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## Dynamics of the Chinese Diet and the Role of Urbanicity, 1991–2011

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### Abstract

China's food consumption patterns and eating and cooking behaviors changed dramatically between 1991 and 2011. Macronutrient composition has shifted toward fats, and protein and sodium intakes remain high and potassium intake low. The rapid decline in intake of coarse grains and, later, of refined grains and increases in intake of edible oils and animal-source foods accompanied by major eating and cooking behavior shifts are leading to what might be characterized as an unhealthy Western type of diet, often based on traditional recipes with major additions and changes. The most popular animal-source food is pork, and consumption of poultry and eggs is increasing. The changes in cooking and eating styles include a decrease in the proportion of food steamed, baked, or boiled and an increase in snacking and eating away from home. Prior to the last decade there was essentially no snacking in China except for hot water or green tea. Most recently the intake of foods high in added sugar has increased. The dietary shifts are affected great by the country's urbanization. The future, as exemplified by the diet of the 3 mega cities, promises major growth in consumption of processed foods and beverages.

### Keywords

China; diet; away-from-home eating; consumer packaged food; Urbanicity

## INTRODUCTION

When the China Health and Nutrition Survey (CHNS) was designed in 1987–88, China had a food rationing system, and small, open, fresh markets sold limited amounts of produce and animal-source foods in towns and cities. There were also a few stores where those with access to US dollars could purchase foreign products, such as Coca Cola, which was viewed as a luxury item served at select banquets. China's food system was dominated by small farms, ration stores, and fresh markets. Over the first two surveys in 1989 and 1991, the rationing system disappeared, private sector open markets became dominant and state stores closed and a modern food system began to take shape. To date most of the changes have affected traditional foods and beverages, but the modern food system represents a new stage in China which will have future profound effects on the diets of the Chinese.

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The elements of a modern food system emerged very slowly. Street food and locally owned Chinese restaurants grew rapidly, but Western fast food restaurants appeared slowly in China. For instance, the first Western fast food restaurant, Kentucky Fried Chicken (KFC), opened in November 1987 in Qianmen, next to Tiananmen Square, and the first McDonalds opened in Shenzhen in 1990. KFC experienced very slow growth until the mid-1990s, when it began to grow rapidly.

Supermarkets and convenience stores developed at a similar slow pace initially. Supermarkets began to experience major growth in 2000, and convenience stores did so somewhat earlier.<sup>1-3</sup> Although Taiwanese, Japanese, American, and European chains attempted to move into China, the large supercenters that dominate the urban landscape of China today began to take hold only in the late 1990s. For instance, the first Wal-Mart Supercenter and Sam's Club opened in Shenzhen in 1996, the same year that Carrefour opened its first supercenter. Convenience stores began earlier, with the first 7-Eleven opening in 1992. Many chains, such as Family Mart and 7-Eleven, are Japanese-based firms, as the Chinese increasingly prefer Western-style convenience purchases.<sup>4, 5</sup> Small stores that resemble a combination of convenience stores and grocery stores are now found in almost all Chinese villages. The most recent trend in China, one occurring across Asia and Africa, is the direct distribution of processed foods high in added sugar, sodium, and saturated fats to small stores in villages across the country.<sup>3</sup>

The profusion of supermarkets and convenience stores has presented challenges and is changing the nature of China's food supply.<sup>6</sup> The growth of supermarket chains in the last decade has affected the agricultural system in complex ways. The food system is consolidating, with the value chain going from the manufacturer or processor directly to the supermarket, eliminating middle market entrepreneurs.<sup>1</sup>

It is against this backdrop of adjustments in the farm sector, growing food imports, and major changes in all phases of the agricultural value chain that we must begin to understand the shifts in the Chinese diet. Factory farms, direct sales from farmers to manufacturers and retailers, and other shifts are changing the landscape in many farming areas.<sup>1, 7, 8</sup> We begin to see what the Chinese diet of the next decades will look like. Packaged processed foods and beverages and foods prepared and consumed away from home are becoming common in China. We describe here one stage of the food and diet revolution, the stage before the complete commercialization of the diet into one dominated by processed and away-from-home food.

In this paper we document dramatic shifts in consumption of macronutrients, including sodium and potassium, which are critical in the etiology of hypertension, grains, edible oils, and animal-source foods along with major changes in eating and cooking patterns and styles. We examine the role of urbanicity, measured here in a manner which captures modernization of urban and rural communities. However, we cannot fully measure and understand yet the implications of the food revolution. It will take some time for the government to learn how to capture these changes in its food composition table (FCT). Many studies have been undertaken, and we build on them to present a picture of the changes between 1991 and 2011.

## METHODS

### Sample

Using CHNS data, we focus on all persons aged two and older in China. The CHNS does not have the sample size and depth of data to capture infant feeding patterns. We only have data for three autonomous cities, Beijing, Shanghai, and Chongqing, for 2011. We refer to

them as the 3 megacities, as they all have approximately 20–35 million residents. Their data are presented separately from that for the nine provinces.

## Dietary Data

**Measurement of the household food inventory**—Household food consumption was determined on a daily basis by calculating changes in the home food inventory. All foods and condiments purchased from markets and picked from gardens were carefully recorded and measured with Chinese balance scales (graduation: 10 grams [g]) before the year 2004 and with digital diet and kitchen scales (graduation: 1 g) thereafter at the start and end of each survey. All foods in stock at the initiation of the survey (including edible oils, sugar, and salt), foods purchased and/or produced at home during the survey period, and food preparation waste (including spoiled rice or food fed to animals) were weighed and considered in the calculation of household food consumption. This was the only method that was used by the Institute of Nutrition and Food Safety for national and large-scale surveys prior to the CHNS, and it was continued with the addition of three consecutive 24-hour recalls with the initiation of the CHNS in 1989.

**Measurement of individual intake**—Individual dietary data for the same three consecutive days were recorded for all household members, regardless of age or relationship to the household head. This was achieved by asking each individual, except children aged younger than 12, on a daily basis to report all food consumed at home and away from home in a 24-hour recall. For children younger than 12, the mother or a mother substitute who handled food preparation and feeding in the household was asked to recall the children's food consumption. Using food models and picture aids, trained field interviewers recorded the type of food, amount, type of meal, and place of consumption of all food items during the 24 hours of the previous day. Respondents were prompted about snacks and shared dishes. Food items consumed at restaurants, canteens, and other locations away from home were systematically recorded. Housewives and other household members were encouraged to provide additional information we used in determining the amounts of particular food items in dishes consumed in the home. The amount of each dish was estimated from the household inventory, and the proportions of each dish consumed were reported by each person interviewed. Thus the amount of individual consumption was determined by the proportion each person consumed of the total amount prepared.

