The Nutrition Transition in High and Low-Income Countries: What are the Policy Lessons?

Barry Popkin
Shu Wen Ng

Invited paper prepared for presentation at the International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12-18, 2006

The Nutrition Transition in High and Low-Income Countries:

What are the Policy Lessons?

Barry Popkin, Professor

Departments of Nutrition and Economics, University of North Carolina

Shu Wen Ng

Department of Health Policy and Administration, School of Public Health, University of North Carolina

Mailing address:

Barry M. Popkin

Carolina Population Center

University of North Carolina at Chapel Hill

123 W. Franklin St.

Chapel Hill, NC 27516-3997

Phone: (919) 966-1732

E-mail: popkin@unc.edu

ABSTRACT

The world has seen a remarkable shift from a period when diets, activity patterns and body composition were characterized by the period termed the receding famine pattern to one dominated by nutrition-related non-communicable diseases (NR-NCDs). This presentation first examines the speed of these changes, summarizes dietary changes, and provides some sense of the way the burden of obesity is shifting from the rich to the poor not only in urban but also rural areas throughout the world. The focus is on the lower- and middle-income countries of Asia, Africa, the Middle East, and Latin America but some examples will come from the United States, Australia, and the UK. After showing that changes are occurring at great speed and at earlier stages of countries' economic and social development, the presentation shifts to some of the critical policy opportunities and some example of options. Few policy lessons exist at a macro level outside of selected countries such as South Korea and Finland. Examples of ways price policy and other options might work, using Chinese longitudinal case studies, are presented. The challenge is for the agricultural economics profession to focus on this major global issue—one which challenges some of the earlier paradigms of food policy an agricultural development.

Keywords: diet composition, price policy, economic growth, health effects

INTRODUCTION TO THE NUTRITION TRANSITION

The world is experiencing rapid shifts in structures of diet and body composition with resultant important changes in health profiles. In many ways these shifts are a continuation of large scale changes that have occurred repeatedly over time; however this paper shows that the changes facing low and moderate income countries are very rapid. Broad shifts have and continue to occur around the world in population size and age composition, disease patterns, and dietary and physical activity patterns. The former two sets of dynamic shifts are termed the demographic and epidemiological transitions. The latter, whose changes are reflected in nutritional outcomes, such as changes in average stature and body composition, is termed the nutrition transition. The developing world is seeing most rapid change in dietary and activity patterns and obesity rates. These changes are reviewed here as a first step toward laying out what is being done and can be done to address them as it relates to the economics field.

Two historic processes of change occur simultaneously with or precede the 'nutrition transition'. One is the demographic transition – the shift from a pattern of high fertility and mortality to one of low fertility and mortality (typical of modern industrialized countries). The second is the epidemiological transition, first described by Omran (Omran, 1971): the shift from a pattern of high prevalence of infectious disease, associated with malnutrition, periodic famine and poor environmental sanitation, to one of high prevalence of chronic and degenerative disease, associated with urban-industrial lifestyles (Olshansky and Ault, 1986).

The three most recent Patterns of the nutrition transition are described in more detail in Figure 1 (Popkin, 2002). In Pattern 3, famine begins to recede as income rises. In Pattern 4, changes in diet and activity pattern lead to the emergence of new non-communicable disease problems and increased disability. In Pattern 5, behavioral change begins to reverse the

negative tendencies and make possible a process of 'successful ageing' (Manton and Soldo, 1985; Crimmins, et al., 1989). Prior to these three later Patterns were earlier Patterns—the first one a Pattern of hunter-gather societies often linked with Paleolithic man and the second one coincided with the second agricultural revolution (crop rotation, fertilizer) and the Industrial Revolution when extensive famine occurred concurrently (Popkin, 1993). The changes are all driven by a range of factors, including urbanization, economic growth, technical change and culture. For convenience, the patterns can be thought of as historical developments: however, 'earlier' patterns are not restricted to the periods in which they first arose, but continue to characterize certain geographic and socio-economic sub-populations.

--- Figure 1 about here ---

DYNAMICS OF THE FOOD SYSTEM AND RELATED CHANGES

Dietary shifts: More fats, more added caloric sweeteners, more animal source foods

The diets of the developing world are shifting rapidly, particularly with respect to fats, caloric sweeteners and animal source foods (Popkin, 2002; Popkin and Du, 2003).

Edible oil:

In the popular mind, the Westernization of the global diet continues to be associated with increased consumption of animal fats. While this has certainly been true during the 1980-1975 period in the higher income world, edible oil has been a major source of dietary change in the lower and middle income countries. The recent shift in the Pattern of the nutrition transition in developing countries typically begins with major increases in the domestic production and imports of oilseeds and vegetable oils, rather than meat and milk. Elsewhere, Williams and also this author have both written in more depth about the technology behind this shift and the broader nature of these changes in both oil seed extraction technology as well as breeding of

new oil seed varieties containing more oil (Williams, 1984; Drewnowski and Popkin, 1997; Popkin and Drewnowski, 1997). Principal vegetable oils include soybean, sunflower, rapeseed, palm and groundnut oil. With the exception of groundnut oil, global availability of each has approximately tripled between 1961 and 1990.

Fat intake increases with income, but there have also been dramatic structural changes in the GNP/capita-fat relationship. These are displayed for the period 1962-90 in Figure 2. Most significantly, even poor nations had access to a relatively high-fat diet by 1990, when a diet deriving 20 percent of energy (kcal) from fat was associated with countries having a GNP of only $750 per capita. In 1962, the same energy diet (20 percent from fat) was associated with countries having a GNP of $1475 (both GNP values in 1993 dollars).

--- Figure 2 about here ---

This dramatic change arose principally from a major increase in the consumption of vegetable fats. In 1990, these accounted for a greater proportion of dietary energy than animal fats for countries in the lowest 75 percent of countries (all of which have incomes below $5800 per capita) of the per capita income distribution. The change in edible vegetable fat prices, supply, and consumption is unique because it affected rich and poor countries equally, but the net impact is relatively much greater on low-income countries.

The intake of edible oil has increased consistently over the past 15 years. In fact in some developing countries, we have documented an upwards shift in the income elasticity for all groups, and a higher one for the poor [see (Du, et al., 2004) for the China example].

Caloric sweetener:

Sugar is the world's predominant sweetener.[1] For this article, however, we use the term caloric sweetener instead of added sugar, as there is such a range of non-sugar products used today. High fructose corn syrup is a prime example as it is the sweetener used in all US soft drinks and it is increasingly being used on a worldwide basis for sweetened beverages and some baked goods (Bray, et al., 2002). There are many items in this category including a wide variety of monosaccharides (glucose and fructose) and disaccharides (sucrose and saccharose), which exist either in a crystallized state as sugar or in thick liquid form as syrups. Included in sweeteners are maple sugar and syrups, caramel, golden syrup, artificial and natural honey, maltose, glucose, dextrose, isoglucose (also known as high-fructose corn syrup), other types of fructose, sugar confectionery, and lactose. In the last several decades, increasingly larger quantities of cereals (primarily maize) have been used to produce sweeteners derived from starch.

The overall trends show a large increase in caloric sweetener consumed (see Table 1) (46). In 2000, 306 kcals were consumed per person per day, about a third more than in 1962; caloric sweeteners also accounted for a larger share of both total energy and total carbohydrates consumed (Drewnowski and Popkin, 1997).

Unsurprisingly, Table 1 shows that all measures of caloric sweetener increase significantly as GNP per capita of the country and urbanization increase. However, the interaction between income growth and urbanization is important. Figure 3 shows the relationship between the proportion of energy from different food sources and GNP, for two

[1]It is not clear exactly when sugar became the world's principal sweetener – most likely in the 17th or 18th century, as the New World began producing large quantities of sugar at reduced prices (Mintz, 1977;Galloway, 2000).

different levels of urbanization [see (Drewnowski and Popkin, 1997) for a description of the analysis]. In the less urbanized case (Panel A), the share of sweeteners increases sharply with income, from about 5 percent to about 15 percent. In the more urbanized case, the share is much higher at lower income (over 15 percent), and hardly increases with income. The analysis confirms previous observations, that people living in urban areas consume diets distinct from those of their rural counterparts (Popkin world development paper urbanization).

--- Table 1 and Figure 3 about here ---

Animal source foods:

The revolution in animal source foods (ASF) refers to the increase in demand and production of meat, fish, and milk in low-income developing countries. IFPRI's Christopher Delgado has studied this issue extensively in a number of seminal reports and papers (Delgado and Courbois, 1999; Delgado, et al., 2001; Delgado, 2003). Most of the world's growth in production and consumption of these foods comes from the developing countries. Thus, developing countries will produce 63 percent of meat and 50 percent of milk in 2020. By 2020, developing countries will consume 107 million metric tons (mmt) more meat and 177 mmt more milk than they did in 1996/98, dwarfing developed-country increases of 19 mmt for meat and 32 mmt for milk It is a global food activity, transforming the grain markets for animal feed. It also leads to resource degradation, rapid increases in feed grain imports, rapid concentration of production and consumption and social change.

