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# Trends in Diet, Nutritional Status, and Diet-related Noncommunicable Diseases in China and India: The Economic Costs of the Nutrition Transition

Barry M. Popkin, Ph.D., Susan Horton, Ph.D., Soowon Kim, M.S., Ajay Mahal, Ph.D., and Jin Shuigao, Ph.D.



*Undernutrition is being rapidly reduced in India and China. In both countries the diet is shifting toward higher fat and lower carbohydrate content. Distinct features are high intakes of foods from animal sources and edible oils in China, and high intakes of dairy and added sugar in India. The proportion of overweight is increasing very rapidly in China among all adults; in India the shift is most pronounced among urban residents and high-income rural residents. Hypertension and stroke are relatively higher in China and adult-onset diabetes is relatively higher in India. Established economic techniques were used to measure and project the costs of undernutrition and diet-related noncommunicable diseases in 1995 and 2025. Current WHO mortality projections of diet-related noncommunicable diseases, dietary and body composition survey data, and national data sets of hospital costs for healthcare, are used for the economic analyses. In 1995, China's costs of undernutrition and costs of diet-related noncommunicable diseases were of similar magnitude, but there will be a rapid increase in the costs and prevalence of diet-related noncommunicable diseases by 2025. By contrast with China, India's costs of undernutrition will continue to decline, but undernutrition costs did surpass overnutrition diet-related noncommunicable disease costs in 1995. India's rapid increase in diet-related noncommunicable diseases and their costs projects similar economic costs of undernutrition and overnutrition by 2025.*

Dr. Popkin and Ms. Kim are with the Department of Nutrition, University of North Carolina, Chapel Hill, NC 27516-3997, USA. Dr. Horton is with the Centre for International Studies, University of Toronto, Toronto, M5S 3K7, Canada. Dr. Mahal is with the School of Public Health, Harvard University, Cambridge, MA 02115, USA. Dr. Shuigao is with the Chinese Academy of Preventive Medicine, Beijing, China 100050.

## Introduction

The dietary structure, levels of physical activity, obesity, and diet-related noncommunicable disease (DR-NCD) patterns are changing rapidly throughout the developing world. China and India, the two most populated nations in the world, reflect many of these changes. Both have achieved remarkable economic progress in recent decades, China more so than India. At the same time, large numbers of people continue to live in conditions of extreme economic deprivation. Both China and India have experienced rapid urbanization, but are still predominantly rural societies. Whereas their economic and nutritional transitions are different, both face comparable rapid increases in DR-NCD problems, albeit manifested in different ways. This article documents the important shift in the burden of disease from problems of dietary deficit to problems of dietary excess in each country, and examines the shift in economic costs linked with this transition.

China is one of the world's most rapidly growing economies, having achieved, from 1978 to 1997, the large annual average rate of growth of real gross domestic product (GDP) per capita of 8.5% (authors' calculations using International Monetary Fund, 1999).[1] At this rate of growth, China has achieved major advances in living standards for its huge 1.26 billion population in the time of less than a generation. Improved economic performance has also led to a significant reduction in the number of people living in poverty in China. Accompanying these economic changes has been a rapid improvement in food security. China has attained a high measure of food security and has seen marked changes in dietary structure.[2,3] However, the distribution of income itself appears to have become more unequal. Moreover, some population groups have seen their living standards worsen, whether measured in terms of income or nutritional intake.[4]

India currently has one billion people and its population is projected to surpass China's by the year 2035. During the period 1978 to 1997, India achieved an impressive annual average rate of growth of real GDP of 3.3%, and the growth rate seems to have accelerated over the last decade (authors' calculations using International Monetary Fund, 1999).[1] India has been successful in reducing the proportion of its population living in poverty, from 55% in 1970 to 26% as per the most recent estimates made available by the Indian Planning Commission.[5] However, India's reduction in poverty is less impressive than China's, which succeeded in lowering the proportion of its population living in poverty from 20% to <10% during the 1980s.[6] Whereas starvation conditions are rarely found in the Indian subcontinent, malnutrition in the form of high low birth weight (LBW) rates, preschooler stunting and wasting, and maternal chronic undernutrition persist. By contrast, the proportion of Chinese children with LBW has been greatly reduced, as have all other measures of hunger and undernutrition.[2,3] During the last decade, in both countries the proportion of the population that is overweight has increased rapidly.

## Economic, Nutritional, and Health Changes in the Post-World War II Period

### *Economic Change*

At the end of World War II, the majority of the populations in China and India were facing hunger, often starvation, and very poor economic and social conditions. The well-documented shifts in China's economy have lifted the vast majority of its population above absolute poverty levels as more recent economic gains have begun to do in India. Figure 1 illustrates this quite clearly; the figure presents time series data on real income per capita and head count poverty ratios based on nationally determined poverty lines in the two countries.[7,8] Both countries experienced rapid increases in GDP per capita in constant 1995 U.S. dollars; the gains were particularly impressive for China during the 1980s and 1990s.