There are clear reasons for collecting 24-hour dietary intake data. China has conquered the problem of food scarcity at the national level and has undergone a remarkable transition in the structure of food consumption. This has gone hand in hand with marked changes in eating behaviors. For instance, away-from-home food consumption has increased in response to the dynamic changes in real, disposable income and market labor force patterns. Variations in food intake and eating patterns within the household appear to be expanding. Food and nutrition policy is focusing less on food security needs and more on the health-related needs of selected age and gender groups. As this occurs individual dietary intake becomes more important.

**Recipes and standard dishes**—A major measurement concern is that the traditional eating pattern in China involves the preparation and serving of a limited number of complex dishes. These dishes consist of staple foods and side foods. The former includes all food made of grains and is served in a separate bowl to each person, and the latter consists of all meat and vegetable dishes, which are placed in the center of the table in big bowls or plates for all people to share. This pattern of household consumption from common plates increases the difficulty of obtaining accurate measurements of individual food consumption. In addition snacks and food eaten away from home are dependent on a respondent's

memory. These limitations have hindered the development of individual dietary intake data collection in China, as they were felt to reduce the validity and precision of the individual 24-hour recall method. The combination of the two methods developed for the CHNS allowed us to reduce the errors associated with this eating tradition. Both the total quantities available for consumption and the ingredients are understood prior to editing the 24-hour recall for each family member.

In three CHNS surveys, 1997, 2000, and 2004, recipe contents were measured by asking the name of the recipe consumed and recording for each individual the quantities of separate items in the recipe. We found huge nutrient variations (e.g., tenfold differences in protein content) between various households' recipes.<sup>9</sup>

**Assessment of oil and other condiment use**—An additional problem relates to the measurement of cooking oil and other condiments used in food preparation, because the Chinese FCT is based on food as purchased, not as cooked. For this reason, measurement of cooking oil would have been omitted from the traditional 24-hour recall undertaken in China. Stir-frying is a significant cooking method for Chinese dishes, and there is no standard recipe for most dishes. Any combination of vegetables and meats is regarded as a dish. As we will show, the amount of cooking oil used with each dish varies considerably from family to family. Since the amount of each dish consumed by each individual within the household varies significantly, we developed a method of allocating oil among household members based on meat and vegetable consumption. We calculated the proportion of meats and vegetables consumed by each individual from the total household consumption of the food groups. This proportion is used to allocate household cooking oil to each individual. Underlying this is the knowledge that Chinese households predominantly fry dishes containing vegetables (including tofu and beans), beef, pork, chicken, fish, and seafood using edible oils, normally soybean, peanut, and vegetable oils. Rarely are oils used with staple foods containing rice, wheat flour, and other grains.

Following this approach, the individual daily consumption of cooking oils and condiments was estimated from the household dietary data. These data, based on the food inventory method and partial weighing and measuring of the dishes, are a very accurate measure of total household edible oil intake. The proportion of these household oils consumed by each individual, based on his or her proportion of the household's consumption of vegetable and meat dishes, was added to the 24-hour dietary recall to measure individual nutrient intake.

**Conversion to nutrients: The Chinese food composition table**—When the CHNS 1989 began, the Chinese FCT was limited to 636 foods and was not poised for the rapid shift in the Chinese food supply with the introduction of multinational and modern processed foods.<sup>10</sup> Also the available FCT was based on food as purchased and grown and consisted of raw food items. It did not measure processing and preparation waste.<sup>11</sup> The FCT has been expanded to encompass closer to 2,500 foods and includes limited representation of processed foods.<sup>12</sup>

However, there is one gap. The Chinese FCT does not include any recipes, so measurement of away-from-home food intake must rely on knowledge of the ingredients used in food preparation. Studies are underway, including work with the CHNS, to collect adequate recipe data to provide at least an understanding of the average components of current dishes consumed in China. However it is clear that for future surveys we will collect both recipe names and all ingredients.

**Validation of dietary intake measurement**—The measurement of total energy intake was validated by using the doubly labeled water method with all assays undertaken in the

Human Nutrition Research Center, Tufts University. The correlation coefficient between the two methods was 0.56 for men and 0.60 for women.<sup>13</sup> We did a validation study to evaluate the accuracy of estimated sodium and potassium intake at the individual level in one of our survey provinces (but not with CHNS participants) by measuring urine excretions from 24-hour urine samples collected for three consecutive days and using para-aminobenzoic acid (PABA) as a marker of completeness of 24-hour urine samples. The correlation coefficients between dietary sodium and potassium intake estimated by weighing with 24-hour recalls and urine sodium and potassium excretions measured from 24-hour urine samples were 0.58 and 0.59, respectively ( $p = 0.005$ ). An independent validation was conducted on monosodium glutamate (MSG) intake, and the correlation coefficient between individual MSG intake estimated by weighing with 24-hour recalls and by using urinary riboflavin marker was 0.82 ( $p < 0.01$ ).<sup>14</sup>

**Food grouping system**—A variety of ways exist to describe patterns of food consumption. One might measure single foods, food groups, or foods by level of processing. One might also measure food use by where foods are purchased or consumed, such as at home versus away from home, by time of day, or as part of specific meal or snack patterns. These possibilities led a working group of researchers from the University of North Carolina at Chapel Hill and the Chinese Institute of Nutrition and Food Hygiene (INFH) to develop a food grouping system that summarizes intake of foods in a nutritionally meaningful way. The complexity of eating behaviors has led most researchers to use simple food grouping systems that measure intake of 8 to 10 food groups, such as starchy staples (cereal-based foods), meats, dairy products, and so forth. We felt that this approach aggregated foods into too few food groups to pick up important shifts in eating behavior and that this approach missed key food trends that had important implications for health. For instance, many studies have examined overall dairy or milk consumption, whereas the health effects of consuming higher- or lower-fat milk and butter or margarine on health are quite different.