Delgado (Delgado, 2003) has shown that the share of the world's meat consumed in developing countries rose from 37 to 48 percent, and their share of the world's milk rose from 34 to 44 percent. Pork and poultry accounted for 76 percent of the large net consumption increase of meat in developing countries from 1982/84 to 1996/98.

There are different developing countries who dominate consumption for different animal products. China and Brazil play this role in meat consumption while India is the key milk consumer. In the mid-1990s, Indian milk consumption amounted to 13 percent of the world's total and 31 percent of milk consumption in all developing countries (Delgado, 2003).

Aggregate meat consumption in developing countries is projected to grow by 106 million metric tons (mmt) between the late 1990s and 2020, whereas the corresponding figure for developed countries is 19 mmt. Similarly, additional milk consumption in the developed countries of 32 mmt of Liquid Milk Equivalents (LME) will be dwarfed by the additional consumption in developing countries of 177 mmt.

China Example of Dietary Changes:

Data from China are useful for summarizing these changes for a typical fast growing economy. Elsewhere we have presented in detail the overall shifts in China in depth (Du, et al., 2002; Popkin and Du, 2003). Here we just summarize these changes. The shift in the Chinese diet follows a classic Westernization pattern. First, we find that intake of cereals decreased considerably during the past two decades in both urban and rural areas and among all income groups. The relative proportion of refined rice and flour increased and coarse grains such as millet, sorghum and corn, decreased greatly.

Second, consumption of animal products increased, more so for the rich than the poor, and for urban than rural residents. The amount and growth of intake of animal foods were positively associated with income levels. The intake level and the increase in the high-income group from 1989 to 1997 were almost three times those in the low-income group (Popkin and Du, 2003; Du, et al., 2004).

Third, and partly as a result of this change, data from the CHNS also show a shift in the diet away from carbohydrates to fat. Energy from carbohydrates fell for all residents, and by over 20 percent for urban residents. Energy from fat more than doubles in the past 15 years.

Finally, when we specifically examine the combined effect of these various shifts in the structure of rural and urban Chinese diets, we find an upward shift in the energy density of the foods consumed (Popkin and Du, 2003).

Higher income country shifts: Most in-depth research on dietary shifts in higher income countries comes from in-depth studies in the US. Japan, the United Kingdom and South Korea actually have more extensive dietary data collection systems—systems that go back to the late 1940s or so. However, very little in-depth research has been carried out by scholars in any country either on national eating patterns or trends. Essentially what we know from nationally representative studies on shifts in either foods consumed or location or timing of meal patterns comes from US research. In the US, scholars have shown very large shifts in dietary behavior over time. The shifts differ by income, education and race (Popkin, et al., 1996; Popkin, et al., 2003) but generally show the following: refined food intake continues to increase, led by caloric sweeteners; meal patterning has shifted from 3 meals a day to an additional 2 meals of close to equal size that are snacks; away from home intake continues to increase rapidly in all age-race-socioeconomic status (SES) groupings; and energy intake is increasing at a time when energy expenditures are decreasing (Jahns, et al., 2001; Zizza, et al., 2001; Nielsen, et al., 2002). The biggest difference with the developing world is that there is much more heterogeneity related to these patterns in the developed world—e.g. there is little snacking or away from home intake or fast food intake in China whereas the Philippines looks more similar to the US (Adair and Popkin, 2005).

CRITICAL RELATED REDUCTIONS IN PHYSICAL ACTIVITY

Clearly, the economics profession is not very involved in address activities related to physical activity. However, shifts in physical activity are half of the reason why global obesity is increasing and a minimal understanding of these issues is useful. There are several linked changes in physical activity occurring jointly. As any economist knows, there have been large changes in the structure of employment, primarily from high energy expenditure activities such as farming, mining and forestry towards lower energy expenditure activities in the service sector. Elsewhere we have shown this large effect (Popkin, 1999). Reduced energy expenditures within the same occupation due to technological advancements are a second change. Other major changes relate to mode of transportation and activity patterns during leisure hours.

China again provides interesting illustrations. For China we have shown a major shift away from physical activity even for adults in the same occupation (Popkin, 2006). In rural areas, however, there has been a shift for some towards increased physical activity linked to holding multiple jobs and more intensive effort. For rural women, there is a shift towards a larger proportion engaged in more energy-intensive work, but there are also sections where light effort is increasing. In contrast, for rural men there is a small decrease in the proportion engaged in light work effort. These shifts in occupation have been shown to represent a major cause for the development of obesity in China (Bell, et al., 2001; Bell, et al., 2002).

In China, 14 percent of households acquired a motorized vehicle between 1989 and 1997. In one study we showed that the odds of being obese were 80 percent higher ($p<0.05$) for men and women in households which owned a motorized vehicle compared to those which did not own a vehicle (Bell, et al., 2002).

A major increasing source of leisure globally is television viewing. In China, ownership of television sets has grown to over 97 percent of the population and color TVs are now found in close to two-thirds of households. Further, TV advertising has sharply increased during the past 15 years as has Western TV programming.

OBESITY DYNAMICS: RAPID SHIFTS IN URBAN AND RURAL AREAS, SHIFT FROM UNDER TO OVERNUTRITION AND TOWARDS THE POOR

Over the past several years, the obesity story has received global attention. We present a set of figures to provide some sense of these global shifts. Figure 4A highlights the large prevalence of overweight and obesity [measured respectively by body mass index (BMI represents kg/m^2) as the standard population-based measure of overweight and obesity status. For adults, the cutoffs used to delineate overweight is a BMI of 25.0 to 29.99 and obesity is 30.0 and over] in low and middle income countries. Figure 4B shows that the rates of change in low and middle income countries are often very high (Popkin, 2002).

The urban-rural patterns of over- and under-weight are shown in Table 5 for 38 countries. All of these data come from weighted samples of nationally representative surveys of women of child bearing age in which the women's weight and height were collected (Mendez, et al., 2005). These data show that overweight status is far greater than underweight status in both urban and rural areas of most developing countries. Also it shows that urban levels of overweight are typically above those in rural areas.

---Figures 4 and 5 about here---

A separate set of studies using these same data plus for some countries data for men explored the issues of the relationships between GNP per capita, individual SES and obesity (Monteiro, et al., 2004, Monteiro, et al., 2004). In these studies, using multilevel techniques

with obesity as the outcome, it was shown that for all countries with GNP per capita above $2500 in 2005 US $ terms, there was greater obesity among women of lower SES groupings that higher ones. This was found for women but the opposite was found for men. In other work done just on trends in Brazil, Monteiro et al have shown these shifts in more depth (Monteiro, et al., 2004).

POLICY EXPERIENCES

Ideally, we would have a large number of examples from both the developing and developed world that would provide guidance related to ways to promote a reduction of obesity and related to that selection of a healthier diet with reduced caloric intake. Unfortunately, there are no national examples of reductions in obesity related to major pushed on the food or activity side at the national level. There are from the Scandanavian countries of Finland and Norway some examples of the use of macroeconomic levers to change the relative pricing of selected foods and then the linkage of these changes with positive changes in nutrition-related chronic diseases (Milio, 1990). There is also an example from South Korea of major policy options that allowed South Korea to consume a much healthier diet with major improvements in health linked with that diet (Kim, et al., 2000, Lee, et al., 2002).

The Scandinavian country that has most systematically merged health and agricultural concerns into an effective nutrition policy is Norway. Norway began to be concerned with reducing dietary fat in the 1960s and developed the Norwegian National Nutrition Policy in 1976, formally linking economic and agricultural policy with nutrition and health (Milio, 1990). The results were impressive: Norway stimulated research on breeding cows for lower-fat milk; denied consumer price subsidies when sugar import prices soared in the mid-1970s; increased consumer subsidies for skim milk more than for whole milk, for poultry more than for pork,

and for fish more than for beef; and implemented a set of producer subsidies to favor fish production over beef production. Thus research and price policy were used actively. As noted above, the results were dramatic, including a large change in the proportion of whole and reduced-fat milk, rapid increases in the consumption of poultry, and changes in the amount of edible fat and the proportion of margarine and light margarine. Norway has most markedly reduced the proportion of energy obtained from animal fats, from 29 percent in 1961 to 23 percent in 1988. The reductions in total fat of about 6 percentage points (from 41 percent to 35 percent) was observed between 1975 and 1989, with equally large declines in saturated fat (Milio, 1991).

Finland also focused on similar issues but its achievements were focused in one region and were much more community-based with minimal attention to macroeconomic factors (Puska, et al., 2002). The North Karelia Project was launched in 1972 as a community based, and later on, national program to influence diet and some other lifestyles that are crucial in the prevention of cardio-vascular diseases (CVD). The intervention focused very much on a local community organization strategy and involved local communities in a most active manner. Studies have shown a strong reduction in total fat intake, a shift away from saturated fat, and major reductions in population serum cholesterol and blood pressure levels (Puska, et al., 2002). It has also shown how ischemic heart disease mortality in a working age population has declined by 73 percent in North Karelia and by 65 percent in the whole country from 1971 to 1995.