Changes in the poverty rates presented in Figure 1 highlight two features. First, for the entire period for which poverty data are presented, there was a significantly lower proportion of poor people in China than in India. Of course, these head counts of poor people use nationally determined poverty lines for each country and are not directly comparable. One comparable measure that is readily available is the proportion of persons with an income below US$1/day in 1993 dollars adjusting for differences in purchasing power of the dollar in each country. The proportion of these people was 18.5% for China in 1998, and 44.2% for India in 1997.[9] Whereas the data show marked economic progress in both countries, particularly China, it is important to note that economic change has been very uneven in terms of its beneficiaries. There are large subpopulations and regions, both in China and in India, that have virtually been bypassed by progress. Some of the western and south-central provinces of China face extensive poverty, for example, a contrast with its eastern provinces that appear to have much lower levels of economic deprivation.[10] Similarly, only approximately 6% of the population of the Punjab are poor, whereas more than 47% of Orissa, an eastern Indian state, are poor.[5]

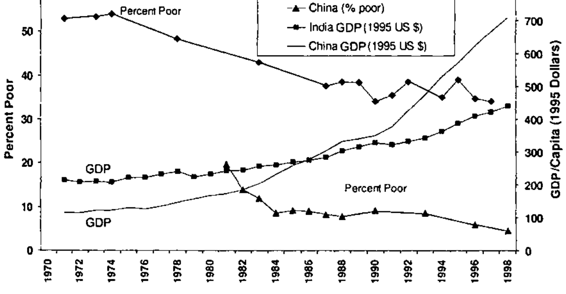


**Figure 1.** Income and poverty trends in China and India. GDP = gross domestic product.

Nonetheless, the shift toward a western lifestyle is rapid in both countries. As other research shows, approximately half of the adults of China consume a high-fat diet. Similarly, more than half of urban residents work at occupations such as office worker or assembly line worker in which the level of energy expenditure is lower.

### *Dietary Change*

Detailed studies of the food consumption shifts in China and India have shown that the following general patterns have existed for both countries in rural and urban populations over the last half-century:[3,11]

- There has been a large shift from consumption of coarse grains such as sorghum, barley, rye, maize, and millet to consumption of rice and wheat among all income groups in both countries, particularly India. There are some variations according to geographic areas (e.g., Maharashtra in India where coarse grain intake is still high).
- Overall, the diets of all income groups have moved away from cereals to other food groups, with greater shifts among the urban populations and the higher-income groups.
- Energy intake has risen for the poor and dropped for the rich, whereas fat intake has risen for all income groups.
- The sources of energy and fat show some unique differences that might explain some of the disease pattern differences. China has increased its meat, edible oil, and fruit and vegetable intake the most, whereas Indians consume a very high level of dairy products, particularly highly saturated ghee. The Chinese consume very little added sugar, whereas Indians consume high amounts of sugar.

The major differences in dietary patterns between China and India can best be illustrated with aggregate food available for consumption data from each country. In

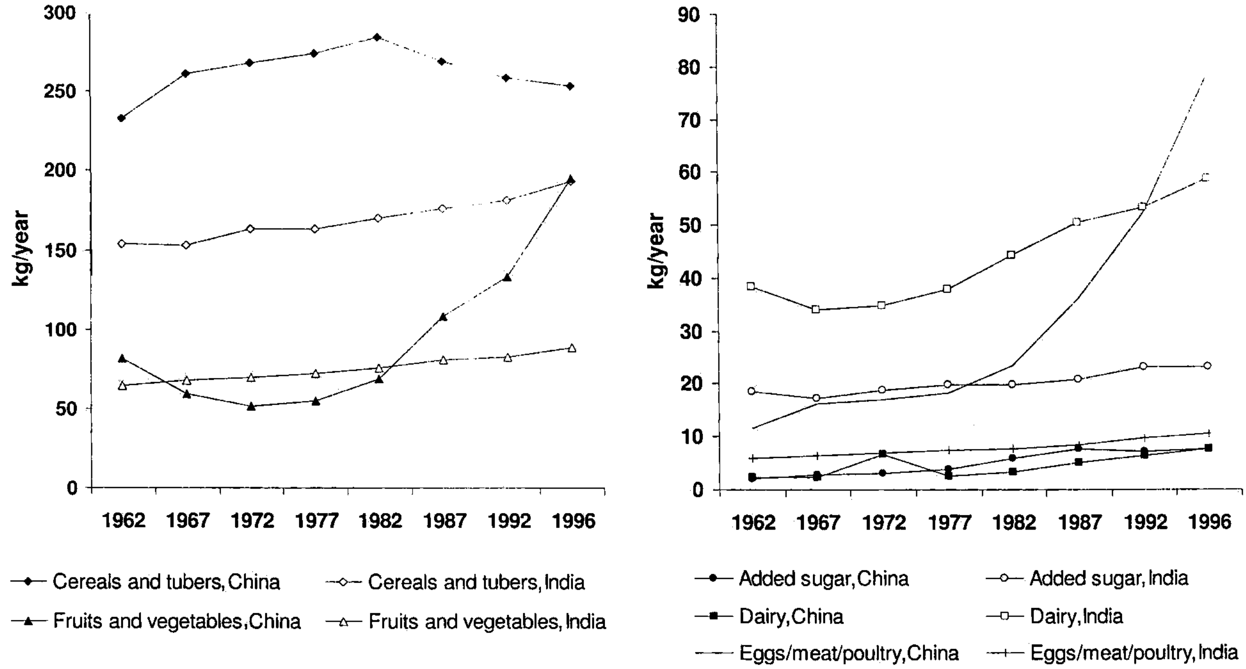


**Figure 2.** A comparison of Chinese and Indian food available for consumption, 1992–1996 (3-year moving averages are presented).

Figure 2, we use food disappearance data for each country to illustrate the major differences in patterns and trends.[12] In the left panel, it is clear that China's food supply of cereals and tubers and fruit and vegetables available for consumption were greater than that for India after 1985 and that the amounts available for consumption in India have increased steadily. The increase in fruit and vegetables available for consumption in China after 1982 is noteworthy. In the right panel, we see the key differences. Dairy products available for intake are increasing in India, and the level of intake of dairy products is much higher in India than in China. Also, added sugar available for consumption is also much higher in India. By contrast, the amount of combined nondairy animal products available from meat, eggs, and poultry is much higher in China than India and is rising quickly.

