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## Synthesis and Implications: China's Nutrition Transition in the Context of Changes Across other Low and Middle Income Countries

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### Abstract

The China Health and Nutrition Survey (CHNS) is important for its insights into current and future diet, physical activity, and obesity-related changes in China and for understanding underlying processes common across low- and middle-income countries (LMICs). While China modernized later than Latin American countries, many changes seen in China echo those in Latin America and in other LMICs. In general changes in physical activity and diet behaviors in China have occurred at a faster pace relative to other LMICs. Modernization of the overall Chinese food system has lagged behind most other LMICs, yet the now-rapid changes in the Chinese food system are similar to what has been seen in other LMICs. Further, there is variation in these changes across social and geographic space. The incidence of obesity and noncommunicable diseases has increased as the major health burden has shifted toward the poor. This paper examines changes in China and addresses the literature and issues that link these changes with those in other LMICs. In many ways the detailed 20-year CHNS, with nine repeated measures, provides a remarkable window through which to understand nutrition-related changes in other LMICs.

### Keywords

China Health and Nutrition Survey; nutrition transition; overweight; diet; physical activity; globalization; urbanicity

### Introduction

The way the Chinese eat, drink, and move and the related effects on their health has shifted enormously since the founding of the People's Republic of China in 1949. The China Health and Nutrition Survey (CHNS) began in 1989 with a survey of selected household members and in 1991 developed into a comprehensive community, household, and individual survey.<sup>1</sup> This more recent adaptation of the CHNS has been used not only to understand the changes in Chinese behaviors that affect nutritional status and health but also to open windows onto the changes across all low- and middle-income countries (LMICs). This paper discusses many ways the detailed monitoring by the CHNS has enabled the exploration of questions and issues worldwide. The very detailed, multilevel, multipurpose survey has provided the means to understand many of the immense shifts underway across all LMICs. Also from a personal perspective, seeing the remarkable shifts in body composition and diet in just the first two years of the CHNS led me to pull back and consider the impacts of the rapid shifts

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in behaviors in all LMICs and layout the framework for my papers developing the concept of the nutrition transition.<sup>2-6</sup>

The lessons from China will be presented briefly below. In particular on the dietary side China was a window to the rapid increases in consumption of edible oils and animal-source foods, snacking, frying food, and many other behaviors occurring across the globe. The Chinese picture prompted scholars to explore the same issues globally or in selected regions with food balance data and small, focused studies. Later we began to see in China other changes that had occurred earlier in other regions (particularly in Latin America and North Africa), such as increased consumption of food away from home and sweetening of the diet with sugar-sweetened beverages (SSBs). Research from these other countries opened us to exploring the dynamics and causal patterns in China. On the physical activity side Chinese research demonstrated that the rapid changes in mechanized transportation, home production, and market production led to dramatic reduction of physical activity and concomitant weight gain. In 1990 the CHNS began recording all aspects of physical activity, such as whether individuals used a bicycle or a car for transportation, which allowed us to track how these modernization-related changes could positively or negatively influence weight gain.

The more recent collection of a vast array of biomarkers promises to raise many new questions and issues, as no other longitudinal study in an LMIC has the long-term physical activity, diet, anthropometry, and hypertension data plus the accompanying household and contextual data. However, it is far too early to be able to evaluate the generalizability and value of these new cardiometabolic markers or the as yet unexplored toxicological and other markers found in the toenails.

This paper focuses on the value of the CHNS and its implications for understanding changes in diet, physical activity, weight-related traits, and health-related factors across all LMICs.

## **Food Shifts in China and across the LMICs**

### **Vegetable (edible) oil consumption increases**

Because of the unique method of weighing and measuring the vegetable oil consumed at the household level and the ingredients for each dish prepared, the CHNS provides insight into the rapid shifts in manufacturing, pricing, purchasing, and using vegetable oils in China. We followed research on Chinese vegetable oil (often termed edible oils) increases with a large global examination of food balance data from the Food and Agricultural Organization of the United Nations to study trends worldwide.<sup>7, 8</sup> This work highlighted the increased oil intake in LMICs. The increase in the amount of total fat in diets in low-income countries was much greater than that found in middle- and higher-income countries. In fact this work showed a reversal in the income-vegetable oil intake pattern such that lower-income countries more often increased fat intake.

Subsequent research has shown that food pricing policy could be used to reduce fat and increase protein intake in China.<sup>9, 10</sup> Further research indicates that readily available edible oils in China have shifted consumers toward purchasing more oil and increasingly frying food.<sup>11</sup> Also we examined in detail the fatty acid compositions of all vegetable oils sold in nine provinces.<sup>12</sup> We found that at that point in time rapeseed oil was the most commonly consumed oil and that it was rich in a potentially toxic component, [C22:1n9 cis (erucic acid)]. In addition we found that about a third of all edible oils differed from their labeled identifications.