The food grouping system we used separates all foods into 41 descriptive and nutrient-based groups. Initially our major food groups were based on those used by the INFH. Subsequently we used fat and beta-carotene compositions to develop more refined food groupings and nutrient thresholds to separate major food groups into more distinct, nutrient-based food groups. Appendix table 1 presents the current food grouping system. This will be updated and modernized over the next year to be comparable to a system used in the United States.<sup>15, 16</sup>

## Eating Behaviors

**Definitions of *snack* and *snacker***—*Snacks* refer to all foods and drinks consumed outside the context of the three main meals (breakfast, lunch, and dinner) and are referred to as morning, afternoon, and evening snacks, which make up the “snack occasions.” Due to the lack of the specific time for each event, late-night snacks or multiple snacking events during the morning, afternoon, or evening could not be determined. A person is defined as a *snacker* if he or she consumes any snack during the three days investigated in this study.

**Away-from-home consumption**—One major complication in examining modern food consumption is that in any meal people may consume food prepared at different locations, both at home and away from home. Item obtained as food prepared away from home may be consumed at the stall/restaurant or at home. For this paper we focus on the proportion of food prepared away from home and do not differentiate between that consumed at home and that consumed away from home.

**Method of cooking**—As part of the dietary intake interview, the type of food preparation was obtained for each dish. The options measured were boiled, stir-fried, deep-fried, steamed, griddled, baked, eaten cooked, eaten raw, and other.

**Processing**—For the CHNS 2011 we created a new measure to learn if each food was purchased as a raw food and prepared by the buyer (e.g., meat, vegetable, or grain), was prepared at a restaurant, or was packaged or processed. We used this measure to begin to understand the role of packaged foods and beverages in the Chinese diet.

**Explanatory variable: The Urbanicity measure**—This has been described in Barry M. Popkin's introduction to this issue<sup>17</sup> and elsewhere.<sup>18</sup> Essentially this is a complex index which used community measures of infrastructure, services, and population to capture major dimensions of what is termed Urbanicity.

### Measures of the Modern Food System

Recent worldwide changes in sales of all packaged foods and beverages are included in data collected by the Euromonitor Passport Global Market Information Database.<sup>19</sup> Total annual food and beverage sales in China between 1998 and 2012 are included. Packaged foods include foods sold at establishments primarily engaged in the sale of fresh, packaged, and prepared foods for home preparation and consumption and packaged food or beverage products sold at outlets that serve the general public in a noncaptive environment (i.e., excludes hospitals, the army, jails, etc.), regardless of whether the products are eventually consumed on or off the premises. We also present food service trends, which are composed of cafés and bars; full-service restaurants; fast food restaurants; 100% home delivery or takeout; self-service cafeterias; and street stalls and kiosks in locations for leisure activities (e.g., museums, health clubs, cinemas, theaters, theme parks, sports stadiums), lodging (e.g., hotels), retail (e.g., department stores, shopping malls, shopping centers), and travel (e.g., airports, rail stations, bus stations, highway service stations).

### Statistics

This is a descriptive paper. All tables and figures are age adjusted to the 1990 census to allow us to compare food changes over time for the same age distribution.

## RESULTS

The sample size of this study is noted in supplemental table 2.

### Nutrient Trends

There was a rapid decline in the energy intake from carbohydrates between 1991 and 2011 (table 1). In the nine provinces in the CHNS survey the percentage of energy consumed from carbohydrates dropped from 66% to 54%. In the three megacities of Shanghai, Beijing, and Chongqing the proportion of energy derived from carbohydrates is even lower, so we expect future declines across China. In the provinces the percentage of energy consumed from fats rose by 10% to 32%, while that from protein did not change. However, in the megacities the percentage of energy consumed from fat rose to 37% and that from protein to 15%, so we might expect further shifts toward this level in the future.

Sodium consumption levels are very high in China, potassium levels are low, and the sodium-potassium ratio levels are high. Ideally sodium consumption levels would be < 2 grams per day (g/d), potassium levels would be 2–3 g/d, and the sodium-potassium ratio would be < 1.<sup>20, 21</sup> Figure 1 shows that while the proportion of the population consuming



adequate sodium and potassium levels has grown, there is still a very large proportion with poor sodium-potassium ratios.

### Food Consumption Trends

Table 2 highlights four important changes in food consumption trends. The first and most pronounced shift was the rapid increase in the proportion of energy consumed from edible oils across all age groups. The largest jump, 1971–1989, is not shown. Between 1971 and 1989 consumption of edible oils increased to about 14.8 g/d from 4.3 g/d.<sup>22</sup> The jump to the 2011 level was equally rapid, with the average Chinese individual consuming close to 30% of his or her energy from edible oils across all ages. Initially the most rapid shifts and higher levels of intake were in the more urban areas, but across adults of all ages (excluding children 2–18 years old) in 2011 the proportion of energy consumed from edible oils was similar. The three megacities show a lower edible oil intake (in contrast to the higher fat intake in table 1).

Declines in real prices underlie these increases in consumption of animal-source foods and edible oils.<sup>23</sup> The prices are collected in each of our communities at each survey from government guided prices (published in local newspapers and posted in major free markets) and from sellers in the free markets. Figure 2 presents the real price declines in edible oils and eggs along with increased prices in pork, flour, and rice in the last decade.

Consumption of animal-source foods has consistently risen among all age groups, with the highest levels of intake over time consistently in the more urbanized areas (table 2). The highest kilocalories per day (kcal/d) consumed from animal-source foods are recorded in the three megacities. Figure 3 highlights the dominant role of pork but also the increasing proportion of eggs and poultry (with slightly more fish) in animal-source food overall consumption patterns.

While edible oils and animal-source foods as a proportion of the diet have increased, marked reductions have occurred in coarse grains. Whereas among the poor and in low Urbanicity areas coarse grains were important sources of energy in 1991, they are rapidly declining in importance. In the three megacities coarse grains represent a tiny contribution to overall energy intake. Similarly there is a decline in legume and legume products (tofu in particular) in the Chinese diet, though much of the larger decline occurred prior to 1991.<sup>22</sup>

### Eating Behavior Changes

We have selected some of the more important nutrition-related eating and cooking behaviors to present. As edible oils have increased in consumption, there has been a marked shift away from the healthier cooking methods of steaming, boiling, and baking to stir-fried and deepfried preparation with a very rapid increase in the proportion of the population consuming more than 30% of its energy from fried food.<sup>24</sup> Table 3 shows that these changes are greatest in the most urbanized communities and that the 60 years age group is the slowest to change. The very low proportion of foods prepared by the healthier methods in the three megacities may point to a future of even less healthy food preparation in China.

