



Nutrition transition and related health challenges over decades in China

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Abstract

Since the Opening of China, the country's economy has continuously and rapidly improved. Various economic, educational, and health policies have been implemented to shape the development of society, which may have greatly affected the Chinese diet and related malnutrition issues. The objective of the present review was to comprehensively review long-term trends in dietary intakes, nutrition status, and subsequent health challenges among Chinese adults. The data sources were mainly the 1982, 1992, 2002, and 2010–2012 China National Nutrition Surveys (CNNS) and reports and the 1989–2015 China Health and Nutrition Survey (CHNS). Over decades, there have been significant changes in the dietary structure of Chinese adults, characterized as decreased intake of cereals and vegetables and increased intake of animal foods with pork dominating. Intakes of eggs, fish, and dairy has remained at a low level, with only a small increase over time. Consumption of cooking oil and salt was substantively far above the recommendations. A great proportion of fat-to-energy intake and “hidden hunger” was still prominent. Despite nutrition deficiency, there have been some modest improvements in related diseases, but overweight and obesity has become a prominent issue, with the prevalence in adults increasing from 16.4% and 3.6% in 1982 to 30.1% and 11.9% in 2012, respectively. In conclusion, this review sheds light on some salient problems with nutrition and malnutrition status in China, especially the dual challenges of undernutrition and overnutrition. Dynamic monitoring of nutritional characteristics in China should be strengthened, and effective strategies to improve nutrition need to be targeted at the national, societal, family, and individual levels.

Introduction

National nutrition and health status is an important indicator of a country's economic and social development, health care level, and population quality, as well as important information for formulating national strategies for public health and disease prevention and control. China has been undergoing rapid economic transitions and has achieved remarkable progress in recent decades. At the

same time as, residents' life expectancy has increased, nutrition and health status has improved. Aging population, rapid urbanization and industrialization, and unhealthy lifestyles have accompanied these economic shifts and related social changes [1–4]. The Rome Declaration on Nutrition, one of the nutrition outcome documents from the second International Conference on Nutrition, recognized that some socioeconomic and environmental changes can have an impact on dietary and physical activity patterns, leading to increased susceptibility to obesity and noncommunicable diseases due to more sedentary lifestyles and consumption of food that is high in fat, especially saturated and trans-fats, sugars, and salt or sodium. Rome Declaration on Nutrition also reaffirmed the definition of malnutrition, including undernutrition, micronutrient deficiencies, overweight, and obesity [5].

Transitions in the structure of foods consumption, increased dietary diversity, and changes in dietary behavior have a great impact on the traditional Chinese diet pattern, which included cereals and vegetables with few animal

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foods. Some scholars considered this diet most healthy when adequate intakes were achieved [6]. As the classic diet shifted, cereals and low-fat, mixed dishes were replaced by a westernized diet, cereal and vegetable intake decreased and, intake of animal foods, processed foods, sugar-sweetened beverages, and ultra-processed foods high in energy, fat, sugar and salt (HEFSS) increased [7–10]. This shift led to a substantial change in the macronutrient composition of the Chinese diet, from a high-carbohydrate diet to a high-fat diet, accompanied by negative changes in health, including undernutrition and overnutrition and their related noncommunicable diseases [11, 12]. Although undernutrition and nutrition-deficiency diseases are still problems that should not be overlooked, the burden is shifting to diet-related noncommunicable diseases with a rapid increase in the prevalence of overweight and obesity.

Because of the new challenges arising in China during this critical period, it is necessary to have a good understanding of the nutrition and health status of Chinese residents in the critical period in order to commit to the Rome Declaration on Nutrition's common vision to eradicate all forms of malnutrition. The aim of the present review is to comprehensively review trends in dietary intake and related health challenges in China. Relevant data sources are the 1982, 1992, 2002, and 2010–2012 China National Nutrition Surveys (CNNS) and national nutrition reports, and China Health and Nutrition Survey (CHNS) (1989–2015) [4, 13–17].