South Korea provides a unique example of the good things a country can do to preserve the healthful elements of its traditional cuisine. A combination of large-scale training of housewives in preparation of the traditional low fat, high vegetable cuisine coupled with strong

social marketing have led to very low fat and high vegetable intake levels (Kim, et al., 2000; Lee, et al., 2002). Obesity is considerably below that expected for a country with its high income level as is the percentage of energy from fat. The relationship between GNP per capita and dietary fat intake was studied for 121 countries. From these studies, we expected that in 1996 the proportion of energy from fat in the Republic of Korea would be 35.5 percent. The actual percentage of energy from fat was 16.7 percentage points less than this expected level. Given the fat intake level in 1996, we calculated that the GNP should be US$ 311. If we estimate food disappearance data for the Republic of Korea, based on the data on which this relationship was calculated in both the studies, we would predict that, in the Republic of Korea, the food disappearance intake of fat as a percentage of energy would be 13.5 percentage points more in 1996 than we actually found. Further similar analyses for GNP and obesity show that obesity levels were also much lower than may be expected given the Republic of Korea's economic development level compared with other Asian countries, let alone most western countries (Kim, et al., 2000).

A few lower income countries have made some initial forays into large-scale prevention activities related to obesity and nutrition-related non-communicable diseases. This includes both China and Brazil, however in both cases there is little evidence of any impact of these early efforts (Coitinho, et al., 2002; Zhai, et al., 2002).

The role for Agricultural economics: price policy

There are several major issues that directly could involve the agricultural economics sector. One is understanding and measuring the vast array of ways that government spending—be it on research or direct subsidies and other mechanisms, affects the relative prices of healthier and unhealthier foods. Second, is to understand how shifts in the relative prices of a

vast array of foods will change overall diet. The latter would involve studying the direct and cross price elasticities and the ways they affect food and nutrient intake patterns. There are many issues that can utilize economic analysis from demand studies to ways to use pricing and regulations to shift portion sizes and other eating behaviours toward more healthful ones.

A central issue affecting the world's public health is the need to shift the relative prices of a range of foods to encourage healthier, less energy dense and more nutrient dense foods. A second key issue is figuring out ways to affect to reduce caloric intake while not adversely affecting the poor's nutritional status. These are quite related issues that this author has examined once for China (Guo, et al., 1999; Guo, 2000) and will present a brief example here of ongoing research on this topic.

One of the items in the diet that has increased most rapidly in China and many other developing countries is edible oil intake (Drewnowski and Popkin, 1997; Du, et al., 2002). A sizable proportion of the total energy increase over the past several decades for Asian, Middle Eastern and African countries has come from this commodity.

China Edible Oil Case Study

Background:

Edible oil was strictly controlled as a key commodity during the period up to 1991 by the Chinese government. In May 1991, the price of grain and edible oil on ration was readjusted by a large margin for the first time since the mid-1960s. The price of grain was raised by 70 percent, and the price of edible oil almost doubled. The government also released supplies previously unseen in China, resulting in demand and consumption increasing significantly during this period (Popkin, et al., 1993; Du, et al., 2002). By 1992, governmental control over price of edible oil was lifted across the country. To lessen the impact of the rise in

costs on the population's living standard, the government provided subsidies on certain non-staple food to urban residents. In addition, in 1996, state-own enterprises (SOEs) were exempted from value-added tax (VAT) when selling oil (Qian, 2000).

The most recent development is China's accession into World Trade Organization (WTO) in 2006. This resulted in the elimination of a quota on sunflower, peanut and corn oil, in place of a 10 percent tariff, as well as a phasing out tariff quota for soy oil in January 2006 (Agri-Canada., 2002). In addition, the supply of domestic oil production has been rising, especially for rapeseed and soy, with improved technology (in seed crushing and processing). There has been enormous rationalization of the Chinese production sector—employment is dropping significantly and larger, much more capital-intensive modern production facilities are emerging.

Data:

All of these signal general declines in oil prices to approach international market prices, and might have implications on consumer demand. Table 3 presents consumption data for adults aged 20-45 for the 1989-2004 period. These data come from the nine-province China Health and Nutrition Survey (CHNS), the source of many China examples in this paper. Three days of weighed household edible oil along with daily 24-hour recalls are used for this analysis. The design of the survey, the diet methodology and other measurement are presented elsewhere (Zhai, et al., 1996; Guo, 2000; Popkin, et al., 2002; Du, et al., 2004). The CHNS data, available free on the web, are a longitudinal survey of about 16,000 individuals with data collected from over 200 communities in 1989, 1991, 1993, 1997, 2000, 2004 and 2006.This analysis focuses on adults between 20 and 45 years old surveyed over the 1989-2000 period.

Prices were collected in a systematic manner from each community surveyed. The key

independent variable of interest is the price of edible oil. Two approaches were used to create an oil price. One option used the cheapest edible oil sold in each community. The second created a weighted price linked with the oils consumed in each region. Since there are a variety of edible oils consumed in China, this analysis matched available edible oil prices and regional consumption patterns from the 1992 China Nationwide Nutrition Survey (CMPH, 1994), to create a weighted edible oil price. Other prices included in the modelling were for key common food groupings: rice, flour, chicken, eggs, fatty pork and the cheapest retail coarse grain for each community (among corn, millet, and sorghum).

Household income was approximated from the survey through responses to direct questions about income and through the summation of net receipts from all reported activities. This detailed estimation of income represents a significant advance in the measurement of income in China, allowing the inclusion of non-monetary government subsidies, such as state-subsidized housing. This study will include all cash and non-cash income components, except food subsidies.

Price and income variables were deflated by year- and province-specific consumer price indices developed for urban and rural areas (CPI) (SSB, 1990; SSB, 1992; SSB, 1994; SSB, 1998; SSB, 2001; SSB, 2005). The use of real deflated values in the analyses will remove the effect of inflation and allow the analysis to focus on the effect of the increase in real price and real income. The 1980 CPI was used as the baseline to deflate the nominal values for urban and rural consumers by province.

Other household level variables include household size, whether the household resides in a community with an urban designation and region of residence. The measurement of region was developed by the World Bank in collaboration with the SSB (World Bank, 1995), reflecting

contiguous groupings with comparable income levels. With respect to agricultural economics and food behavior, samples were regrouped into three regions: the South Hinterland (Guezhou, Guangxi, Hunan); the Central Core (Henan, Hubei, Jingsu); and the North (Liaoning, Heilongjiang, Shangdong).

Individual level data controlled for in the models include age, gender and education. Age and number of years of education are continuous variables and gender is a dichotomous variable. In addition, year dummies were included to account for possibly time trends.

Estimation:

Our focus is on the estimation of own-price and cross-price elasticites in a rigorous manner. In our specifications, all models include time, region, household income, food prices, age, gender, education, urban residency, household size and interactions between edible oil price with time dummies and interactions between edible oil price with income tertiles as control variables. All estimations were also clustered at the household level due to possibility of having multiple adults within each household, and hence related error terms across observations. Alternative specification explored included using income as a continuous variable together with the square of household income, as well as different interaction terms between income, region, prices and time.

This analysis presents the estimation of only the proportion of energy from fat, protein and carbohydrate. We use two sets of estimations. The first is based on percent of energy from protein, fats and carbohydrates and is constrained such that they always sum to 100%. Therefore, the sum of the coefficients across the 3 dependent variables should always be zero. The second set of estimation looks at elasticities.

For ease of interpretation, we derived predictions on macronutrient consumption to estimate the effect of a 10 percent increase in the price of the cheapest oil in the community on the average consumption decisions of adults in China. In addition, we derived predictions by income tertiles to see what differences in consumption decisions due to changing edible oil prices might exist.

RESULTS:

Results from using the two oil prices, were generally similar, except for some slight differences in significance for the effects of other food prices on energy from fat and carbohydrates. We only present the estimation results from using the cheapest oil price available to each community (Table 4) because the results appear more stable. We can see that there is a relationship between the real price of the cheapest edible oil, the percentage of energy from fat (strongly negative) and the percentage of energy from carbohydrates (strongly positive). This suggests substitution for fats with carbohydrates as the price of edible oil increases. Meanwhile, there is little change in consumption of proteins.

The results are consistent across the two sets of estimations, and show that there are strong negative elasticities between the demand for energy from protein and the real price of flour and eggs, while there are positive elasticities between this outcome and the real prices of rice and fatty pork. It also appears consistent across the various macronutrient that flour and rice are substitutes. Moreover, income appears to have a strong affect on macronutrient composition, as were region, education, urban residency and gender.