The most recent eating behavior shift has been the rapid increase in snacking during the 2000 to 2011 period (see figure 4, which shows the percentage of the population aged two and older that snacks, the overall percentage of energy consumed from snacks, and the percentage of energy consumed from snacks among those who snack). This new behavior represented a miniscule proportion of consumed kcal/d in 1991 but increased rapidly with the growth of the modern food system and modern marketing in the past decade. The percentage is much lower than that found in more modernized countries, where about 20 to

25% of energy comes from snacks. The direction and speed of change, personified by children in the three megacities, is toward the levels of more modernized countries.

Concurrent changes are seen in the proportion of home-prepared food that is eaten at home and overall energy intake from home-prepared food. Again the more urbanized communities show smaller proportions of food prepared and eaten at home, and the three megacities show the smallest proportions. At the same time the older Chinese are more likely to prepare food at home. In contrast the proportion of food prepared at restaurants, food stalls, canteens, schools, and other away-from-home venues (excluding food eaten at other homes) has increased, particularly in the more urbanized areas, most strikingly in the three megacities. As expected, there is a large age effect, and older individuals have not shifted their behaviors as greatly as younger ones.

### The Modern Food System

There are a number of ways, none perfect, to provide some sense of the rapid growth not only of modern convenience stores, supermarkets, and mega food markets but also of modern eating establishments. The CHNS 2011 recorded whether fresh meat, vegetables, or other foodstuffs were prepared and eaten at home, purchased at restaurants, or purchased as packaged processed food. Table 4 highlights the beginning of this shift to packaged processed food. This is an imperfect measurement, as much greater detail would be needed to understand the degree of processing and convenience in the item, as these foods could vary from frozen pizzas or Ramen noodles to oatmeal or other cereals or grain-based dessert products that do require food preparation as well as heating or cooking. Again the more urban areas show greater consumption of processed foods, especially the three megacities. Interestingly children 2 to 18 consume a much higher proportion of these modern foods than do adults, suggesting that future cohorts of adults might eat and shop quite differently.

Figure 5 presents the data from Euromonitor. These data show the sales trends for both packaged foods and restaurants. However, they do not capture many of the Chinese elements of either market. In a much deeper analysis of the modern food system combined with interviews of all sectors in the system, from farmers to retailers and manufacturers, Tom Reardon et al.<sup>1</sup> found that the Chinese food retail sector had grown at an annual compound growth rate of 32.4% from US\$13.1 billion in 2001 to US\$91.5 billion in 2009. They measured the sales of 47 store chains; far different from the smaller number Euromonitor had access to.

Another set of studies have examined the proportion of modern chains in the retail market share of fresh food (animal source foods, fruit and vegetables) and in processed/packaged food. For China about 30% of meat, fruits and vegetables come from these modern chains of stores and 80% of processed/packaged foods.<sup>3</sup>

## DISCUSSION

The changes in the Chinese diet between 1991 and 2011 are significant when one considers that it is a nation of 1.34 billion people. The increasing consumption of energy from fats, the high level of sodium consumption, and the high sodium-potassium ratios are major nutrient shifts. The increases in intake of vegetable oils and animal-source foods have been rapid and appear to be continuing, and coarse grains, legumes, and other healthful foods we have not highlighted (e.g., vegetables) have declined in importance and intake levels. The relative prices of animal-source foods and oils partially explain these shifts and income increases are a second important cause.<sup>23, 25</sup> At the same time the entire food system and ways of cooking and eating are changing rapidly, including a decline in the proportion of food cooked in healthy ways (steamed, baked, boiled) and the increases in fried foods, snacking, and away-



from-home food consumption. This all has come with the very rapid modernization of the restaurant and packaged food manufacturing and retail sectors.

We do not present data on sugar-sweetened beverages, sweet cakes, and other products high in added sugar that are rapidly increasing in intake in China but still represent a tiny component of the Chinese diet.<sup>26</sup> The high added sugar products are one of the newest additions to the Chinese diet. As is shown in the Susan Kleiman paper, sales of sugar-sweetened beverages are rapidly increasing in China, and we would expect those drinks to become a major component of the diet within the next decade.<sup>26</sup>

We have focused on the nutritional aspects of the modern system. Clearly food safety issues are another factor that warrants study.<sup>27</sup> The changes in the Chinese diet are also seen across most low- and middle-income countries (LMICs). The edible oil intake increases are most pronounced in the countries that are major producers, such as Indonesia and Malaysia, but are universal.<sup>28</sup> Similarly the animal-source food increases are seen in other rapidly growing LMICs, where almost all the growth in the per capita intake of animal-source foods is occurring.<sup>29, 30</sup> In contrast the healthier foods in the Chinese diet, such as legumes, vegetables, and coarse grains, have been in decline over the past decades.<sup>22</sup>

While the actual foods consumed are changing, many of the cooking and eating behaviors are driven both by the low price of edible oils (encouraging increased frying and reduced boiling, steaming, and baking) or by the modern food system and modern food marketing. Snacking, a behavior that did not exist in China prior to the 1990s is rapidly increasing as a component of the diet. To date snacking is not dominated by savory snacks, sugary beverages, and other unhealthy foods as in the West, but these traits are emerging.<sup>31</sup> In Brazil, Mexico, the United States, and many other countries snacks represent about 20% or more of the diet and are composed completely or partially, depending on the country, of unhealthy foods<sup>32–34</sup> (unpublished data for Mexico). In contrast in China fruit has been one of the more popular snack items, and only recently have less healthy foods, savory snacks, and soft drinks become popular.