Dietary structure shifted from plant-based diets to animal-and plant-based diets

The 2016 Chinese Dietary Guidelines (CDG) support that the major characteristic of a balance diet pattern is to eat a variety of foods with cereals as the staple and plenty of vegetables, milk, and soy beans [18]. The traditional Chinese diet included cereals and vegetables with few animal foods. However, from 1982 to 2012, Chinese residents significantly decreased their intake of cereals, tubers and vegetables, which declined from 509.7 g/d to 337.3 g/d, 179.9 g/d to 35.8 g/d, and 316.1 g/d to 269.4 g/d, respectively [15, 16, 19]. CHNS also showed the same trends in the intake of cereals and vegetable among adults from 1989 to 2006 and from 1991 to 2011 [20, 21]. Furthermore, because of advances in technologies and processing, varieties of refined grain and wheat flour merged, and there was a marked decline shift in consumption of coarse grains. The CDG still necessary to emphasize coarse grain goes with rice or/and wheat, and appropriately increase the substitution of coarse grain and tuber for refine traditional staple foods.

In addition, consumptions of fruit, dairy, eggs, and nuts increased slightly, from 37.4 g/d to 40.7 g/d, from 8.1 g/d to

24.7 g/d, 7.3 g/d to 24.3 g/d and 2.2 g/d to 3.8 g/d, respectively [15, 16, 19]. Although these intakes had increased, overall intake were sustained at lower levels and remained far below the CDG recommendation. Chinese residents still need to improve their consumption of fruit, dairy, eggs, and nuts.

Consumption of animal foods increased rapidly but meat eating dominated by pork intake

The CDG suggests that consuming an appropriate amount of fish, poultry, eggs, and lean meat is an important part of a balanced dietary pattern. However, from 1982 to 2012, the average intake of animal foods continued to increase dramatically in China, from 52.6 g/d to 137.7 g/d. Livestock and poultry intake was especially far above the recommendations, increasing from 34.2 g/d to 89.7 g/d (Fig. 1) [15, 19], and 49.9% of adults consumed more than the recommended amount of livestock and poultry [22]. Egg, fish, seafood intake was lower than the recommended level. In 2015, only 42.9% of adults consumed fish and seafood, and ~77.3% of adults did not meet the 40–75 g/d recommendation in the CDG [23]. Consumption of animal foods play a major role in the shift in the dietary structure. Because of the higher intake of meat, especially fatty pork, formulating relevant strategies and acting on them are imperative. The most important strategy should be to encourage replacing pork with poultry, fish, or seafood.

Consumption of both cooking oil and salt sustained significantly far above the recommendation

From 1982 to 2012, daily cooking oil intake gradually increased from 18.2 g/d to 42.1 g/d. Daily cooking salt intake decreased from 12.7 g/d to 10.5 g/d over the past few decades [15, 19]. The consumption of both cooking oil and salt was far above the CDG recommendation. The results based on the CHNS also showed that ~55.9 and 71.8% of the population's cooking oil and salt intake exceeded the

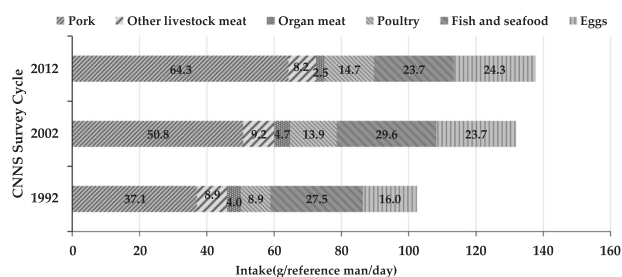


Fig. 1 Trends of animal-food consumption in China. The figure legends from left to right are represented the intakes of pork, other livestock meat, organ meat, poultry, fish and seafood, and eggs. Data sources: 1992, 2002, 2010–2012 China National Nutrition Surveys and national nutrition reports.

recommended level in China [24]. High oil and salt intake is strongly linked to increased risk of chronic diseases. Therefore, controlling the consumption of oil and salt in China should be a priority.

Another issue is challenges for traditional dietary survey methods to evaluate cooking oil and salt intake because of dietary behavior transitions. For example, eating away from home and intake of processed and pre-packaged foods were growing rapidly, an important feature of nutrition transition. The proportion of Chinese residents eating away from-home was ~20.2% in 2012 [25]. Evidences support that eating away from home is associated with high intake of oil and salt [26, 27]. The consumption rate of prepackaged foods among adults in urban areas was 85.3% in 2011 [28]. Traditional dietary survey methods cannot obtain oil and salt intake from eating away from home and prepackaged foods. Therefore, cooking oil and salt consumption may be underestimated when evaluated by the household weighing accounting method. Advocating for the reduction of oil and salt in the catering industry and food-processing industries is a crucial element of oil and salt control in China.