Household food consumption surveys conducted over several decades in a consistent and quite similar manner in each country are used to provide some sense of shifts in the structure of energy intake. Whereas these data exist for as long as a half-century for parts of each country, nationally representative urban and rural data exist only for the past 30 years. In China, it would have been most insightful to present data that covered the major famine of the late 1950s (the Great Leap Forward period),[13] but such data are not, as yet, publicly available.

Figure 3 uses these household food consumption data and presents information on the proportion of energy that the populations of China and India obtain from carbohydrates, fat, and protein.[14,15] Over a 20-year period, there has been more than a doubling of the proportion of energy from fat in the Chinese diet, and levels are presently very high, particularly in urban areas. By contrast, India's aggregate shift in energy from fat and protein is much less noticeable. Nonetheless, as Hanchate and Dyson[11] show in an unpublished study on food consumption and poverty in India among all income groups, cereal intake has declined and dietary diversity and dairy intake have increased. Only among the top 10% of the income distribution in India does intake of energy from fat resemble that for China.

### Shifts in Undernutrition Versus Overnutrition

Within limits, national comparisons of undernutrition and overnutrition levels in China and India are possible for all groups, except for adult men. For China, there are several sources of data that together account for major segments of its population. For India, however, there is only one nationally representative source of data available, namely the National Family Health Survey 1998–99.[16] The recently completed survey covered all the 25 states of India, with a sample size of nearly 83,000 women in the 15–49-year-old age group and their children. In our comparisons, we took a body mass index (BMI = weight in kilograms/height in meters squared) of less than 18.5 to indicate chronic energy deficiency, a BMI of 25.0–30 indicated overweight, and a BMI >30 indicated obesity.[17]

In China, the proportion of people who are overweight is much greater than the proportion with chronic energy deficiency, the latter being typically quite small. Among adults in eight provinces (ages 20–45 years), only 5.2% were found to be chronically energy deficient and 17.6%

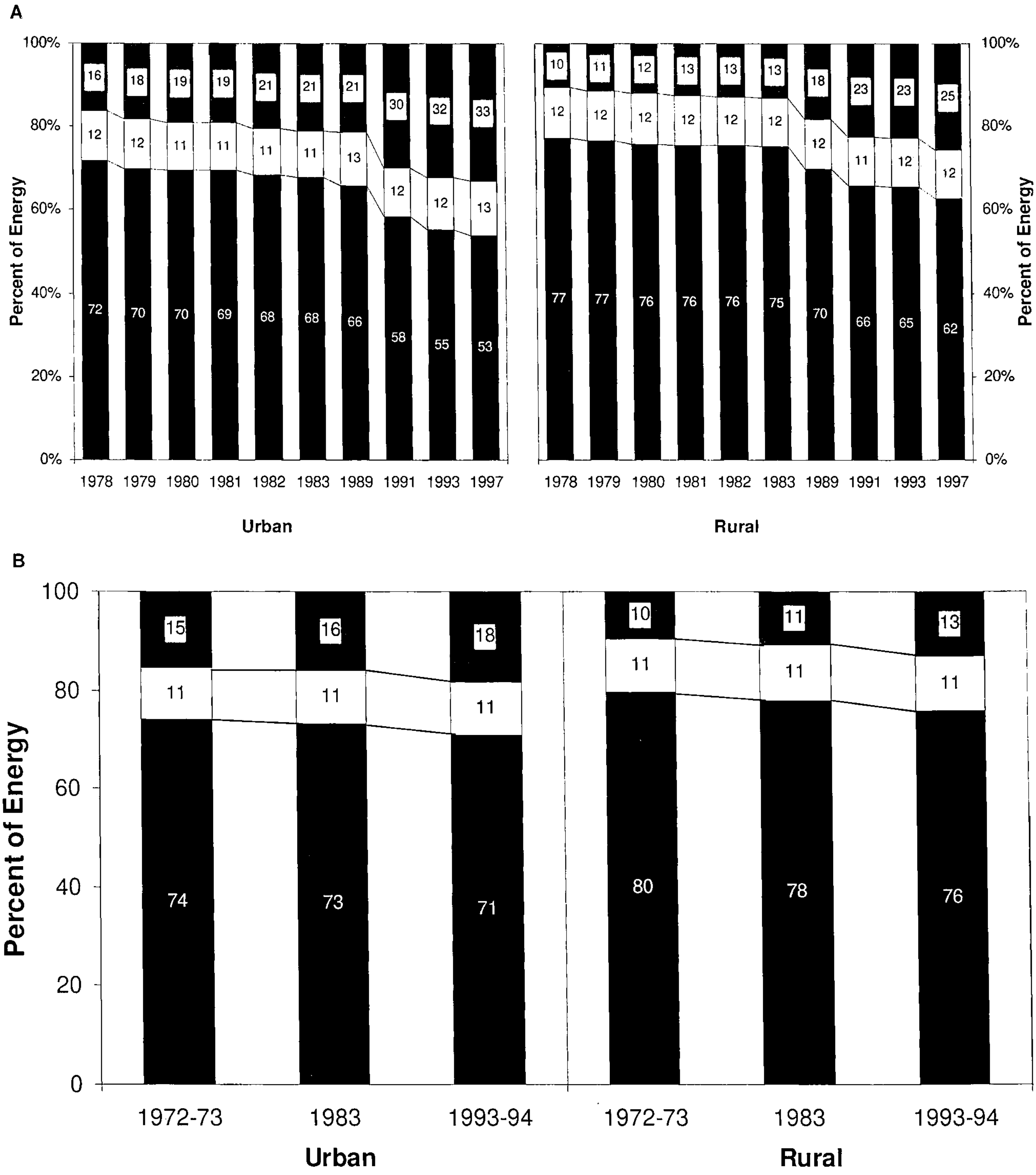


**Figure 3.** (A) Trends in sources of energy intake: China, 1978–1997. (B) Trends in sources of energy intake: India, 1973–1994. ■ Carbohydrates; □ protein; ▩ fat.