The Chinese diet revolution of 1991–2011 is a precursor to the next stage, which we might expect to be completely dominated by modern packaged foods, modern retailers, and modern restaurants. The US\$91.5 billion in sales by retail chains in 2009 is just the beginning of a penetration happening globally.<sup>1, 2, 35</sup> In just the last few years most rural communities have gained small convenience stores or grocery stores that receive foods and beverages directly from manufacturers. This global trend<sup>3</sup> has mainly affected packaged foods and beverages in China and not yet produce and meats. That will be the next stage, accompanied by ever-increasing consumption of processed and packaged foods and beverages. Already children in the three megacities consume 28% of their calories from packaged processed food.

The only truly healthy trends are the reduction in overall sodium intake levels and increases in potassium intake levels. This is a result of shifts toward refrigeration and away from salted fish and other salted staples. But in the future this may be offset by increased processed food intake<sup>36</sup>. Small amounts of animal-source foods are an important source of iron and many other micronutrients, but beyond limited levels they can have adverse health effects.<sup>37–40</sup>

Our research has several limitations. One is the areas we did not cover in depth, namely the roles of food prices, incomes, food marketing, education, and food supplies and the impact of Urbanicity. Second is the limitation of the Chinese FCT. It is based mainly on food as purchased and ignores food preparation and losses in the home, which called for our careful weighing and measurement of condiments and oils. A third is our inability to fully capture

the modern shifts in the foods consumed, as the Chinese FCT, like most FCTs in the world, cannot keep up with the pace of change in the packaged food sector. Even in the United States, where several hundred thousand packaged foods and beverages with unique ingredients are available, the federal food surveillance system is unable to capture the changes in the commercial food sector, as 10 to 20% of these products each year are reformulated, *inter alia*.<sup>41</sup>

The Chinese diet will continue to evolve very rapidly. How it will be shaped by the modern retail and packaged food and beverage sector and away-from-home food eateries in the next stage is unclear. However, this paper does make clear that the changes will be marked and rapid and that the health implications remain to be understood. The CHNS is an important monitoring system for understanding these shifts and their underlying causes.

## Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

## Acknowledgments

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## Abbreviations

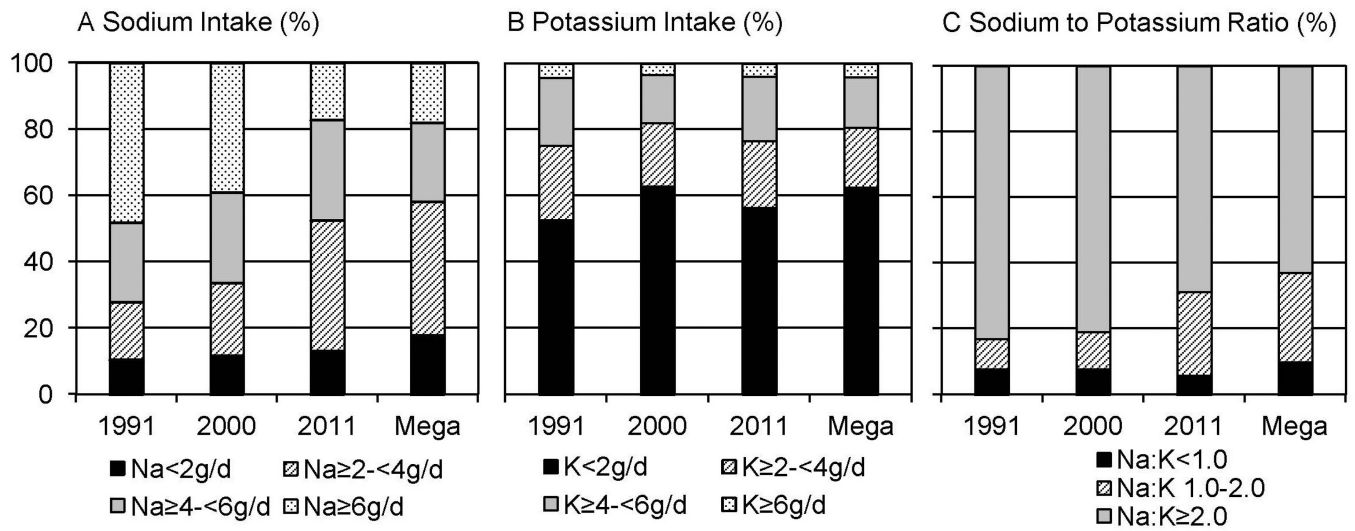
<b>CHNS</b>	China Health and Nutrition Survey
<b>LMICs</b>	low- and middle-income countries
<b>SSB</b>	sugar-sweetened beverage
<b>NCD</b>	noncommunicable disease
<b>GPAQ</b>	global physical activity questionnaire
<b>WHO</b>	World Health Organization
<b>STEPS</b>	STEPwise Approach to Surveillance
<b>BMI</b>	body mass index
<b>SES</b>	socioeconomic status
<b>COHORTS</b>	Consortium of Health-Oriented Research in Transitioning Societies