Unhealthy in the percentage of energy intake from macronutrients

Chinese residents experienced a decreased trend in average daily energy intake, from 2491.3 kcal/d in 1982 to 2172.1 kcal/d in 2012. The percentage of energy intake from carbohydrates declined from 70.8 to 55.0%. The contribution of fat-to-energy intake increased beyond the CDG recommendation, from 18.4.0% in 1982 to 32.9% in 2012 (Fig. 2) [14, 15, 19]. The decline in daily energy intake or the percentage of energy intake from carbohydrates was mainly associated with decreased intake of cereals, it is noteworthy that the percentage of energy intake from animal foods and intake of pure energy foods greatly increased over the decades. There were slight increases in

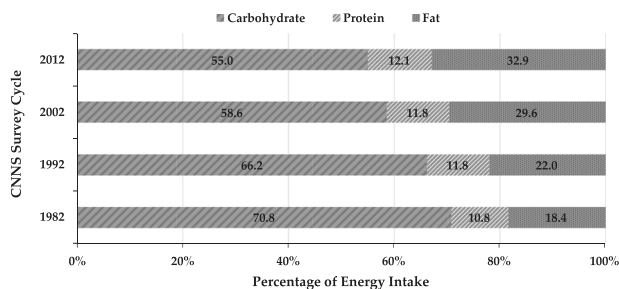


Fig. 2 Trend in percentage of energy intake from carbohydrate, protein, and fat among Chinese by CNNS survey cycle from 1982 to 2012. The figure legends from left to right are represents the carbohydrate, protein and fat. Data sources: 1982, 1992, 2002, 2010–2012 China National Nutrition Surveys and the national nutrition reports.

the proportion of energy intake from protein. Contribution of protein intake from food sources mainly included intake of cereal and animal foods. The shift toward a high-fat diet is shown more pointedly by examining the trends in the proportion of adults consuming levels of energy intake.

High prevalence of “hidden hunger” still a problem

The World Health Organization (WHO) refers to micronutrient deficiency or nutrient imbalance as “hidden hunger” [29]. Adequate intake of cereals, vegetables, fruits, dairy, and other foods can ensure sufficient intake of various nutrients. Insufficient intake of these foods leads to a lack of nutrients. From 1982 to 2012, the average daily intake of dietary iron can be regarded as sufficient and also met the recommendation (37.3 mg in 1982 and 21.5 mg in 2012). This was closely related to the dramatic increase in the consumption of animal foods over the past few decades. However, the average daily intake of retinal equivalents, thiamine, riboflavin, ascorbic acid, calcium, and potassium remained far below the recommended values. Results from the CHNS showed that more than 50% of adults still consumed less than the average requirement of retinol equivalents, thiamine, and vitamin C in 2015, and the proportion of adults with insufficient riboflavin and calcium intakes exceeded 85% and 95%, respectively [30]. This insufficiency in major micronutrients may have resulted from the decline in intake of cereals, the dominance of refined cereal processing, and insufficient intake of coarse grains, vegetables, fruits, dairy, and so on. Remarkably, sodium intake decreased from 6268.2 mg to 5702.7 mg, substantively far below the CDG recommendations [15, 19]. Because more people were eating away from home, and eating processed and prepackaged foods during this period, it was difficult to estimate sodium intake.

“Hidden hunger” affects not only human’s health, but also economic development. CNNS in 2002 showed that the rate of nutritious supplementary utilization was only 5.1% among adults in China [31]. Under the condition of insufficient intake of multiple micronutrients in the Chinese population, it is necessary to properly supplement the diet to ensure that people get appropriate vitamins, minerals, and essential nutrients, which will help prevent micronutrient malnutrition or “hidden hunger”. This supplementation is in addition to recommended consumption of more vegetables, fruits, dairy, and other foods.

Multiple health challenges in China

With the shifts in dietary structure and the overall diet environment and with the acceleration of urbanization, lifestyle and working conditions have greatly improved in China. The country has also experienced major shifts toward more

sedentary occupations and decreases in labor intensity among adults through the acquisition of new technologies, the rise of the service sector, and transitions away from a mostly agricultural economy [32]. Ownership of televisions and electronic products increased considerably, representing a major potential cause of reduction of outdoor activities. These shifts have been accompanied by negative changes in health, such as noncommunicable diseases.

