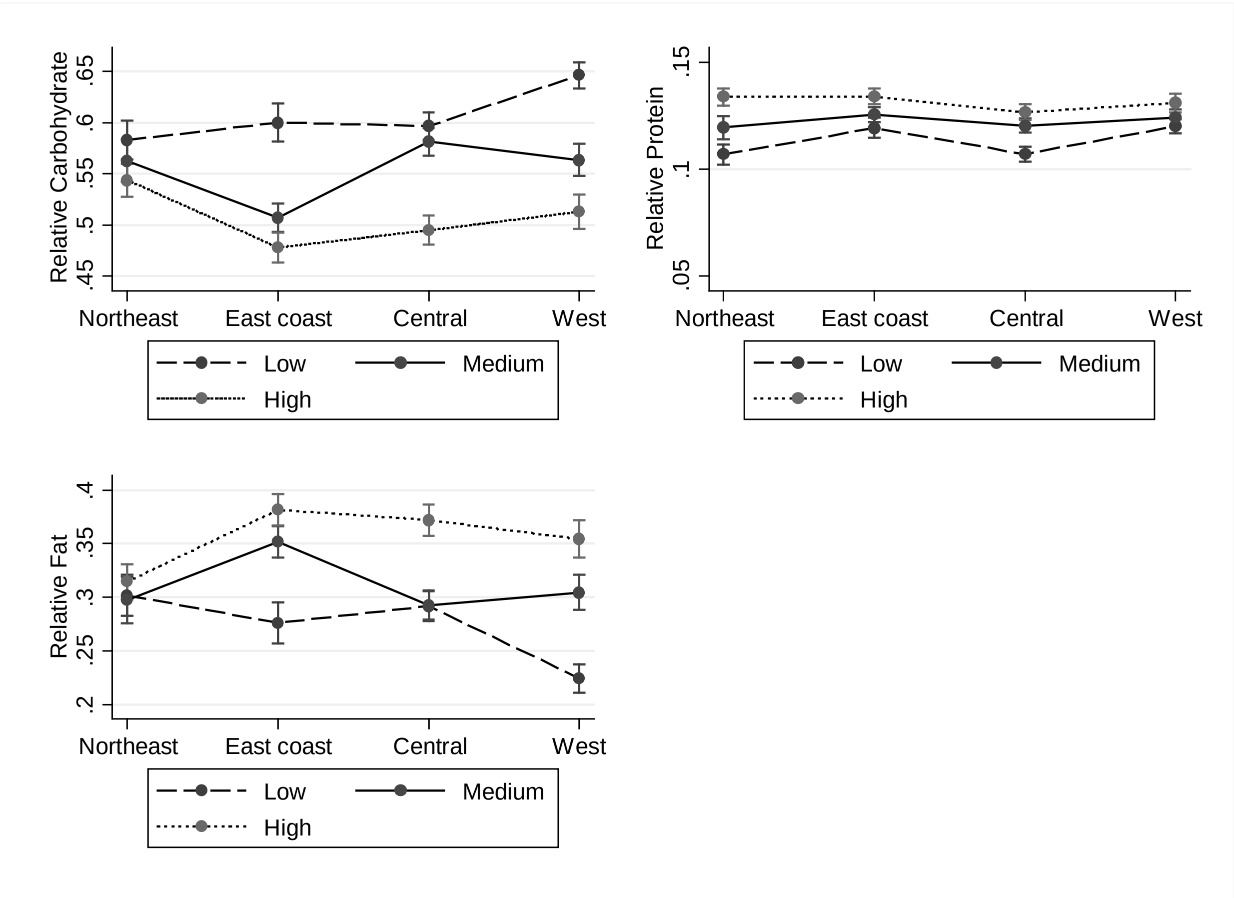
CHNS study provinces

Non-selected provinces in CHNS

**Nine provinces selected in CHNS: Northeast China (Heilongjiang, Liaoning); East Coast (Shandong, Jiangsu); Central China (Hennan, Hubei, Hunan); West China (Gunagxi, Guizhou).*

Source: Carolina Population Center. China Health and Nutrition Survey 2011 [7/8/2013]. Available from: http://www.cpc.unc.edu/projects/china.