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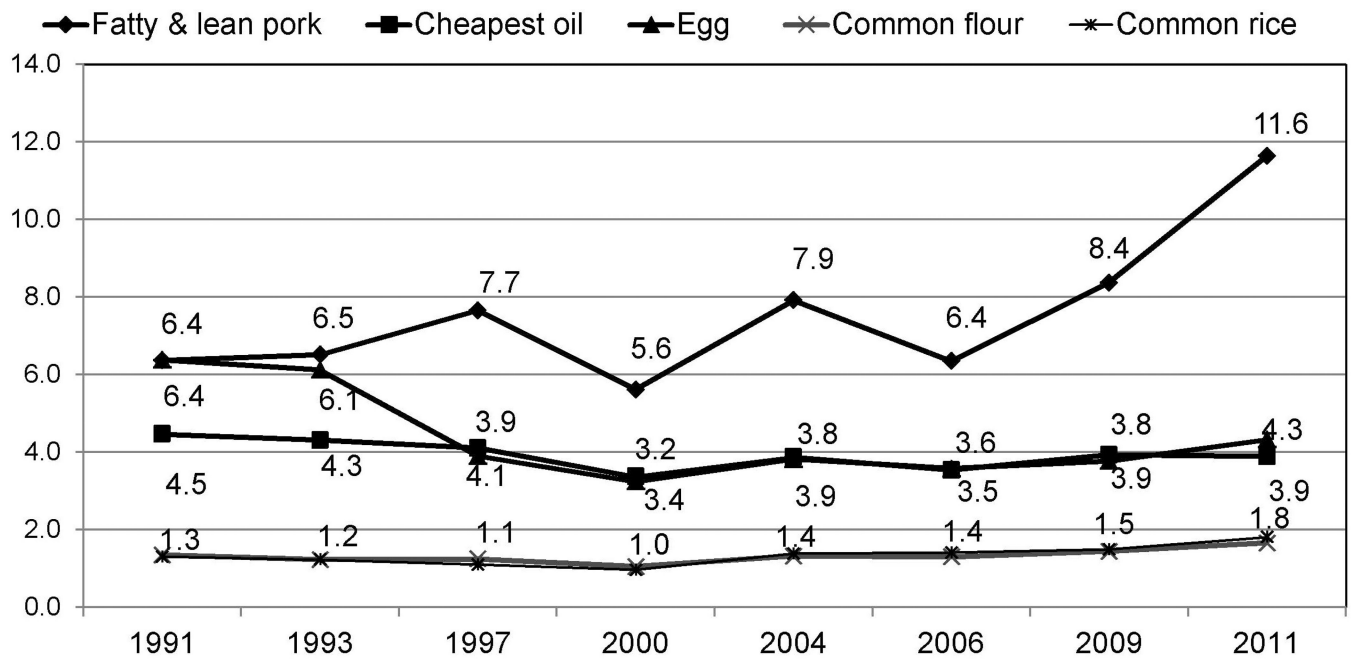
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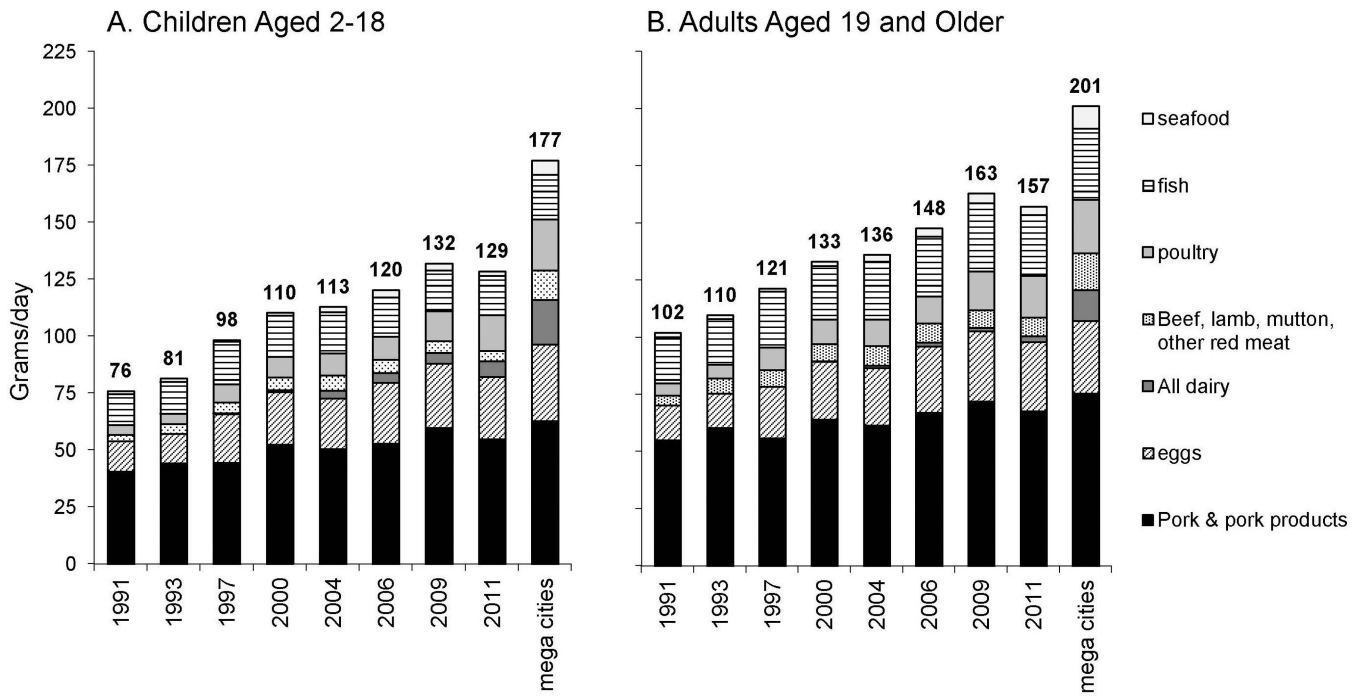