As a result in May 2006 we organized, with the China Nutrition Society and the Chinese Oil Institute, a national conference to understand the dietary role of vegetable oils in China. The conference discussed the industry's consolidation in preparation for the World Trade Organization forcing China to reduce import tariffs and other barriers keeping foreign vegetable oils out of the Chinese market. Subsequent research by Carlos Monteiro and others has pointed out that ultraprocessed foods use an increasing proportion of the globe's cheap vegetable oils.<sup>13, 14</sup>

More and more LMIC scholars are considering edible oil-related components of the diet. However, most methods for collecting and analyzing edible oil intake focus on either food balance data, food expenditure surveys, or 24-hour recall surveys, which make it difficult to actually measure the oil consumed.

### **Animal-source foods**

The increase in consumption of animal-source foods in China has been remarkably rapid.<sup>15, 16</sup> As Shufa Du et al. showed, income increases play a major role, as these products have high prices and income elasticity. Pork remains the most common animal-source food, but as Fengying Zhai's paper in this issue notes, intake of eggs, poultry, and dairy products is growing quickly. This occurrence in China is comparable to the increase in animal-source food consumption across Asia and other LMICs and is due to population growth as well as increased per capita intake.<sup>17</sup> Greater consumption of animal-source foods has enormous implications for global climate and other environmental concerns,<sup>18</sup> including water use, carbon emissions, and land use to produce feed.<sup>19, 20</sup>

As many studies have shown, excessive intake of animal-source foods, particularly processed meats, have significant adverse effects on adult health.<sup>21</sup> Notably scholars have found that the nutrition transition, particularly the shift toward what is often called a Western diet, accounts for the growth in the animal-source food sector.<sup>22, 23</sup>

### **Sweetening of the global diet**

Few countries have dietary data on intake of added sugar. Yet with food balance data or Euromonitor commercial sales data, it is possible to document really rapid increases in consumption of sugar and SSBs.<sup>24-27</sup> For instance, Euromonitor data show that sales of SSBs in China rose from 10.2 liters per capita in 1998 to 55.0 liters per capita in 2012.<sup>28</sup> In the few countries where the patterns or trends in caloric beverage intake have been studied, levels are found to be very high. For instance, the proportion of calories from beverages in the Mexican diet is as high as that in the US diet and is rapidly growing.<sup>29, 30</sup> Susan Kleiman et al. showed that big beverage companies moved away from selling heavily sugared products in the United States to the LMIC market.<sup>25</sup> They found that the Chinese steep rate of increase in caloric intake from SSBs is matched by that in Brazil. This trend in LMICs is expected to accelerate as public pressure in higher-income countries forces these companies to market low-calorie beverages there and the companies look for new SSB outlets.

Interestingly in 1989, when the CHNS began, the added sugar intake in China was essentially nonexistent at 1 to 2 grams per capita per day (personal communication Professor Ge Keyou). However, today China has a sugar reserve to protect against large global price swings and hence to buffer against higher prices of foods and beverages with large amounts of sugar. Euromonitor data indicate that in 2012 China's caloric sweetener intake was 40 grams per capita per day.<sup>28</sup>

## Declining consumption of coarse grains and legumes

A common dietary trend monitored by CHNS research and that of scholars throughout most LMICs has been a shift toward refined grains away from coarser grains and away from nutrient-rich legumes.<sup>3, 31</sup> Some studies discuss this in the context of abandoning traditional diets for ultraprocessed, high-fat, and sugary foods,<sup>14</sup> and results have been comparable in studies of specific regions or countries.<sup>31-33</sup> Although most public health and agricultural economists see this as an adverse agricultural and dietary trend, few attempts have been made to understand it and turn it around.

## Eating Behaviors

### Shift in cooking methods

With the rapid increase in the use of vegetable oils in China has come an equally marked shift away from healthy methods of cooking, including baking, steaming, and boiling, to deep-frying and stir-frying. No other country has published patterns and trends on this issue; however, I would expect that the worldwide pattern reflects the large global increase in vegetable oil intake.