were overweight or obese in 1997. During the 8-year period of 1989–97, the proportion of overweight adults in this age group doubled for females (from 10.4% to 20.8%) and almost tripled for males (from 5% to 14.1%) in a cohort of approximately 2500 adults.[18]

By contrast, under the currently accepted cutoffs, the major nutrition problem facing Indian women age 15–49 years continues to be chronic energy deficiency, with 36% having a low BMI (<18.5). However, 11% of the women can be classified as overweight (BMI >25) and 2% are obese (BMI >30). There were significant differences by residence (i.e., rural or urban) with 41% of the rural women having a low BMI (contrasted with 23% of the urban women), and only 6% of the rural women being overweight or obese (compared with 24% for urban women). Unfortunately, there are no comparable data for men in India.

Research on children and adolescents in China suggests a shift toward overnutrition as compared with undernutrition—a shift more pronounced among older children, ages 6–11 years, than among adolescents.[19] In urban China, increasingly more children and adolescents are overweight than underweight but there are slightly more underweight than overweight children and adolescents in rural China. The China Health and Nutrition Survey has 23.9% stunted and 3.6% wasted (–2 Z-score on the height-for-age and weight-for-height growth charts, respectively) in the 0–4-year-old age group for 1993, and these figures were reduced to 20.4% stunted and 2.9% wasted in 1997. Whereas direct comparisons are difficult because of the differing age-categories for which data are available, the rates of stunting and wasting in India appear to be much higher. Thus, in the 1999–2000 survey (National Family Health Survey 2), nearly 46% of the children aged <36 months were found to be stunted, and 16% were wasted.[16] This marks only a very slight improvement from the 1992–1993 survey (NFHS1), which found 52% of children <36 months to be stunted and 17.5% to be wasted.[20]

There is one additional comparable measure of undernutrition available for both China and India. The proportion of infants born with a weight <2500 grams (defined as LBW) is much lower in China.[21] De Onis et al. could identify only one well-executed study in China from 1982, which found 4.2% LBW, whereas in India, similar research shows a rate of 28.2%. Current government estimates from hospital birth data are rates of 6% for China and 28% for India.[21] The NFHS2 also provides estimates of the babies' birth weights based on recall by the mother in the preceding 3 years. Although only approximately one-third of the mothers in the sample of 33,000 births could recall the relevant birth weights, approximately 19% of those who did, reported their child to have LBW.[16] Three decades ago, the LBW rate in China was approximately 20–25%, whereas in India it was greater than 40–48%.[21]

### *The Epidemiologic Transition*

The morbidity patterns that have emerged in the two populations, accompanying greater inactivity and dietary change, are quite different. Both countries are facing rapidly increasing mortality from DR-NCDs at a time when infectious and parasitic diseases are declining as causes of mortality. China has followed the classic East Asian shift from infectious diseases and malnutrition to diseases related to hypertension, coronary heart disease (CHD), stroke, and a subset of cancers.[22] By contrast, in India there is far more cardiovascular disease (CVD), predominantly ischemic heart disease, and adult-onset diabetes.[23,24] The most comparable set of mortality patterns by cause, as well as projections of mortality, come from the Global Burden of Disease project and are presented in Figure 4.[25]

Research by the International Diabetes Institute and the WHO provide a basis for an estimate of the prevalence of diabetes morbidity in China and India.[24,26] Estimates are based on the best available adult-onset diabetes measures for each country, but few countries have high-quality, reliable measures of adult-onset diabetes. Both the International Diabetes Institute and WHO have developed country-specific estimates of diabetes prevalence. WHO has projected that the most rapid increase in diabetes will be in India, where the 1995 estimate of diabetes cases was 19.4 million, and the year 2025 estimate is projected to be 57.2 million.[24] In China, the 1995 figure was 16.0 million cases, and was projected to rise to 37.6 million in 2025.

## The Economic Costs of Undernutrition and Overnutrition

As communicable diseases decline in importance, the costs of lost productivity shift from those associated with undernutrition to those associated with overnutrition. Similarly, the share of healthcare system costs attributable to noncommunicable diseases increases in parallel with the shift in mortality patterns. At the same time, health system costs increase because noncommunicable diseases are more costly to treat than communicable ones.

China is at an advanced stage of this process of epidemiologic transition relative to India. For China, 41.6% of all deaths in 1995 were already from DR-NCDs, and the proportion is projected to reach 52.0% by 2020. In 2000, by comparison, 31.6% of deaths were attributable to DR-NCDs in India, a figure that will increase to 43.3% of all deaths by 2020 (here, DR-NCDs include cancer, coronary heart disease, cerebrovascular disease, hypertension, and diabetes).