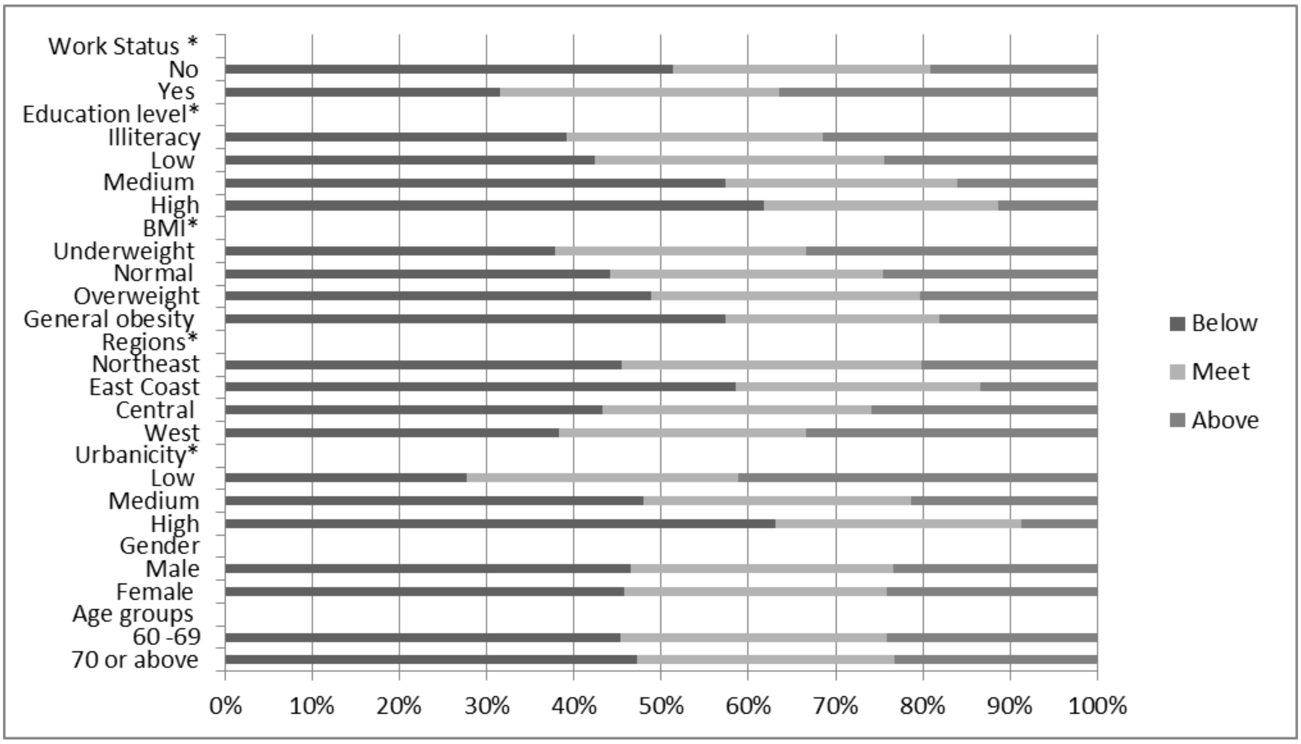
Figure 2. Relative macronutrient intakes by urbanicity levels across four regions ǂ