### Snacking

Almost universally the food industry has pushed to create a demand for and access to an array of snack foods. This promotion was measured in Brazil, where, as in China and some other LMICs, many of the favored snack foods are healthier than those in the United States, the United Kingdom, and other higher-income countries, where the dominant snacks have added sugar or saturated fats.<sup>34, 35</sup> In contrast studies in Brazil, Mexico, and China found consumption of a greater proportion of healthier snack foods, in particular fruit (Brazil, China and Mexico), than in the United States.<sup>36, 37</sup> Nevertheless all those countries include beverages with added sugar (e.g., SSBs, coffee with excessive added sugar) among the top snack foods along with salty, savory snacks. Brazil and Mexico have already reached high levels of snacking (over 21% of all kilocalories consumed in Brazil and 12% in Mexico at age two and older). With the major global food companies promoting snacking, we would expect to see increases in all LMICs.<sup>13</sup>

### Away-from-home consumption

This topic has received considerable recent attention in the literature. Dozens of papers from scholars in LMICs and in higher-income countries have pointed to a major shift in the last several decades. This universal change is not the result of one element, such as marketing by McDonalds and other Western fast food chains, as these chains represent a small proportion of the food consumed away from home across most LMICs. While some have noted that McDonalds, Kentucky Fried Chicken, and others were part of a change in the culture of marketing, restaurant management, and eating,<sup>38</sup> street foods have been around for a very long time.<sup>39, 40</sup> Rather this is, as noted in a recent paper from Singapore,<sup>41</sup> often just a matter of convenience; price; the increased desire to spend time in activities other than food preparation; and a set of economic, psychosocial, and broader factors affecting societies when they gain income and/or street food and food purchased away from home becomes cheaper relative to preparing food at home. In Bangkok, Thailand, most low- and middle-income citizens eat dinner in vast array of street stalls located throughout the city. For decades the nutrition and sanitation of street food in LMICs have been of concern.<sup>39</sup> However, only recently have a few countries linked street food with excessive energy intake and noncommunicable diseases (NCDs) and begun to design health-centered strategies, such as reduction of frying and added salt.<sup>41</sup>

## Modern food system

The modern food system, which encompasses packaged foods and beverages and retailer networks, is growing rapidly in China.<sup>42, 43</sup> China lags behind higher-income Asian countries and India, whose food system transition occurred in state-owned stores decades ago.<sup>44</sup> Whereas the system is expanding in India, Thailand, and China, Latin America, the Middle East, and North and South Africa moved toward food systems dominated by packaged goods earlier. As Tom Reardon and others have shown, during the 1990s the food system in Latin America shifted from fresh (wet) markets to supermarkets and smaller retail outlets, and the proportion of incomes expended on packaged foods rose from about 10% to over 60% in that decade.<sup>42, 45–47</sup> In China produce is still predominantly sold in fresh markets, and this appears to be the case in many other LMICs.<sup>48</sup> In a separate paper S. W. Ng and Elizabeth Dunford documented increases in packaged foods between 1998 and 2012 in many LMICs.<sup>49</sup>

## Physical Activity Patterns and Trends

### Patterns and consequences

The CHNS has contributed as much to the physical activity literature as to the food area. The CHNS is the only long-term survey that has measured occupational, home production, transportation, and leisure activity consistently over several decades and has also documented sedentary behaviors. Consequently studies of the unique CHNS data have documented the effects of changes in each component of activity on adult risk of obesity and other health parameters. For instance, Colin Bell examined the impact of changes in occupational activity on the risk of weight gain and also the role of active transport, like bicycle riding, versus inactive car or motorcycle driving in incident obesity.<sup>50, 51</sup> Popkin and Linda Adair led joint studies across countries as the instruments measuring child activity and some aspects of adult occupational activity (standing time, lifting, etc.) were added to Cebu and Russian cohort surveys.<sup>52–57</sup> However, this work, while useful in efforts to document the patterns and consequences of physical activity, like diet studies, did not motivate others to perform similar cohort studies. In fact significant new measurements of activity across LMICs occurred only with the development of the global physical activity questionnaire (GPAQ) in the early twenty-first century.<sup>58, 59</sup>

In general the measurement and understanding of physical activity in LMICs is weak. The CHNS and GPAQ did not stimulate major national activity monitoring until the World Health Organization (WHO) initiated the STEPwise Approach to Surveillance (STEPS) monitoring surveys early 2002–3<sup>60</sup> and the World Health Surveys in 2002–4 which were only conducted once in each country.<sup>61</sup> Several comparative studies that emerged from the CHNS detailed physical activity and inactivity data that provided the basis for parts of the Nike Access to Sports global initiative to increase physical activity.<sup>62, 63</sup> A major review of the small-scale and crude surveys of physical activity across the globe is a recent contribution.<sup>64</sup>

### Determinants

Aside from the work in China on the effects of income, urbanization, and other determinants of physical activity trends, there has been little longitudinal work in LMICs, so comparative research is lacking. A recent issue of *Lancet* was based on small-scale studies and crude data mainly from higher-income countries on determinants<sup>65</sup> with minimal review of the studies from China or other LMICs.