### *Assumptions Employed*

Previous studies have estimated the costs of undernutri-

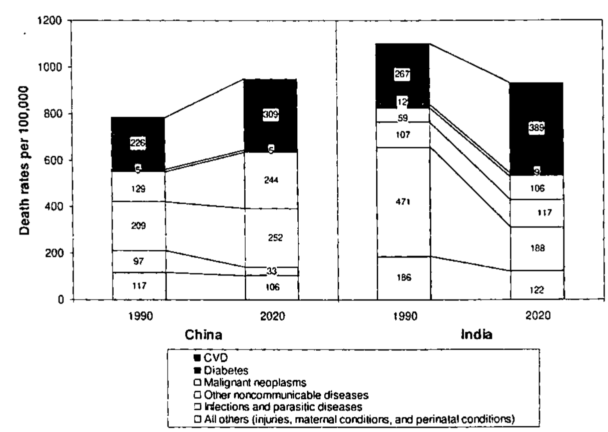


**Figure 4.** Mortality trends in China and India, 1990 and 2020. CVD = cardiovascular disease.

tion as the following: the average productivity loss per child born to a mother with goiter is estimated as 10.3%. The average loss of productivity in manual work is estimated as 8.6% (associated with severe stunting) and 6% (associated with moderate stunting). The productivity loss associated with anemia is estimated as 5% (blue-collar work) and 17% (heavy manual labor) (Table 1).[27–34] Note that these losses are not necessarily additive, although the same individual may suffer from several aspects of undernutrition at the same time. These losses do not include (for anemia and stunting) the very serious cognitive losses; the relevant literature is not as well developed. Ross and Horton,[28,29] in an unpublished study on the economics of iron deficiency, speculate as to the cognitive losses for iron deficiency anemia, and find that they often exceed the physical productivity losses; longitudinal studies of dietary energy inadequacy find there are significant cognitive effects.[35]

Costs of overnutrition have been estimated for developed countries,[36–38] as have costs of diet-related chronic diseases,[39] but rarely has this been done for developing countries. We estimate here the costs of five DR-NCDs: cancer, CHD, stroke, hypertension, and diabetes. Two elements of these costs are included; namely, the costs to the healthcare system (costs of hospitalization, outpatient visits, drugs, etc.) and the costs of premature mortality in terms of lost work. Data are not available to estimate the costs of lower productivity by those who continue to work despite illness; the estimates of lost work output associated with morbidity (available for India only) are likely serious underestimates.

Estimates of costs of premature mortality are obtained by combining mortality data[25] with the following assumptions: (a) an average loss of 10 years of working life per death, (b) 60% of the adult population belongs to the labor force (data on labor force participation rates),[28] and (c) real wage growth in both countries of 3% per annum, along with a real discount rate of 12% per annum.

**Table 1.** Estimated Costs of Undernutrition in China and India, 1995 and 2025

| Country/Nutrient or Condition | Prevalence of Undernutrition | Share of Work Affected | Loss of GDP |
|---|---|---|---|
| **China 1995** | | | |
| Iron | 22.7% (women), 11.4% (men) | 60% (blue-collar work), 12.1% (heavy manual work) | 1.82% |
| Iodine | 20% | All | 0.82% |
| Stunting | 12.7% (severe), 17.7% (moderate) | 60% (manual work) | 0.52% |
| **China 2025** | | | |
| Iron | 5.7% (women), 2.9% (men) | 50% (blue-collar work), 6% (heavy manual work) | 0.05% |
| Iodine | 5% | All | 0.20% |
| Stunting | 10% (severe), 14% (moderate) | 11.5% (manual work) | 0.08% |
| **India 1995** | | | |
| Iron | 59% (women), 47% (men) | 70% (blue-collar work), 17.25% (heavy manual work) | 1.13% |
| Iodine | 20% | All | 0.82% |
| Stunting | 38% (severe), 29% (moderate) | 34.5% (manual work) | 0.69% |
| **India 2025** | | | |
| Iron | 45% (women), 36% (men) | 60% (blue-collar work), 12.1% (heavy manual work) | 0.69% |
| Iodine | 15% | All | 0.62% |
| Stunting | 31% (severe), 22% (moderate) | 24% (manual work) | 0.38% |

GDP = gross domestic product.

Assumptions:

1. Labor share in GDP is 40%.
2. Female share of labor force is 32% (India) and 45% (China) based on World Bank.[27]
3. Productivity losses are 5% for anemic workers in blue-collar work and an additional 12% loss in heavy manual labor.[28]
4. Average productivity loss per child born to mother with goiter is 10.27% (100% for the 3.4% of infants born as cretins, 25% for the 10.2% born with severely impaired IQ, and 5% for the rest born with mildly impaired IQ).[29]
5. Productivity loss associated with severe stunting is 8.625%, 6.0375% associated with moderate stunting, in manual work.[30]
6. China is assumed to reduce prevalence of iron and iodine deficiency by 75%, based on a strong commitment to programs and rapid increase in dietary diversity and meat intake. India is assumed to reduce prevalence of iron and iodine deficiency by 25%, based on weaker commitment to programs and slower increase in dietary diversity and meat intake.
7. Stunting levels for 2025 are based on stunting at 24 months in 1995, and those stunting levels for 1995 are estimated rates for stunting at 24 months in 1965, using WHO trends.[31] Assumes adult height is highly correlated with child height at 24 months (adult height data are not readily available).
8. Prevalence of anemia from Micronutrient Initiative website;[32] prevalence of iodine deficiency from Mason et al.[33]
9. Shares of blue-collar work from International Labor Organization Yearbook,[34] using representative values for countries at similar income levels: blue-collar work is taken as occupations in agriculture, construction, transport, and production; white-collar work is taken as professional and managerial occupations. It is assumed that service occupations are split between blue- and white-collar work, in the same proportion as the overall split in the labor force. Share of manual labor is taken as the share of GDP in agriculture and construction; share of heavy manual labor is taken as half the share of manual labor.

We use epidemiologic models to estimate the proportion of the DR-NCDs (there are other causal factors such as smoking). Figures 5, 6, and 7 summarize the relative risks of particular diet-related factors for noncommunicable disease outcomes.[40–47] This literature is still relatively underdeveloped, particularly for Asian populations. To estimate this accurately would require meta-analyses for each of the postulated links, holding constant the other links, and carefully separating out the relative risks for morbidity and mortality, for men and for women, specifically for Asian populations; however, these analyses are not currently available. Figures 5 through 7 should therefore be regarded as current best estimates, and the basis for future work.