In 2012, the underweight prevalence of Chinese adults was 6.0%, defined by the Chinese standard of body mass index (BMI) < 18.5 kg/m², 3.7 percentage point decrease as compared with the prevalence in 1992. There was a remarkable decrease in anemia among the Chinese population, from 20.1% in 2002 to 9.7% in 2012 [14, 19].

The prevalence of overweight and obesity in China had accelerated growth over the decades. Based on the Chinese standard (overweight: 24 kg/m² ≤ BMI < 28 kg/m², obesity: BMI ≥ 28 kg/m²), the prevalence of overweight and obesity in adults was 16.4 and 3.6% in 1992 and steadily increased to 30.1 and 11.9% in 2012, with the number of overweight and obese adults increasing by more than 100 million among the Chinese population (Fig. 3) [14, 15, 19]. Moreover, the ratio of overweight and obesity was almost 3:1; the development of obesity has great potential to increase rapidly in the future.

Abdominal obesity reflects the distribution of fat in the body, especially the extent of abdominal fat accumulation. It is an independent risk factor for chronic diseases. The rate of abdominal obesity (waist circumference ≥90 cm in males and ≥85 cm in females) has also risen rapidly over the past few decades, and was 25.7% in 2012 [33]. The results from the CHNS showed that increases in abdominal obesity were pronounced, from 18.6% in 1993 to 37.4% in 2009 [34]. This rapid increase in abdominal obesity has become an urgent public health problem in China.

According to 2010 Chinese guidelines for the management of hypertension, the prevalence of hypertension among those aged 18 and older was 25.2% in 2012. It shows an increasing trend when compared with 2002 (18.8%) [35]. In addition, the China Hypertension Survey

revealed that in 2015 the overall crude prevalence of hypertension and pre-hypertension was 27.9% and 39.1%, respectively. The awareness, treatment, and control rates of those with hypertension were 46.9%, 40.7% and 15.3%, respectively [36]. Although the awareness, treatment, and control rates of hypertension had improved significantly, they were still much lower than in Western populations, and were associated with significant excess mortality [36, 37].

The prevalence of diabetes among those aged 18 and older increased remarkably over the decades, from 2.6% in 2002 to 9.7% in 2012 [35]. The 2016 Global Burden of Disease study showed that, from 1990 to 2016, all-age prevalence of diabetes rose from 3.7 to 6.6%, and all-age diabetes mortality rates increased by 63.5% [38]. The International Diabetes Federation's Diabetes Atlas 8th edition estimated that the number of diabetes patients in China was 114 million, equating to nearly a quarter of cases worldwide [39]. However, the awareness, treatment, and control rates of diabetes were 36.5, 32.2, and 49.2% [40].

The prevalence and mortality of cardiovascular diseases were also on the rise in China. The number of cardiovascular diseases was estimated to be 290 million in 2016 [41]. Chronic disease mortality nationwide was 533 out of 100,000 people in 2012, accounting for 86.6% of all deaths. Cardiovascular diseases remain the top cause of death in China [35]. From 1980 to 2016, the annual growth rate of discharged patients with cardio-cerebrovascular diseases in China was 9.85%, and total hospital expenses were also rising rapidly [41]. Cardiovascular diseases constitute a huge health burden in China, and the substantial increase represents an ongoing challenge. Thus, a targeted control and preventative strategy needs to be developed at decreasing the risk factors so as reduce this burden.

Challenges of the traditional dietary survey in China

Nutrition work in China was also confronted with challenges. Because of dietary behavior transitions, such as increased eating away from home and consumption of prepackaged foods, and the booming processed-foods industry, it is becoming more difficult to accurately capture the dietary consumption of subjects with dietary survey methods. In addition, dietary surveys tend to be conducted over a period of time that fails to consider the seasonality of foods, therefore, it would not be truly representing all four seasons. Moreover, a wide variety of foods is constantly emerging, so the food composition database needs to be constantly updated and improved, especially the composition of prepackaged foods. In accordance with dietary behavior transition and the developments in science and technology, a variety of technologies will be combined to improve the dietary survey in order to obtain relatively precise dietary data in the future.