## Obesity

There are several unique ways the CHNS has contributed to the literature and the understanding of obesity. First and foremost, the data have contributed to understanding some of the dynamics in weight change. A number of studies have shown large increases in obesity at the upper end of the body mass index (BMI) distribution. Again the CHNS work came early, and more recently other large-scale studies have addressed this topic.<sup>66, 67</sup> Further, the CHNS has been used to and separate out age, period, and cohort effects to show that a very large cohort effect is occurring in China.<sup>68</sup> This cannot be replicated without the type of population-based cohort the CHNS represents.

Second, the CHNS work provides insights into the dynamic determinants of obesity in other countries and has opened avenues of scholarship. This is particularly the case with respect to environmental factors, such as transportation modes, food prices, and many other underlying dimensions.<sup>51, 69, 70</sup> Complex longitudinal models explore how environmental factors affect diet and activity and in turn BMI shifts.<sup>71</sup>

The role of urbanization has been a major focal point for scholars across the globe. Most of the literature has ascribed to urbanization a major role in association with obesity.<sup>72–78</sup> The CHNS not only focuses on urban-rural differences but also explores the more complex measure of urbanization and differences across the full spectrum of urbanicity.<sup>79, 80</sup> This is highlighted by most of the papers in this issue.

Third, the CHNS has contributed to the topic of the changing burden of obesity in subpopulations with lower versus higher incomes and educations. The literature on obesity among women in LMICs is large, but most of it is based on repeated cross-sectional surveys, mainly the Measure Demographic and Health Surveys.<sup>72, 81–85</sup> The only longitudinal study that shows the systematic change in the burden of obesity by socioeconomic status (SES) within a country is one using the CHNS data.<sup>86</sup>

Fourth, the CHNS records long-term patterns of weight change. Few studies have applied latent class trajectory methods to study weight change in populations undergoing modernization. Other studies that tackle trajectories have focused on overweight and obesity as opposed to weight change and have not used 20 years of data. Penny Gordon-Larsen et al. derived latent class trajectory methods in their paper in this issue and a series of forthcoming papers to examine the effects of weight trajectories on cardiometabolic risk factors (inflammation, lipids, hypertension, diabetes).<sup>87</sup>

Other important research on obesity uses longitudinal data from the exceptional set of studies of developmental origins and their effects on body composition, growth, obesity, and other cardiometabolic risk factors in the Consortium of Health-Oriented Research in Transitioning Societies (COHORTS), a group of birth cohort studies in LMICs (Brazil, Guatemala, India, the Philippines, and South Africa),<sup>88–93</sup> but there are few LMIC birth cohorts. The cohort studies provide insights into the role of early life undernutrition and future health outcomes. The CHNS is not a birth cohort, so it does not contribute to this area of research in same way. Alternatively the CHNS collects data on young children who are followed over time, allowing longitudinal follow-up and recording of early life exposures in relation to future health outcomes.

## Other Cardiometabolic Risk Factors

The cardiometabolic fasting blood measures in the CHNS were collected only recently, and studies in China and across the LMICs by notable scholars have added to our understanding.<sup>94–99</sup> After a second round of fasting blood collection and the beginning



analysis of forthcoming genome-wide analysis data, the cardiometabolic and gene-cardiometabolic research from the CHNS may turn out to be very important in incidence analysis, but for now the CHNS contribution is in its infancy.

There are two exceptions. First is the number of studies on diet and hypertension, in particular the role of sodium, potassium, and the sodium-potassium ratio. No large-scale study has measured these dietary factors so precisely and thus allowed longitudinal analyses of time to hypertension, among other outcomes.<sup>100, 101</sup> Second is the effect of urbanicity and many long-term behaviors in relation to cardiometabolic outcomes,<sup>80</sup> where many forthcoming or recent CHNS studies promise to add to the literature.

## Summary

Probably more than anything else, the CHNS has allowed this author and others to understand some of the key factors linked with the nutrition transition as viewed from the LMIC perspective. This has included urbanicity but also many other factors not discussed in detail here, such as prices; household assets; income; and other individual, household, and community measures.<sup>10, 16, 71, 102</sup> A unique feature of the CHNS is its detailed, multilevel collection of data at the community, household, and individual levels with precise dietary and physical activity measures and many other health-related behaviors and health outcomes. As a result the set of CHNS users crosses the social, behavioral, and biomedical sciences. To date 14,000 individuals have downloaded the CHNS, and many hundreds of dissertations and extensive publications have come from this public resource. This symposium highlighted some of the unique contributions of the CHNS to nutrition and did not encompass the many other areas covered by this survey in research usage spanning the globe.

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