**Figure 1.** Distribution of sodium, potassium and sodium-potassium ratio among Chinese aged 2 and older, 1991–2011

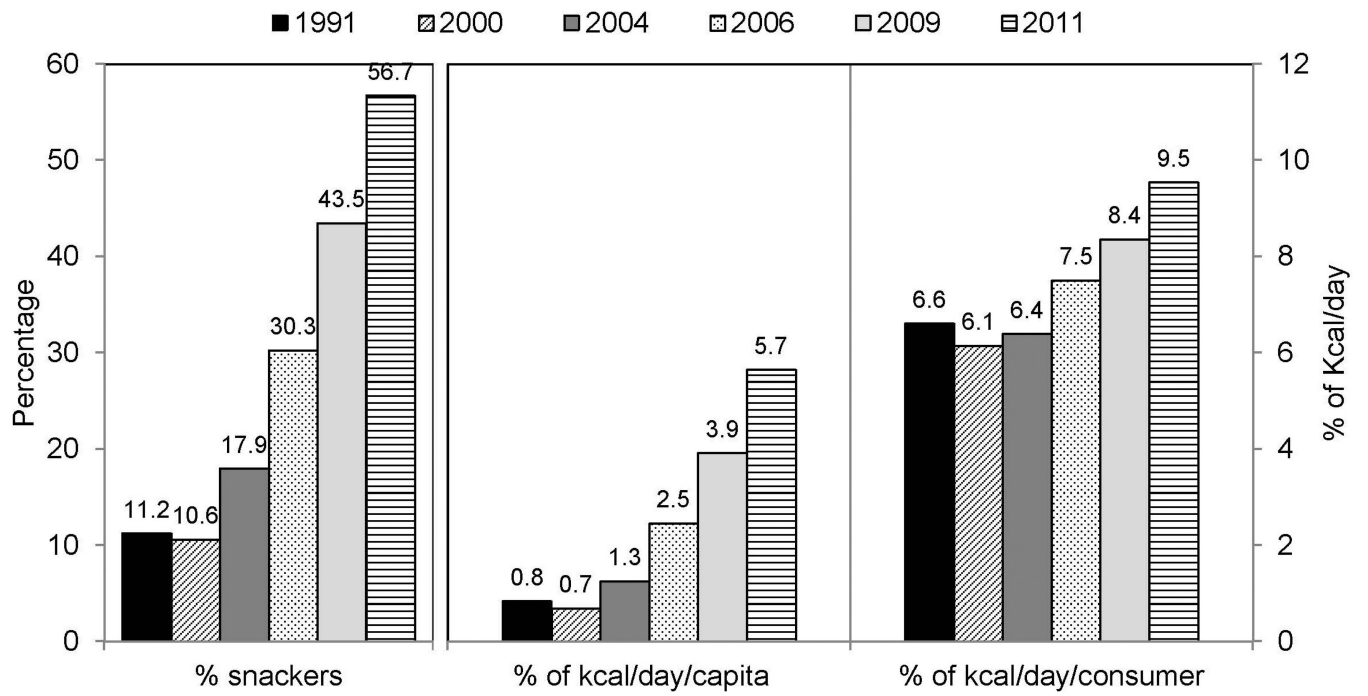


**Figure 2.**  
Real prices of selected food items (yuan/kg), China, 1991–2011

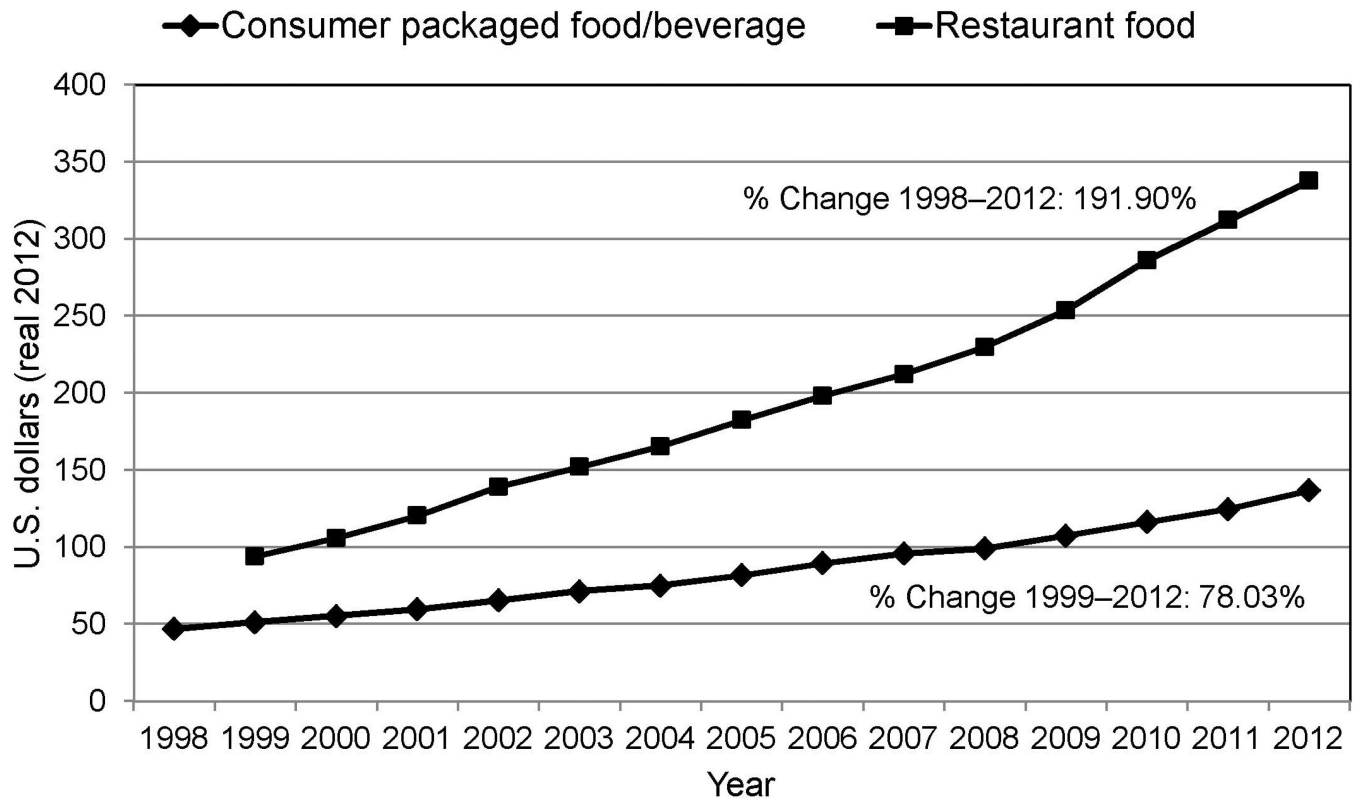




**Figure 3.** Daily Intake of Animal Source Foods in China (grams/day), 1991–2009\*



**Figure 4.** Snacking patterns and trends in China, ages 2 and older, 1991–2011



**Figure 5.**  
The Modern Food Sector's Growth in China

**Table 1****Micronutrients and Minerals ages 2 and over, China 1991–2011**

	1991	2000	2011	Mega cities 3
A. Macronutrient distribution				
% energy from fat	21.8	27.8	32.0	36.9
% energy from carbohydrates	66.0	59.8	54.3	47.2
% energy from protein	11.8	12.1	13.3	15.5
B. Sodium				
Sodium g/day	6.8	5.9	4.3	4.4
Potassium g/day	1.7	1.5	1.6	1.6
Sodium/potassium ratio	4.4	4.2	3.0	3.1