We then combined the relative risks outlined in Figures 5 through 7 with prevalence data for 1995 and predicted prevalence of the risk factors for 2025 (summarized in Table 4) to calculate the etiologic fractions.[10,20,21,23,31,48–50] Because studies on relative risk do not necessarily hold constant all other risk factors involved, it is not possible to add up different channels of effect on risk. Hypertension, diabetes, and overweight, for example, all are risk factors for CHD; however, it could be double-counting to sum each of these etiologic fractions as if they were independent. We therefore adopt the most conservative approach, and identify the strongest channel as the minimum effect of diet on the outcome.

### Data and Results

Data available for the cost estimates are given in Table 4. Projections of costs in 2025 require assumptions as to the trends in nutritional status (detailed in Table 4). Health service cost data were obtained from the 1998 National Survey of Health Services for China, and the 1995–96 National Sample Survey for India.[51,52] The data for China correspond to costs incurred by the state, which until recently accounted for >90% of health expenditures; the costs for India correspond to out-of-pocket costs by patients, augmented by estimates from hospital cost studies of cost per hospitalization per day, and cost per outpatient visit (detailed in an unpublished study on chronic illness in India by Mahal).[53]

Undernutrition accounts for significant economic costs, particularly in India. For China, individual nutritional deficiencies account for between 0.5% and 1.8% of lost GDP, and for India individual nutritional deficiencies account for between 0.7% and 1.1% of GDP. The overall cost of undernutrition, also including cognitive costs, is almost certainly higher. The costs of undernutrition are projected to diminish by 2025 for China (when individual nutritional deficiencies account for ≤0.2% of lost GDP), but remain important for India (ranging from 0.4% to 0.7% of lost GDP).

The DR-NCDs impose a significant burden on healthcare services. In 1995, they accounted for 22.6% of costs to the healthcare system in China. (Data are from

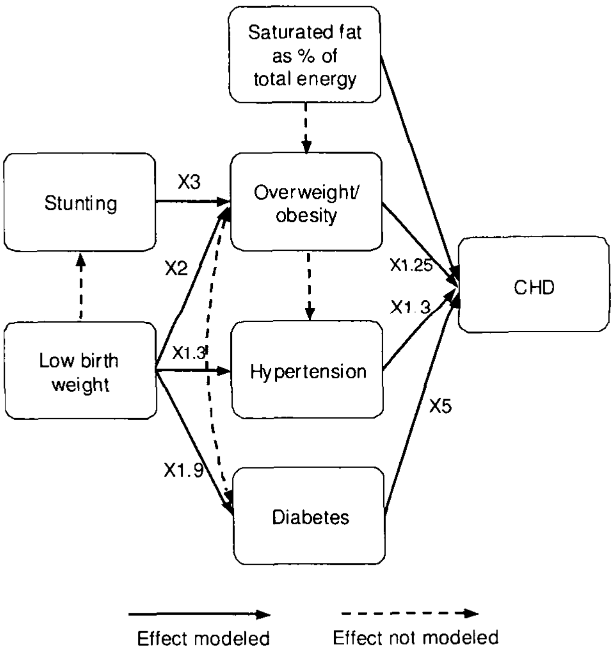


**Figure 5.** Relative risks for coronary heart disease. Data compiled from references 40–47. CHD = coronary heart disease.

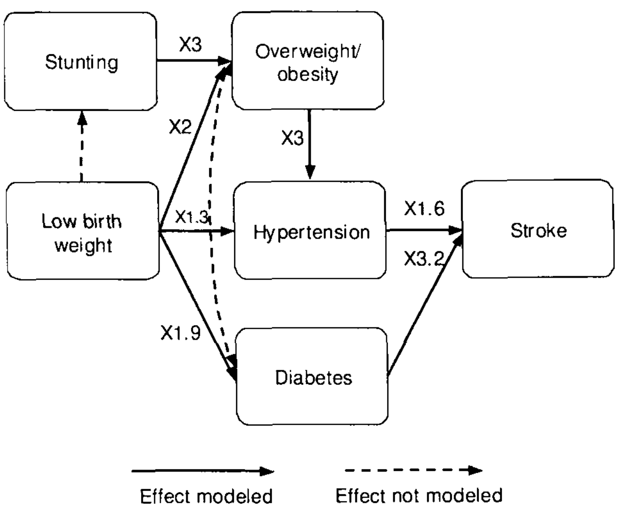


**Figure 6.** Relative risks for stroke. Data compiled from references 40, 41, and 47.

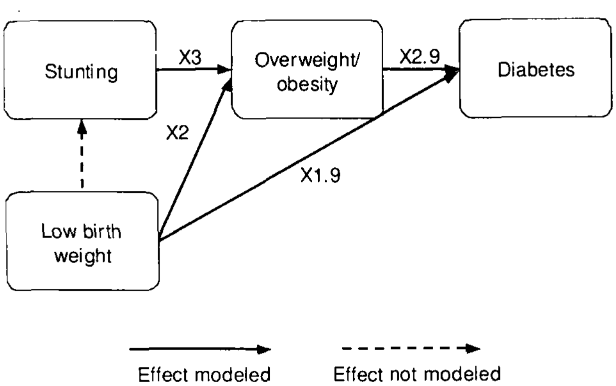


**Figure 7.** Relative risks for diabetes. Data compiled from references 41 and 47.

National Survey of Health Services, calculations in Popkin et al.[54] Costs include hospitalization costs, outpatient costs, and prescription drugs; the large majority of costs were state expenditures.) In India, the corresponding share was 13.9%.[53] (Costs include hospitalization costs, outpatient costs, and prescription drugs; private expenditures constitute approximately 90% of the costs and the rest are state expenditures.) The corresponding costs as a share of GDP were 1.6% for China and 0.35% for India (Table 2).