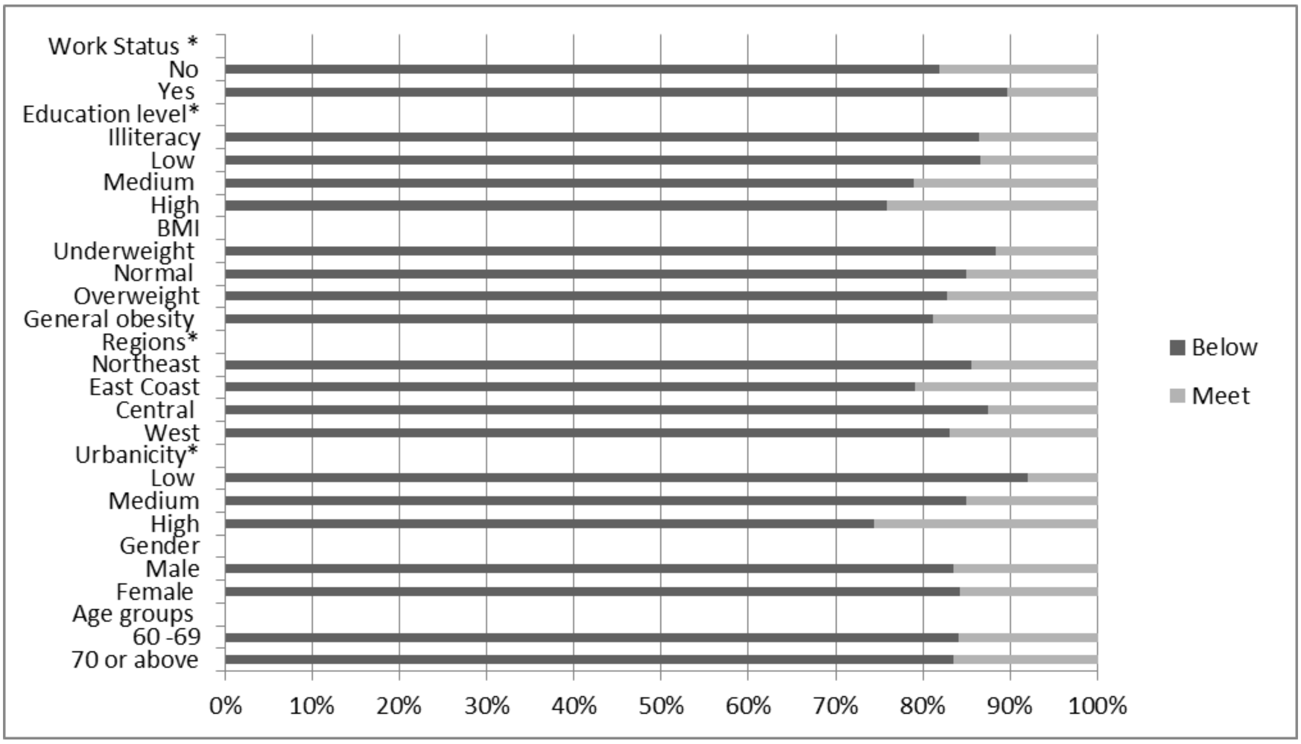
ǂ Sample Size: n=2746

Figure 3. The percentage of older people who met, are below and are above the DRIs for macronutrients (Carbohydrate, Protein, Fat)

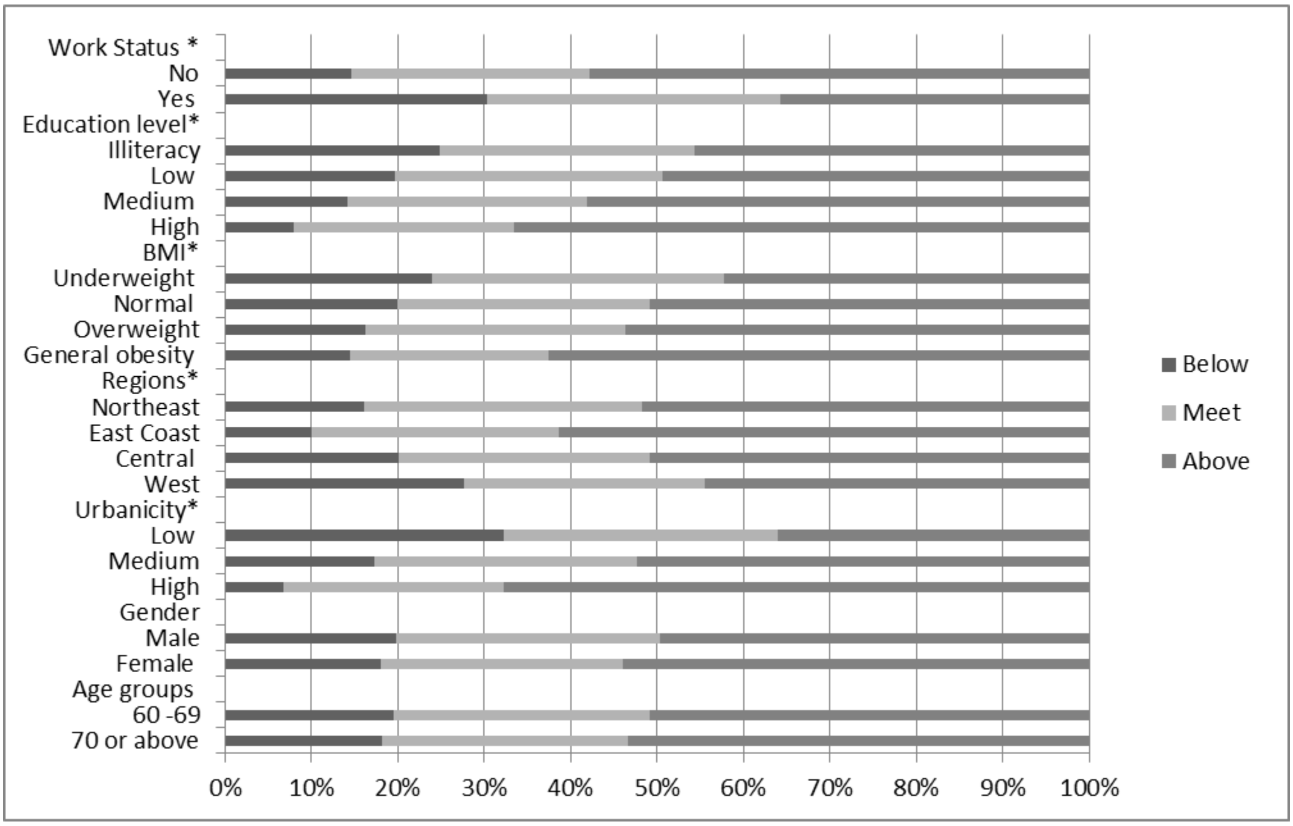
(a) Carbohydrate



(b) Protein



(c) Fat



*Chi-square test for three different levels of meeting DRIs with age groups, gender, BMI, education levels, work status, urbanicity levels and four regions (p<0.005).

Figure 4. Distribution of total carbohydrate-energy, protein-energy and fat-energy by gender