\* All results age-standardized to 1990 census age distribution

**Table 2**  
Food consumption changes and urbanization relationship by age, China 1991–2011

Key Food Changes Per Capita	3 Mega cities											
	1991			2000			2011			2011		
	2-18	19-59	60+	2-18	19-59	60+	2-18	19-59	60+	2-18	19-59	60+
Edible Oils – grams	17.6	23.4	22.7	19.8	29.4	30.1	20.9	29.9	30.6	17.0	23.0	22.0
Edible Oils – % of total energy	7.8	7.8	9.0	9.7	11.2	13.3	12.0	13.0	14.7	10.0	12.0	12.0
Low Urbanization	15.1	21.1	20.4	18.6	29.9	28.5	16.2	29.7	31.9			
Middle Urbanization	20.9	25.6	25.2	16.8	25.8	26.1	21.2	30.2	28.4			
High Urbanization	22.2	26.8	21.9	24.4	32	32.3	21.8	29.8	31.6			
Total Animal source foods-kcal/d	178.6	239.8	217.4	236.4	287.7	265.9	266.2	333.0	266.1	321.8	379.8	330.1
Low Urbanization	131.3	168.9	141.5	1411.9	169.9	146.9	167.3	218.8	166.2			
Middle Urbanization	242.3	309.7	270.9	229.6	271.9	231.8	239.2	299.7	239.2			
High Urbanization	355.4	401.0	292.6	369.4	413.6	343.8	319.4	388.3	310.4			
Coarse Grains – kcal/d	87.6	114.0	87.0	41.8	56.6	56.8	25.4	39.0	48.0	10.0	17.0	25.0
Low Urbanization	100.3	143.2	109.3	72.1	99.6	108.9	39.2	64.1	59.9			
Middle Urbanization	82.3	103.8	98.7	28.3	44.3	47.6	20.5	47.3	54.5			
High Urbanization	14.2	11.9	3.3	23.8	31.4	34.3	24.3	28.5	41.1			
Legumes & Products – kcal/d	59.5	77.5	78.9	59.5	78.4	74.3	46.1	73.6	73.0	33.0	52.0	66.0
Low Urbanization	58.6	76.0	74.4	59.1	73.0	56.0	29.5	67.6	48.1			
Middle Urbanization	60.8	78.9	65.4	61.6	84.9	80.7	52.6	87.4	82.6			
High Urbanization	62.1	77.8	121.6	57.5	77.8	80.1	44.4	65.8	72.7			

**Table 3**  
Eating Behavior Changes China aged 2 and older, 1991, 2000, 2011 – Age Standardized to 1990

Nine Provinces Key Behavior Changes	1991			2000			2011			3 mega cities 2011		
	2-18	19-59	60+	2-18	19-59	60+	2-18	19-59	60+	2-18	19-59	60+
% Kcal from boiled/steamed/baked	81.9	82.4	82.5	76.3	77.5	76.1	65.7	68.4	70.5	54.9	58.4	64.0
Low Urbanization	84.1	85.1	85.3	78.8	81.3	80.2	71.8	74.6	77.0			
Middle Urbanization	79.4	80.2	80.7	77.6	79.3	78.2	67.3	69.1	72.4			
High Urbanization	76.2	77.1	79.6	72.1	72.9	73.4	62.5	66.8	68.0			
% Kcal from snacks per capita	1.5	0.5	0.6	1.1	0.5	0.6	8.8	4.1	3.7	13.3	8.6	7.8
Low Urbanization	1.2	0.5	0.5	0.6	0.4	0.4	6.2	2.4	1.3			
Middle Urbanization	1.5	0.4	0.5	1.1	0.4	0.3	8.1	3.7	2.3			
High Urbanization	3.4	1.0	0.7	1.6	0.6	0.8	10.3	4.7	5.1			
% of population snacking	15.1	9.4	8.8	12.7	9.3	11.1	67.1	52.2	47.4	74.8	65.6	68.0
Low Urbanization	11.3	6.4	5.1	8.1	7.6	6.2	48.5	33.0	22.4			
Middle Urbanization	18.4	9.8	11.7	11.3	6.6	6.6	62.4	48.5	37.5			
High Urbanization	30.1	21.9	10.6	19.8	13.1	15.1	76.1	58.0	58.7			
% Kcal from snacks per snacker	8.9	5.4	6.3	7.8	5.3	5.3	13.0	7.8	7.9	17.5	13.0	11.5
Low Urbanization	10.3	7.7	10.2	7.0	5.4	6.1	12.7	7.6	6.0			
Middle Urbanization	7.2	4.0	4.5	8.8	7.2	4.2	12.6	7.6	6.2			
High Urbanization	9.6	4.6	7.7	7.6	4.6	5.3	13.4	8.0	8.6			
% Kcal prepared and eaten at home	90.4	89.7	93.0	86.2	86.5	89.2	72.2	74.6	83.1	51.2	57.9	75.8
Low Urbanization	93.8	93.4	96.6	92.6	92.2	93.4	75.2	78.5	84.1			
Middle Urbanization	86.8	86.6	90.7	88.2	88.8	93.4	80.4	79.1	87.9			
High Urbanization	80.6	82.8	89.8	76.6	80.0	85.5	65.2	71.1	80.2			
% Kcal prepared away from home	6.7	7.0	5.0	10.0	9.8	7.5	15.6	18.0	9.2	26.7	26.6	10.2
Low Urbanization	3.3	2.9	1.4	3.7	3.7	1.9	13.5	16.4	10.8			
Middle Urbanization	10.7	10.6	7.3	8.6	7.5	3.3	9.2	14.4	6.5			
High Urbanization	16.5	14.4	8.6	18.9	16.7	11.7	20.7	20.5	10.5			



**Table 4**

Processed foods: Percent of energy among 9 provinces & 3 mega-cities in 2011

	9 Provinces 2011			3 Mega Cities		
	2-18	19+	Total	2-18	19+	Total
Home Made						
Low Urbanization	83.7	83.2	83.3			
Middle Urbanization	71.9	76.1	75.6			
High Urbanization	66.3	74.0	73.1			
Restaurant Made						
Low Urbanization	5.4	6.7	6.5			
Middle Urbanization	10.3	10.5	10.5			
High Urbanization	15.5	12.4	12.7			
Processed						
Low Urbanization	10.9	10.1	10.2			
Middle Urbanization	17.8	13.4	14.0			
High Urbanization	18.2	13.6	14.2			
Total						
Home Made	76.2	78.4	78.1	52.5	63.4	61.4
Restaurant Made	9.0	9.5	9.4	19.2	16.2	16.7
Processed	14.7	12.1	12.5	28.3	20.4	21.8