--- Table 4 about here ---

To understand the full effect of increasing the price of oil, we ran simulations, and they are shown in Figures 7A and 7B. Figure A shows the predicted change in the composition of

energy due to a 10 percent increase in the real weighted price of edible oils for all observations and also for those in the rich and poor tertiles. The poor are more price responsive in reducing their consumption of fats and possibly substituting by increasing their carbohydrate and protein intake as a proportion of total energy consumed. Figure 7B illustrates the change in demand for percent of energy from protein, fats and carbohydrates due to a 10 percent increase in the real prices of edible oil. Again, the elasticity is large and negative for fats and small and positive for carbohydrates and proteins.

--- Figure 7 about here ---

DISCUSSION

The agricultural economics profession has done little to examine policy options as they relate to the remarkable shift in diet, activity and body composition toward a pattern of the transition linked with non-communicable diseases. Obesity is the norm globally and undernutrition, while still important in a few countries and in targeted populations in many others, is no longer the dominant disease. While there are great disputes and limited understanding of the full set of economic, technological and other factors that explain this transition, the reality is that globally far more obesity than undernutrition exists and the rates of change for the former are large and positive while those of the latter are negative. The first part of this paper essentially uses a combination of multi-country studies, ecological data plus some case studies from China and a few other countries to layout the nature of the shifts underway.

The issue of policy options is really quite complex. There is little knowledge on the role of major macro mechanisms which must be an element in our arsenal to shift demand and supply toward a healthier food supply and reduced total energy intake. The example from China is an important one. It shows that a situation where price changes are used against one element in the

diet which contributes fairly adversely to health can be reduced in intake. By examining total direct and cross elasticities and looking here just at the overall effect on energy from fat, protein and carbohydrates, we gain insights into this option for China and can see the potential power embedded in the vast array of subsidies and credit and price shifts currently used in most countries. Essentially if China used taxation or other policies to increase the price of edible oils, one would see a shift away from fat [each gram of which contains 9 calories of energy], a bit away from protein (4 calories per gram) and toward carbohydrates (4 calories per gram).

The effect of price policies and many other regulations need much more careful exploration prior to our being able to undertake massive shifts of a healthy nature in the structure of diet. Many other mechanisms available to the economic sector must be rigorously explored. This area is really one relatively ignored by the profession but one deserving of much more research.

REFERENCES

Adair, L.S., Popkin, B.M., 2005. Are child eating patterns being transformed globally? Obes. Res. 13, no. 7, 1281-1299.

Agri-Canada., 2002. China's Vegetable Oil Industry, from http://atn-riae.agr.ca/asia/e3282.htm.

Bell, A.C., Ge, K., Popkin, B.M., 2001. Weight gain and its predictors in Chinese adults. Int. J. Obes. Relat. Metab. Disord. 25, no. 7, 1079-1086.

Bell, A.C., Ge, K., Popkin, B.M., 2002. The road to obesity or the path to prevention: motorized transportation and obesity in China. Obes. Res. 10, no. 4, 277-283.

Bray, G.A., Nielsen, S.J., Popkin, B.M., 2002. High fructose corn sweeteners and the epidemic of obesity. Am. J. Clin. Nutr. 79, no 4, 537-543.

CMPH. Report of the 1992 China National Nutrition and Health Survey. 1994 (in Chinese).

Coitinho, D., Monteiro, C.A., Popkin, B.M., 2002. What Brazil is doing to promote healthy diets and active lifestyles. Public Health Nutr. 5, no. 1A, 263-267.

Crimmins, E.M., Saito, Y., Ingegneri, D., 1989. Changes in life expectancy and disability-free life expectancy in the United States. Pop. Devel. Rev. 15, 235-267.

Delgado, C.L., Rosegrant, M., Steinfield, H., Ehui, S., Courbois, C., 1999. Livestock to 2020: The Next Food Revolution. International Food Policy Research Institute.

Delgado, C.L., Rosegrant, M., Meijer, S., 2001. Livestock to 2020: The Revolution Continues. Auckland, New Zealand.

Delgado, C.L., 2003. A food revolution: rising consumption of meat and milk in developing countries. J. Nutr. 133, no. 11 Suppl 2, 3907S-3910S.

Drewnowski, A., Popkin, B.M., 1997. The nutrition transition: new trends in the global diet. Nutr. Rev. 55, no. 2, 31-43.

Du, S., Lu, B., Zhai, F., Popkin, B.M., 2002. The nutrition transition in China: a new stage of the Chinese diet. Caballero, B., Popkin, B.M. (Eds.). London, Academic Press, pp. 205-22.

Du, S., Mroz, T.A., Zhai, F., Popkin, B.M., 2004. Rapid income growth adversely affects diet quality in China--particularly for the poor! Soc. Sci. Med. 59, no. 7, 1505-1515.

Galloway, J.H., 2000. Sugar. In: Kiple, K.F., Ornelas, K.C. (Eds.) The Cambridge World History of Food. Vol. I, Cambridge University Press, New York, pp. 437-49.

Guo, X., Popkin, B.M., Mroz, T.A., Zhai, F., 1999. Food price policy can favorably alter macronutrient intake in China. J. Nutr. 129, no. 5, 994-1001.

Guo, X., Mroz, T.A., Popkin, B.M., Zhai, F., 2000. Structural changes in the impact of income on food consumption in China, 1989-93. Econ. Dev. Cult. Change. 48, 737-760.

Jahns, L., Siega-Riz, A.M., Popkin, B.M., 2001. The increasing prevalence of snacking among US children from 1977 to 1996. J. Pediatr. 138, no. 4, 493-498.

Kim, S., Moon, S., Popkin, B.M., 2000. The nutrition transition in South Korea. Am. J. Clin. Nutr. 71, no. 1, 44-53.

Lee, M.J., Popkin, B.M., Kim, S., 2002. The unique aspects of the nutrition transition in South Korea: the retention of healthful elements in their traditional diet. Public Health Nutr, 5, no. 1A, 197-203.

Manton, K.G., Soldo, B.J.,1985. Dynamics of health changes in the oldest old: new perspectives and evidence. Milbank Mem. Fund. Q. Health Soc. 63, no. 2, 206-285.

Mendez, M.A., Monteiro, C.A., Popkin, B.M., 2005. Overweight exceeds underweight among women in most developing countries. Am. J. Clin. Nutr. 81, no. 3, 714-721.

Milio, N., 1990. Nutrition policy for food-rich countries: a strategic analysis. The Johns Hopkins University Press, Baltimore.

Milio, N., 1991. Toward health lessons in food and nutrition policy development from Finland and Norway longevity. Scand. J. Soc. Med. 19, no. 2, 209-217.

Mintz, S., 1977. Time, sugar, and sweetness. In: Counihan, C., Van Esterik, P. (Eds.), Food and Culture: A Reader. Routledge, New York, pp. 357-369.

Monteiro, C.A., Conde, W.L., Lu, B., Popkin, B.M., 2004.Obesity and inequities in health in the developing world. Int. J. Obes. Relat. Metab. Disord. 28, no. 9, 1181-1186.

Monteiro, C.A., Conde, W.L., Popkin, B.M., 2004. The burden of disease from undernutrition and overnutrition in countries undergoing rapid nutrition transition: a view from Brazil. Am. J. Public Health 94, no. 3, 433-434.

Monteiro, C.A., Moura, E.C., Conde, W.L., Popkin, B. M., 2004. Socioeconomic status and obesity in adult populations of developing countries: a review. Bull. World Health Organ. 82, no. 12, 940-946.

Nielsen, S. J., Siega-Riz, A.M., Popkin, B.M., 2002. Trends in energy intake in U.S. between 1977 and 1996: similar shifts seen across age groups. Obes Res 10, no. 5, 370-378.

Olshansky, S.J., Ault, A.B., 1986. The fourth stage of the epidemiologic transition: the age of delayed degenerative diseases. Milbank Q. 64, no. 3, 355-391.

Omran, A.R., 1971. The epidemiologic transition. A theory of the epidemiology of population change. Milbank Mem. Fund. Q. 49, no. 4, 509-538.

Popkin, B., 1993. Nutritional patterns and transitions. Pop. Devel. Rev. 19, no. 1, 138-157.

Popkin, B.M. Keyou, G., Zhai, F., Guo, X., Ma, H., Zohoori, N., 1993. The nutrition transition in China: a cross-sectional analysis. Eur. J. Clin. Nutr. 47, no. 5, 333-346.

Popkin, B.M., Siega-Riz, A.M., Haines, P.S., 1996. A comparison of dietary trends among racial and socioeconomic groups in the United States. N. Engl. J. Med. 335, no. 10, 716-720.

Popkin, B., Drewnowski, A., 1997. Dietary fats and the nutrition transition: New trends in the global diet. Nutr. Rev. 55, 31-43.

Popkin, B.M., 1999. Urbanization, lifestyle changes and the nutrition transition. World Dev. 27, 1905-1916.