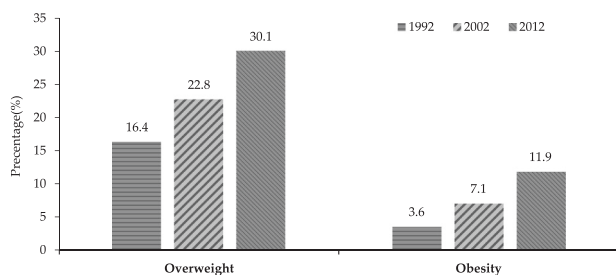


Fig. 3 The prevalence of overweight and obesity among Chinese adults, from 1992 to 2012. The figure legends from left to right are represented the survey cycle 1992, 2002 and 2012. Data sources: 1992, 2002, 2010–2012 China National Nutrition Surveys and the national nutrition reports.

Policy, technology, and knowledge key to promote healthy and sustainable nutrition in China

Although China has taken significant steps toward improving nutrition over the decades, such as modest increases in consumption of fruit, dairy, eggs, and decreases in sodium intake, the intake levels remained far from the recommended values of CDG; however, the prevalence of underweight malnutrition and anemia has decreased greatly. Yet the present review shows that China is undergoing a nutrition transition and face dual challenges of undernutrition and overnutrition among Chinese adults, including unbalanced dietary structure and micronutrient deficiency, which have led to a far greater burden of prevalence of and mortality from chronic non-communicable diseases than infectious diseases. Considering the above-mentioned factors, work to prevent and control chronic noncommunicable diseases will face huge challenges. The government and relevant departments also take powerful and effective measure to curb the occurrence of chronic noncommunicable diseases and to improve nutrition and health conditions.

The Global Nutrition Report (2016) proposed a strategic goal: ending all forms of malnutrition by 2030 [42]. Nutrition is closely linked with national health. Concerted efforts are needed to improve the dietary environment, behaviors, and quality at the national, societal, family and individual levels. Concerning the dual challenges of undernutrition and overnutrition among Chinese adults and the challenges of nutrition work in China, the government has implemented relevant nutrition policies. China's central leadership published an outline in 2016 to guide the Healthy China 2030 Initiative. It is an action strategy for implementing health in China that explicitly asserted that a "healthy diet" should be guided [43]. The National Nutrition Plan (2017–2030) is formulated to implement the outline of the Healthy China 2030 Initiative with the goal of raising awareness of nutrition among the Chinese people, reducing obesity, and reducing anemia among students [44]. The government will consistently integrate nutrition improvement and chronic disease prevention into public policies.

With the rapid development of the food-processing and catering industries, people's dietary consumption patterns are changing to high-consumption prepackaged foods and eating away from home, which may contribute to poor dietary quality (such as intake of HEFSS foods) and chronic non-communicable diseases. Therefore, in order to control this intake of HEFSS food, corresponding policies and measures for the food-processing and catering industries should be put forward, insisting on the "nutrition to guide consumption, consumption to guide production" concept. At the same time, strict implementation of food or dishes with low oil, low salt, and low sugar should be advocated. The catering, online

catering, and food industries also need scientific market supervision and consumption guidance. We suggest promoting the "nutrition and health + Internet" service, realizing the precise and intelligent nutrition under the guidance of science and technology, upgrading the supply and consumption level, and forming a new pattern of nutrition and health work.

Furthermore, nutrition is a lifestyle choice depends on self-discipline. Therefore, nutrition and popular science education should be implemented in communities and schools to improve national awareness of nutrition and healthy diets, especially targeting heads of households who determine nutrition and meal planning for families and adolescents who in a critical period for developing behaviors.

Nutrition legislation will play an important role in improving nutrition and health in China. Legislation can identify the government responsibility for nutrition and health, make full use of nutritional resources to meet the national demand and establish a guarantee mechanism to improve national nutrition status and health. Therefore, nutrition legislation will still be important work in China in the near future.

In conclusion, the overall dietary structure still exhibits problems, and micronutrient deficiency is ubiquitous among Chinese adults. At this stage of transformation, the dual challenges of nutrition are highlighted, especially the prevalence of overweight and obesity. It is inevitable that China's economy will continue to move forward and transform. In the development process, nutrition will be constantly confronted with challenges. Therefore, the government, multi-sector collaborative efforts and individual participation are all needed to optimize the food-supply structure, strengthen nutrition education, and adopt effective intervention strategies to improve nutrition in China.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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