Although projections of health costs cannot easily be made for 2025, it is clear that they will increase. Cancer and diabetes in both countries require hospital stays at least twice as long as the average for other diseases, and the costs per hospital stay are two to four times as high as for other diseases.[54] In China, the average hospital stay for cancer costs more than annual per capita GDP; the same is true in India for "heart failure."

Productivity losses associated with premature death are also costly and on the rise (Table 2). If, on average, each premature death is associated with 10 years of lost work output by the 60% of adults who are in the market labor force, then the estimated costs of premature death in 1995 are 0.5% of GDP (China) and 0.7% (India). These are underestimates of the productivity losses because they do not include loss of work output owing to morbidity. For India, the self-reported costs of lost work output associated with hospitalization and outpatient visits amount to approximately another 0.04% of GDP (no data are available for China). These still do not account for all the costs of lost work due to morbidity, to lower productivity due to people retiring early for health reasons, to lower productivity due to switching to less strenuous work, etc.

Hence, the overall costs of healthcare and lost work output owing to premature death (associated with DR-NCDs) were estimated as (at minimum) 2.1% of GDP for China and 1.1% for India in 1995. We cannot predict these values for 2025; by comparison, however, the corresponding costs for the United States in 1993 (at a more advanced stage of the nutritional and epidemiologic transition) were 3.8% of GDP.[39]

We further estimate the share of DR-NCDs that can be attributed to particular diet factors, in an effort to prioritize interventions. We see that individual indicators of adult diet account for ≥21–25% of each of the five DR-NCDs studied in China in 1995, a figure that increases to 23–53% by 2025 (Table 3).

As in China in 1995, individual adult diet indicators accounted for 8–23% of each of the five DR-NCDs in India, a figure that increases to 10–32% by 2025. Similar factors are at work in both countries: fruit and vegetable intake is modeled as the strongest modulator of cancer risk (work on the diet foundation of cancer is relatively new), overweight is the main contributor to both diabetes and hypertension, and hypertension is the main contributor to stroke. For CHD there are different factors implicated: in China in 1995, hypertension was the main contributor, but overweight will become the main factor by 2025. Diabetes is the main contributor in India during both periods.

Childhood factors tend to have a somewhat smaller influence; LBW is estimated to account for 0.3–17% of four of the five DR-NCDs in China in 1995, 1–28% of these four conditions in India in 1995, and 2–20% in India in 2025 (the effects on CHD and stroke are low, between 1% and 3%, but childhood factors account for 12–16% of hypertension and 20–28% of diabetes in 1995 and 2025 in India). By 2025 in China, due to a greater reduction in LBW than stunting over the last 30 years, stunting becomes the main contributory childhood factor, accounting for 3–14% of the four DR-NCDs considered. (Note that there is no work currently on childhood risk factors as a contributory factor to cancer.) Hence, in China the

**Table 2.** Summary of Costs of Diet-related Noncommunicable Disease in China and India, 1995 and 2025

| Type of Cost | China | India |
|---|---|---|
| Number of deaths/year owing to DR-NCDs: 1995 | 2.57 million | 3.00 million |
| Deaths owing to DR-NCDs as percentage of all deaths: 1995 | 41.6% | 31.6% |
| Number of deaths/year owing to DR-NCDs: 2020 | 7.63 million | 4.944 million |
| Deaths owing to DR-NCDs as percentage of all deaths: 2020 | 52.0% | 43.3% |
| Annual healthcare system costs of DR-NCDs: 1995 | $11.74 billion | $1.10 billion |
| Healthcare system costs DR-NCDs as percentage of all diseases: 1995 | 22.6% | 13.9% |
| Healthcare system costs DR-NCDs as percentage of GDP: 1995 | 1.6% | 0.35% |
| Productivity costs DR-NCDs owing to premature death: 1995 | $3.41 billion | $2.25 billion |
| Productivity costs as percentage of GDP: 1995 | 0.5% | 0.71% |
| Total costs DR-NCDs (health + productivity): 1995 | $15.1 billion | $3.4 billion |
| Total costs DR-NCDs as a percentage of GDP: 1995 | 2.1% | 1.1% |

Authors' calculations, based on real wage of $170/year (India) and $300/year (China), assuming each death implies 10 years of productive life lost, 60% participation rate in labor force for adult population, real wage growth of 3% per year, and real discount rate of 12% per year. DR-NCD = diet-related noncommunicable disease, GDP = gross domestic product.

**Table 3.** Contribution of Key Diet Factors to Diet-related Noncommunicable Disease, China and India, 1995 and 2025

| Condition | Key Diet Factor | PAR China 1995 | PAR China 2025 | PAR India 1995 | PAR India 2025 |
|---|---|---|---|---|---|
| **Adult Factor** | | | | | |
| Cancer | Fruit and vegetable intake | 22.7% | 22.7% | 22.7% | 22.7% |
| CHD | Various | 20.6% (hypertension) | 32.3% (overweight) | 7.7% (diabetes) | 14.7% (diabetes) |
| Diabetes | Overweight | 22.7% | 33.1% | 14.6% | 31.3% |
| Hypertension | Overweight | 24.0% | 53.3% | 15.3% | 32.4% |
| Stroke | Hypertension | 25.2% | 24.5% | 8.9% | 10.4% |
| **Childhood Factor** | | | | | |
| CHD | LBW (except for China 2025: stunting) | 0.3% (indirect, via hypertension) | 2.8% (indirect, via overweight) | 2.4% (indirect, via diabetes) | 3.0% (indirect, via diabetes) |
| Diabetes | LBW (except for China 2025: stunting) | 17.1% | 13.7% (indirect, via overweight) | 28.4% | 20.1% |
| Hypertension | LBW (1995), stunting (2025) | 6.5% | 14.0% (indirect, via overweight) | 11.7% | 16.1% (indirect, via overweight) |
| Stroke | LBW (except for China 2025: stunting) | 0.3% (indirect, via hypertension) | 2.3% (indirect, via overweight) | 1.2% (indirect, via diabetes) | 1.7% (indirect, via diabetes) |

The PAR calculations are used to identify the contribution of the strongest current diet-related factor and childhood diet factor. The contribution of this factor is then used as an estimate of the minimum contribution of dietary factors to the particular outcome.
CHD = coronary heart disease, LBW = low birth weight, PAR = population attributable risk.
Author's calculations are based on prevalences in Table 4 and relative risks in Figures 5–7 (all others).