Popkin, B.M., 2002. An overview on the nutrition transition and its health implications: the Bellagio meeting. Public Health Nutr. 5, no. 1A, 93-103.

Popkin, B.M., 2002. The shift in stages of the nutrition transition in the developing world differs from past experiences! Public Health Nutr. 5, no. 1A, 205-214.

Popkin, B.M., Lu, B., Zhai, F., 2002. Understanding the nutrition transition: measuring rapid dietary changes in transitional countries. Public Health Nutr. 5, no. 6A, 947-953.

Popkin, B. M., Du, S., 2003. Dynamics of the nutrition transition toward the animal foods sector in China and its implications: a worried perspective. J. Nutr. 133, no. 11 Suppl 2, 3898S-3906S.

Popkin, B.M.,Zizza, C., Siega-Riz, A.M., 2003. Who is leading the change?. U.S. dietary quality comparison between 1965 and 1996. Am. J. Prev. Med. 25, no. 1, 1-8.

Popkin, B.M., In press. Global nutrition dynamics: the world is shifting rapidly toward a diet linked with noncommunicable diseases (NCDs). Am. J. Clin. Nutr.

Puska, P., Pirjo, P., Uusitalo, U., 2002. Influencing public nutrition for non-communicable disease prevention: from community intervention to national programme- experiences from Finland. Public Health Nutr. 5, no. 1A, 245-251.

Qian, Y.-Y., Wu, J.-L., 2000. China's Transition to a Market Economy: How Far across the River? Stanford University, Palo Alto, CA

SSB., 1989. Statistical Yearbook for China.

SSB., 1991. Statistical Yearbook for China. State Statistical Bureau of China.

SSB., 1993. Statistical Yearbook for China.

SSB., 1997. Statistical Yearbook for China.

SSB., 2000. Statistical Yearbook for China.

SSB., 2004. Statistical Yearbook for China.

Williams, G.W., 1984. Development and future direction of the world soybean market. Q. J. Int. Agr. 23, 319-337.

World Bank. China regional disparities. World Bank.

Zhai, F., Guo, X., Popkin, B., Ma, L., Wang, Q., Yu, W., Jin, S., Ge, K., 1996. Evaluation of the 24-hour individual recall method in China. Food Nutr. Bull. 17, 154-161.

Zhai, F., Fu, D., Du, S., Ge, K., Chen, C., Popkin, B.M., 2002. What is China doing in policy-making to push back the negative aspects of the nutrition transition? Public Health Nutr. 5, no. 1A, 269-273.

Zizza, C., Siega-Riz, A.M., Popkin, B.M., 2001. Significant increase in young adults' snacking between 1977-1978 and 1994-1996 represents a cause for concern! Prev. Med. 32, no. 4, 303-310.

Table 1 World Trends in Caloric sweetener intake for GNP and Urbanization Quintiles (1962 values)

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	Total
A. Quintiles of GNP (using 1962 GNP levels for each country)						
Caloric sweetener (kcal/capita/day)						
1962	90	131	257	287	402	232
2000	155	203	362	397	418	306
Total Energy (kcal/capita/day)						
1962	2008	2090	2157	2411	2960	2322
2000	2346	2357	2716	2950	3281	2725
B. Quintiles of % Urban (using the 1962 values for % urban for each country)						
Caloric sweetener (kcal/capita/day)						
1962	79	131	236	335	389	232
2000	151	201	339	403	441	306

Source: Popkin and Nielsen (46); Food and Agriculture Organization FAOSTAT data set for food balance data

Table 2. Shifts in energy sources in Chinese diet, for adults aged 20 to 45 years

	Received more than 10% energy from animal source food (%)				
	1989	1991	1993	1997	2000
Urban	49.8	55.8	59.8	57.2	62.0
Rural	33.3	34.8	37.6	37.6	44.0
Low-income	26.2	28.9	28.7	27.1	35.4
Mid-income	42.8	42.9	45.3	42.4	51.3
High-income	47.8	52.4	61.5	61.6	60.7
Total	**38.8**	**41.2**	**43.9**	**43.5**	**49.4**

Table 3. Shift in edible oil consumption in the Chinese diet (China Health and Nutrition Study, 1989-2004) for adults, ages 20 to 45. (Mean intake grams/per capita/per day)

Edible oil	Urban	Rural	Low Income	Mid Income	High Income	Total
1989	17.2	14.0	12.9	15.8	16.4	15.0
1991	23.9	22.6	19.1	23.0	26.5	23.0
1993	27.6	23.0	22.3	24.1	26.7	24.3
1997	31.8	27.8	26.4	29.5	31.2	29.0
2000	33.5	31.4	30.9	32.1	33.3	32.0

Table 4. Coefficient Estimates from random effects models clustered at household level using cheapest oil price.

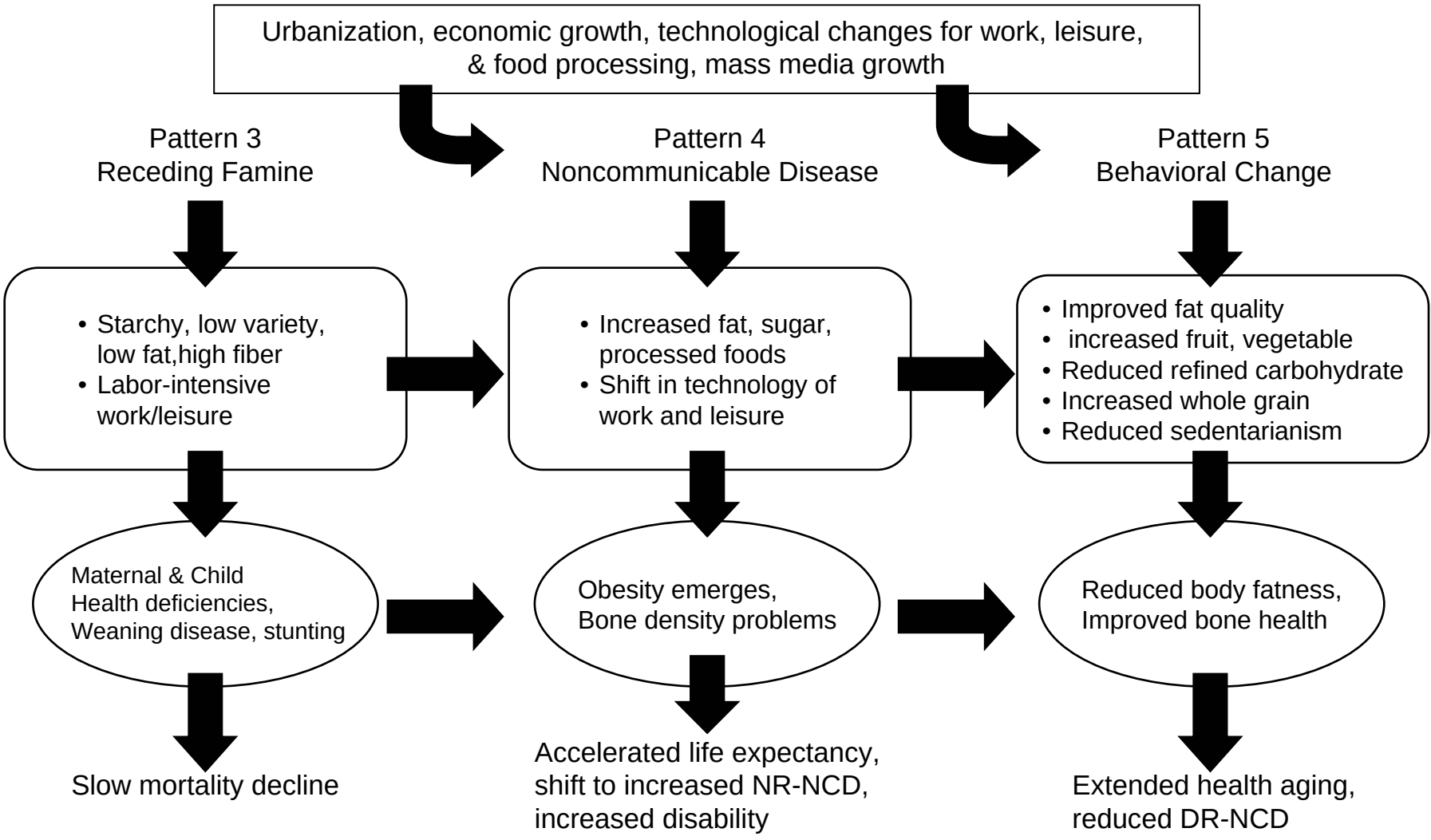
N=21,389	**%energy from protein**	**%energy from fat**	**%energy from carbs**	**log % energy from protein**	**log % energy from fat**	**log % energy from carbs**
log real weighted oil price	0.36	-5.71 **	5.35 **	0.02	-0.43 **	0.08 **
log real wgt oil price*1991	0.40	-9.26 **	8.85 **	0.05	-0.52 **	0.13 **
log real wgt oil price*1993	0.84	-3.02	2.18	0.09 **	0.02	0.06
log real wgt oil price*1997	1.70 **	-2.64 **	0.95	0.17 **	0.09	0.04
log real wgt oil price*2000	0.12	-1.46	1.34	0.05 *	0.09	0.05
log real wgt oil price*medium income	-0.40 **	0.88	-0.49	-0.03	0.14 **	0.01
log real wgt oil price*high income	-0.79 **	1.86 **	-1.06	-0.06 **	0.21 **	0.01
1991	-0.13	6.08 **	-5.95**	-0.01	0.42 **	-0.07
1993	-0.86	2.08	-1.22	-0.10 *	-0.11	-0.05
1997	-1.68 **	0.48	1.18	-0.17 **	-0.23 *	-0.01
2000	0.55	1.24	0.69	0.01	-0.23 *	-0.002
Medium income tertile	0.71 **	2.46 **	-3.17 *	0.05 *	-0.001	-0.07 **
High income tertile	1.72 **	4.51 **	-6.24 **	0.13 **	0.05	-0.14 **

N=21,389	**%energy from protein**	**%energy from fat**	**%energy from carbs**	**log % energy from protein**	**log % energy from fat**	**log % energy from carbs**
North	0.43 **	-5.00 **	4.57 **	0.04*	-0.21 **	0.09 **
Central	0.03	-3.34 **	3.31 **	0.01	-0.15 **	0.06 **
log real price rice	0.43 **	-1.29 *	0.86 *	0.04 **	-0.08 **	0.01
log real price flour	-2.09 **	1.16	0.92	-0.18 **	0.04	0.02
log real price eggs	-0.11 **	-0.17	0.27 *	-0.01	0.02	0.01 *
log real price fat pork	2.78 **	-2.87 **	0.10	0.24 **	-0.10 *	0.01
log real price cheap grain	-0.01	-0.78	0.80	-0.001	-0.05 *	0.01
Age (years)	-0.002	0.04 **	-0.04 *	-0.0003	0.001	-0.001 **
Household size	0.03	-0.78 **	0.75 **	0.003	-0.04 **	0.01 **
Education (years)	0.06 **	0.42 **	-0.48 **	0.005 **	0.02 **	-0.01 **
Male	-0.05 *	-1.33 **	1.38 **	-0.004	-0.06 **	0.02 **
Urban	0.80 **	2.24 **	-3.03 **	0.07 **	0.11 **	-0.05 **
Constant	4.99 **	37.91 **	57.11 **	1.86 **	3.81 **	4.01 **
R-square	0.10	0.22	0.25	0.09	0.23	0.21

** denotes significance at the 1% level; * denotes significance at the 5% level

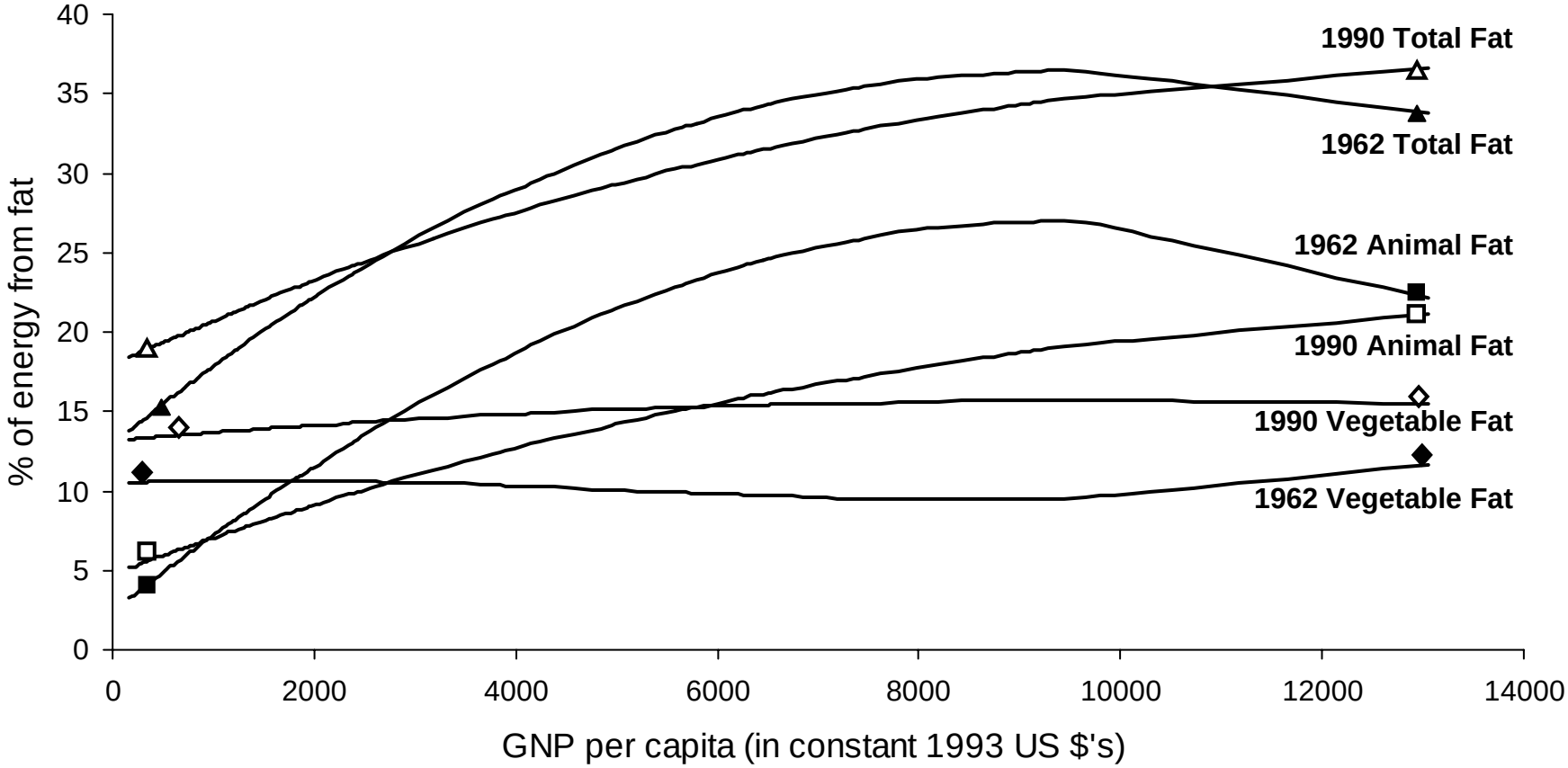
Reference categories for year is 1989; for income tertile is poor; and for region is South.

Figure 1. Stages of the Nutrition Transition



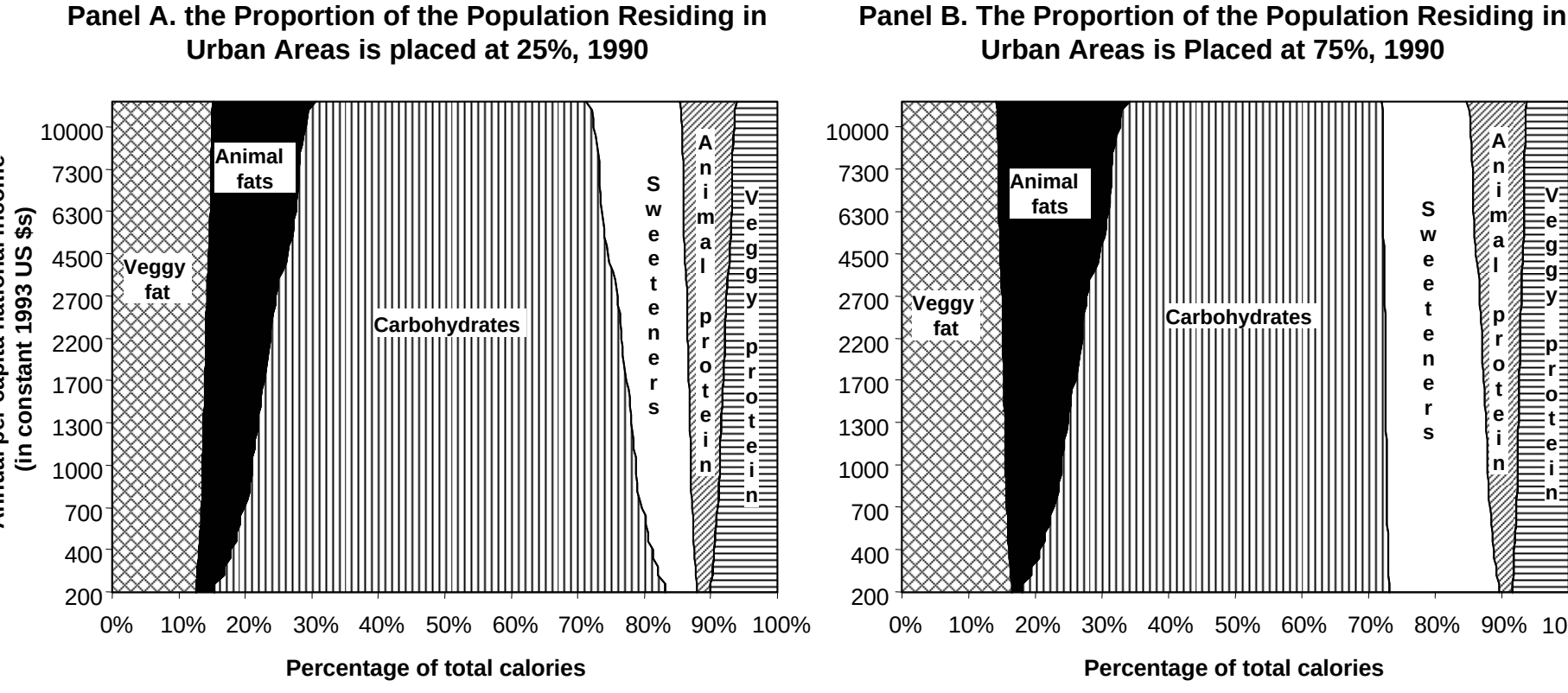
Source: Popkin, Barry M. (83): Owns copyright