**Table 4.** Data for Cost Calculations

| Category | China 1995 | China 2025 | India 1995 | India 2025 |
|---|---|---|---|---|
| Overweight (including obesity) | 10.05% | 38.25% | 9% | 24% |
| Saturated fat, % of total energy | 7.0% | 12.7% | 4.7% | 9% |
| Low birth weight (30 years ago) | 23% | 6% | 44% | 28% |
| Stunting (30 years ago) | 45% | 24% | 57% | 53% |
| Hypertension | 18.6% | 25% | 16.3% | 19.4% |
| Diabetes (% of whole population) | 1.4% | 2.4% | 2.1% | 3.0% |
| Population size (millions) | 1188 | 1547 | 929 | 1330 |
| Percentage rural | 70% | 45% | 73% | 48% |
| GDP/capita (1995 US$) | $620 | $6600 | $340 | $875 |
| Annual wage (US$) | $300 | | $170 | |

Sources: Overweight/obesity: reference 20. Low birth weight: reference 21. Stunting: reference 31. Hypertension: reference 23. Diabetes: reference 48. Population: references 49, 50. GDP/capita: reference 10.

importance of childhood factors diminishes as childhood malnutrition improves; in India the slowness of improvement in birth outcomes and stunting, and the urban diet and exercise patterns, make a deadly combination.

## Discussion

Health has been seen as a major component of international development for some time;[55] however, most of the focus in the developing world has been on infectious diseases and undernutrition. For example, the World Bank's 1993 World Development Report on Investing in Health focused its entire assessment in the diet and nutrition area on undernutrition. This paper highlights the important economic and nutritional achievements of countries representing 2.4 billion persons. China and India still have hundreds of millions of children and adults who face poverty and undernutrition, but the data show the shifts in diet, activity, and obesity are linked now with a growing specter of major health costs from DR-NCDs.

The structural shift in China's diet is more rapid than in India. In terms of macronutrient composition of energy from fat, protein, and carbohydrate, the Chinese diet looks far more like the higher-fat American diet. Close to 33% of energy comes from fat in urban areas and 25.4% of energy comes from fat in rural areas. By contrast, the shifts in macronutrient structure of the diet for the Indian population are much smaller. Even in India, however, tens of millions consume a higher-fat diet.

There are important differences in dietary transition in each country. China's transition features a large contribution of energy from edible oils and large increases in egg, meat, and poultry consumption. By contrast, in India high intakes of dairy products and added sugar are distinguishing features.

Whereas India still has a larger proportion of current deaths from infections, malnutrition, and parasitic diseases than China, morbidity and mortality related to CVD and cancer have risen rapidly in both countries. Obesity is much higher in China, whereas undernutrition is still much higher in India; however, India does have significant pockets of female obesity. In both countries, there is evidence that even the BMI cutoff for overweight (BMI = 25) underestimates the true health costs of overweight.[56–58]

The pathways by which nutrition-related factors affect the noncommunicable diseases of China and India are different. In the early stages of the transition toward DR-NCDs, China faced relatively much more stroke and hypertension, whereas India faced much more adult-onset diabetes. There have not been adequate comparative nor within-country analyses to fully understand the nutrition and genetic pathways that explain these differences. Undoubtedly, the differences relate partially to the differences in diet—edible oil and meat products versus dairy products and sugar. The distinct very high incidence of stroke and hypertension in East Asia has long been discussed.[22] Similarly, the much greater incidence of diabetes and other CVD morbidities at lower levels of BMI among Indians have been prominent in the literature.[23]

The economic analysis shows that for China, current costs of DR-NCDs are of similar magnitude to costs of undernutrition, but that DR-NCDs will dominate by 2025. For India, current costs of undernutrition are greater, but the two are more likely to become equal by 2025. Costs to the healthcare system dominate: already in China in 1995, almost a quarter of these costs were from DR-NCDs.

Diet is a major culprit underlying these costs, currently accounting for, at minimum 20–25% for China, and rising to 20–50% by 2025. These are similar to current estimates for the United States of 20–40%.[40] India is still not quite as far along, with diet implicated as causing 8–22% of annual costs currently, and rising to 10–32% in 2025. The methodology and assumptions used to derive these estimates for China and India are described in detail in Popkin, Horton, and Kim.[55] These may even be underestimates for Asia, if there are indeed genetic factors affecting patterns of fat deposition that predispose these populations to higher relative risks than in the United States. The rapid changes in diet and body composition lead to the large effects of fetal and child undernutrition on hypertension and diabetes, accounting for between 6% and 38% of these conditions. This effect is higher for India where undernutrition rates are higher.

What is most remarkable about the transitions in each country is how rapidly the burden of disease is shifting toward DR-NCDs and how little these countries have focused on fully understanding these shifts, their causes, and the ways to address them. Elsewhere in Asia, comparable changes are occurring in most countries,[55] as they are throughout the developing world.

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