Figure 2. Relationship Between the Percentage of Energy from Fat and GNP Per Capita, 1962 and 1990



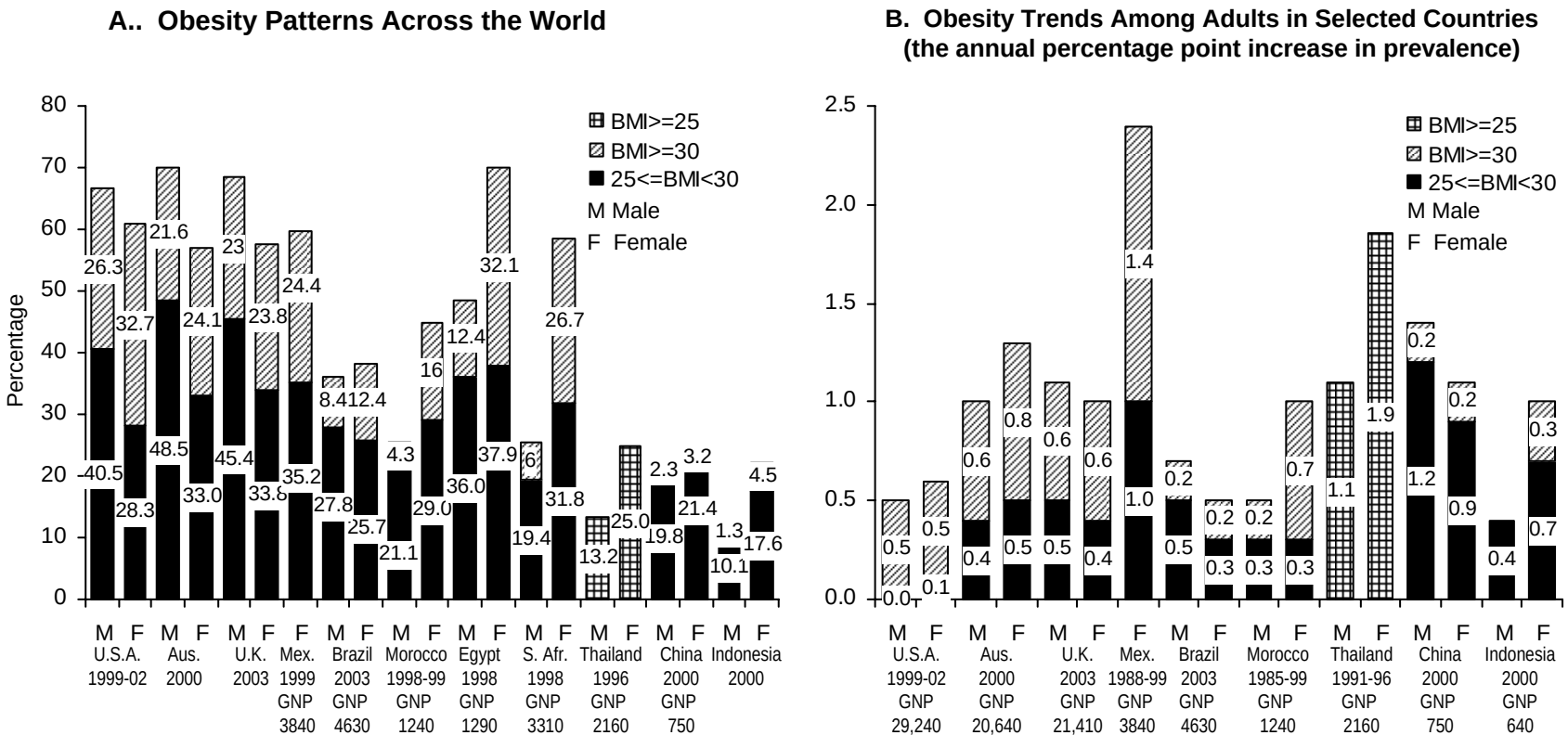
Source: Nonparametric regressions run with food balance data from Food and Agricultural Organization of the United Nations and the GNP data is from the World Bank for 134 countries. Guo (84): Reprinted with the permission of Econ Dev & Cultural Change.

Figure 3. Relationship Between the Proportion of Energy From Each Food Source and Gross National Product Per Capita and Urbanization



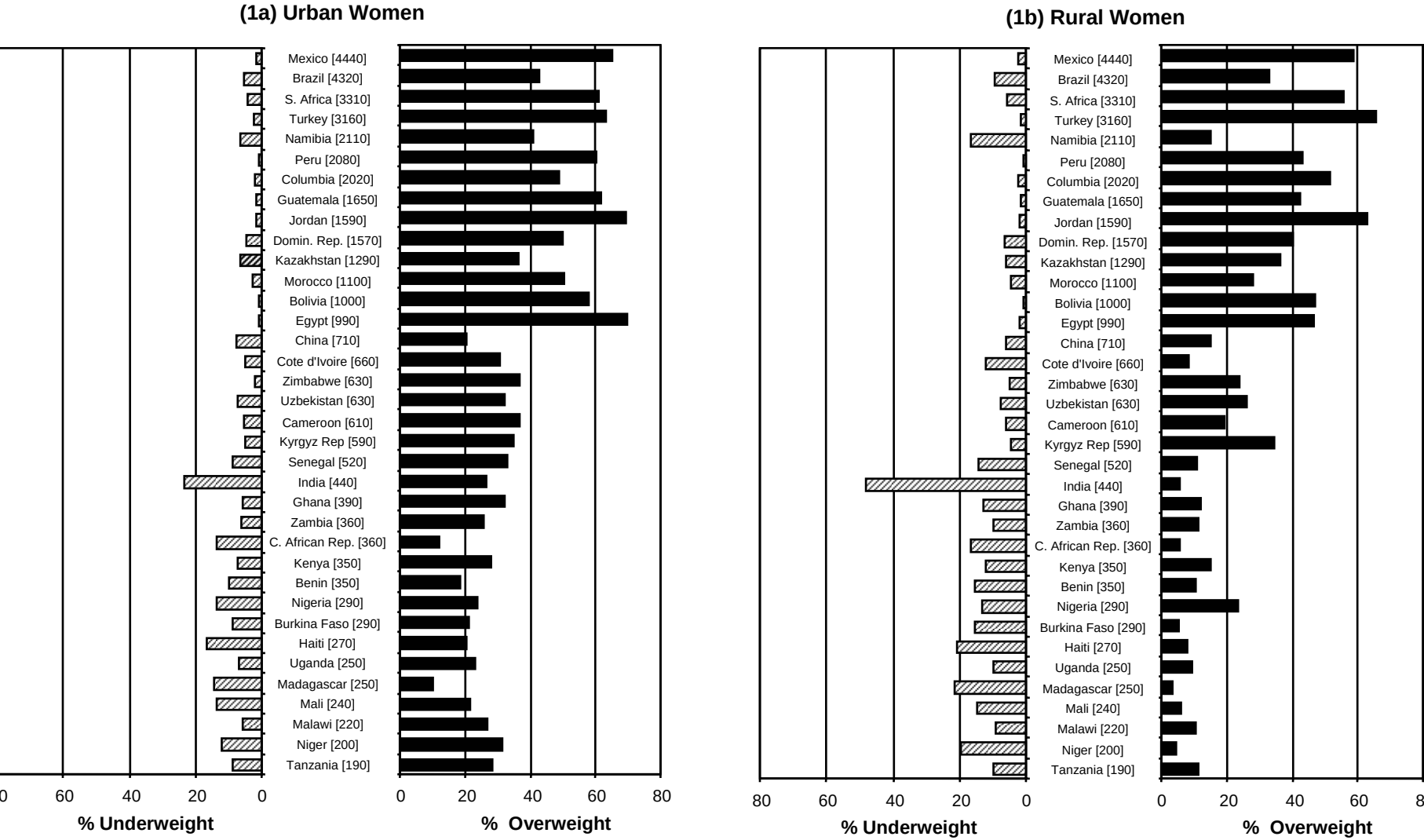
Source: Drewnowski & Popkin (14); Food balance data from the FAOUN; GNP data from the World Bank; regression work by UNC-CH

Figure 4. Global Obesity Patterns and Trends



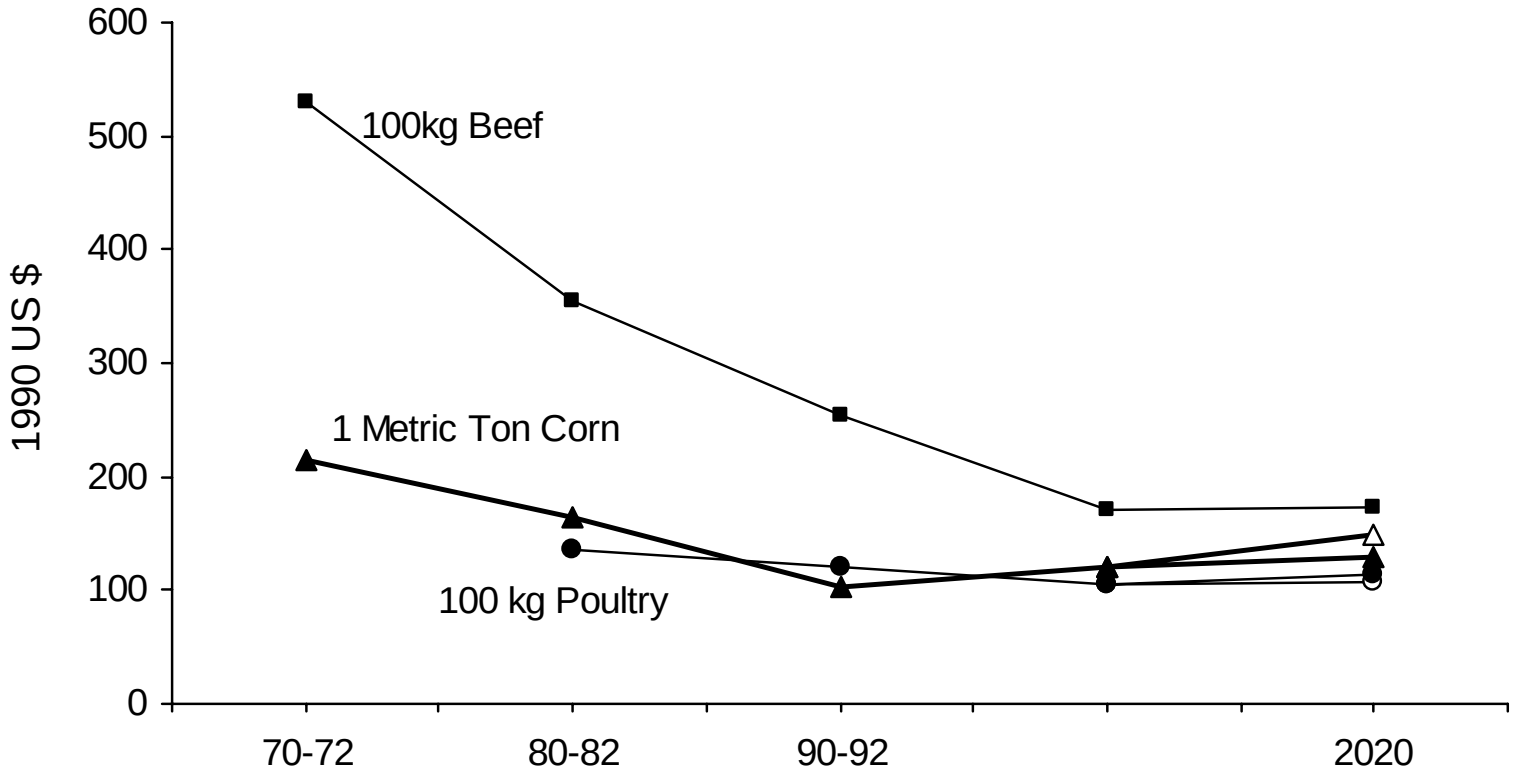
Source: Popkin, Barry M. (83): Owns copyright GNP stands for Gross National Product Per Capita

Figure 5: Overweight and Underweight Prevalence in Women 20-49y in 36 Developing Countries Ranked by Gross National Income (GNI) Per Capita



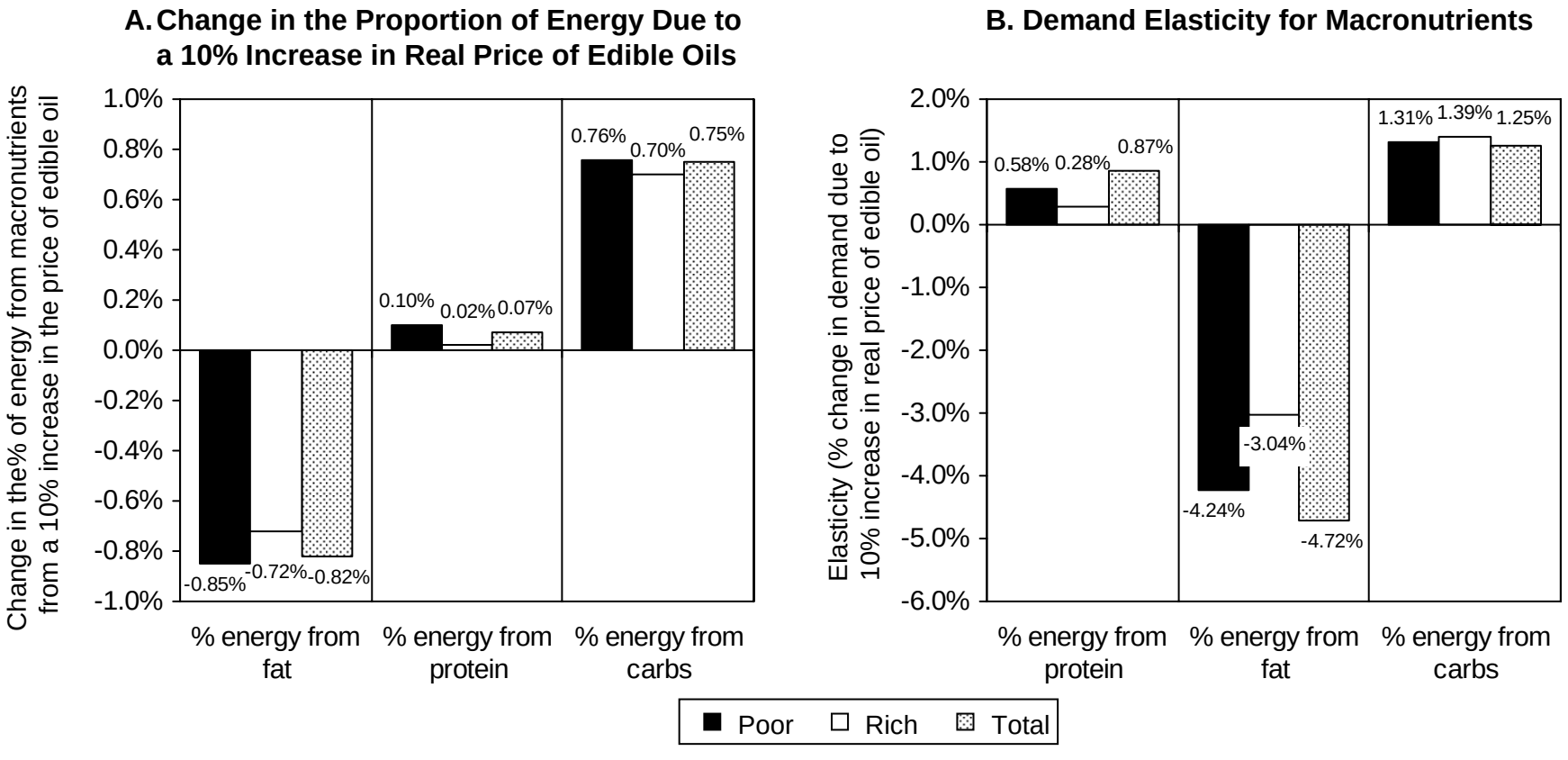
Overweight = BMI ≥25; underweight = BMI <18.5.
Source: Mendez et al : Reprinted with permission of AJCN.

Figure 6. Real World Prices, 1990 US $



AIDS Demand Models Various Sources Cited in Delgado & Courbois (58).
Reprinted with the permission of the authors

Figure 7. The Effects of Changes in the Price of Edible Oil



Source: China Health and Nutrition Surveys 1989,1991,1993,1997,2000