

SCIENCE AND SOCIETY

Understanding global nutrition dynamics as a step towards controlling cancer incidence

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Abstract | As we look to understand future forces that will affect cancer risk, poor dietary patterns, overweight and obesity are significant concerns. In the past two decades these factors have shifted from issues that face higher-income countries to a global pandemic, and are rapidly becoming less a problem of affluence and more a problem of poverty. Rapid shifts in food systems, food pricing and marketing are the causes that underlie this trend. It is imperative to understand these factors and implement global interventions to slow this pandemic. The alternative is an acceleration of the incidence of the main nutrition-related cancers, primarily in developing countries.

The global transition in nutrition patterns — from stages of periodic famine, heavy physical activity and undernutrition to a situation in which dietary and physical activity patterns are among the main causes of noncommunicable diseases — has happened slowly over this past century in higher-income countries, and much more recently in many lower-income and moderate-income countries. By contrast, chronic undernutrition — in combination with communicable diseases (for example, measles, tuberculosis and malaria) — remains an important but shrinking global health problem. Since 1980, this trend towards poor diets, physical inactivity and energy imbalance (obesity) has accelerated globally, and is increasing the burden on the poor. It is imperative to understand the trends in these key global nutritional factors linked with cancer and push for large-scale policy research and interventions — including legal, fiscal and regulatory policies and programmes — if this pandemic is to be controlled and decelerated.

What are the nutrition-related cancers?

A large systematic review published in 1997 found that 30–40% of all cancer incidence in the world can be attributed to unhealthy diets (including alcoholic drinks) and the related factors of obesity and physical inactivity. Subsequent reviews and meta analyses have clarified many factors (some being dropped as important factors and some added), linking diet, physical activity and obesity to a range of cancers^{1–3} (TABLE 1).

The general thrust of most of this research remains valid — that a large proportion of all cancers can be prevented by an expanded set of nutritional factors including diet, physical activity, low weight gain and/or normal weight. The current key recommendation is that a physically active person with low alcohol intake, who has carefully avoided selected types of foods (for example, minimal intake of Cantonese-style salted fish and aflatoxin-contaminated foods) and consumed large amounts of non-starchy vegetables, will have a lower risk of developing various cancers and possibly a reduced risk of developing others. Most convincing is the role of excessive body fatness, or weight gain, as a causal factor for many cancers. These various reviews, and other studies conducted in the past decade, have led us to limit what were once important recommendations (for example, that increased fruit and vegetable intake was key for the prevention of many cancers)^{4–8}. At best, the evidence for fruit intake as a direct causal factor for cancer risk reduction is limited today.

The evident importance of weight maintenance, regular physical activity and avoidance — or only occasional consumption — of alcoholic drinks has increased^{9–14}. This is particularly true for colon cancer and postmenopausal breast cancer^{8,15}, but is also probably true for many other cancer sites^{9,16}. High consumption of red meat remains a possible or probable contributor to elevated colon cancer risk; evidence on the consumption of processed, overcooked meats is stronger^{17–19}.

Perhaps the most important recent finding relates to the effect of obesity, overweight (short of obesity) and weight gain as important causes of several cancers that in general are becoming more common, including colon cancer and post-menopausal breast cancer^{1,20,21}. A relatively new finding, based on a pooled analysis of 54 studies conducted worldwide, shows the benefits to the mother of breastfeeding her children in preventing subsequent breast cancer for the mother²². Physical activity, not discussed in depth here, represents another new area with important findings among adults, with definitive associations found for reducing the risks of colon and breast cancer, and probably endometrial cancer^{9,12}.

It is important to note that a forthcoming review to be published in November 2007 by the World Cancer Research Fund (WCRF) in association with the American Institute for Cancer Research will considerably update our current state of knowledge of these factors²³. This 4 year WCRF effort by a panel of eminent scholars systematically reviewed all literature on this topic, and their published review will be an important addition to the literature.

Current thinking classes obesity in the context of cancer the same as in the context of heart disease — as both an indirect and direct cause; therefore, the causes of obesity noted briefly above can also be considered causes of cancer. There is strong and even compelling evidence about certain associations (some contested by the food industry) with cancer. For example, consuming energy-dense fatty and/or sugary foods, and consuming soft drinks that contain caloric sweeteners are thought to be causative, whereas consuming nutrient-dense foods low in energy, such as vegetables, fruit and water are thought to be protective. In addition, being a breast-fed infant is thought to reduce the likelihood of obesity for this infant; conversely, formula feeding an infant increases the risk of obesity for the infant. Similarly, regular sustained physical activity protects against some cancers, and inactivity — sedentary behaviour — is a cause of these same cancers. Regionally, there are also some problematic types of food and drink such as yerbe maté tea (a food many feel provides medicinal benefits), which is consumed through a metal straw in southern Latin America; consumption increases the risk of oesophageal cancer. The consumption of Cantonese-style, decomposing, salted fish eaten habitually in Guangzhou, China, increases the risk of nasopharyngeal cancer. And the consumption of aflatoxin-contaminated grains and legumes

Table 1 | The relationship between dietary, physical activity and obesity changes and cancer

Cancer	Evidence	Associated with decreased risk	Associated with increased risk	Refs
Pre-menopausal breast	Convincing	Breastfeeding behaviour of the mother; physical activity	Alcoholic drinks	9,12,14, 22,88,89
	Probable		Attained height	90,91
Post menopausal breast	Convincing	Breastfeeding behaviour of the mother; physical activity	Alcoholic drinks; overweight/obesity; weight gain; attained height	1,9,12,14,22, 25,88,89,91
Colon/rectum	Convincing	Physical activity	Processed red meat/overcooked red meat; alcoholic drinks (men); overweight/obesity; central adiposity	1,9,14, 25,88,89
Endometrium	Convincing		Overweight/obesity; central adiposity	3,14, 25,88
	Probable	Physical activity		9
Oesophagus	Convincing		Alcoholic drinks; overweight/obesity (oesophageal adenocarcinoma only)	3,88
Gallbladder	Probable		Central adiposity	25,89
Kidney	Convincing		Overweight/obesity; central adiposity	3,14, 25,88
Liver	Convincing		Aflatoxin-contaminated food; alcoholic drinks	88,89
Lung	Probable	Fruits; physical activity; non-starchy vegetables		7,14,89
Mouth, pharynx and larynx	Convincing		Alcoholic drinks	88,89
Nasopharynx	Convincing		Cantonese-style salted fish	31,89,92
Pancreas	Probable		Obesity; central adiposity	1,89
Prostate	Probable		Milk and dairy foods	8,14,89
Stomach	Convincing		Preserved salty foods	88,89
	Probable	Allium-containing vegetables	Grilled meat, high salt intake	88,89

affects liver cancer²⁴. However, the nutritional components of greatest concern are those that will increase cancer incidence (for example, the increased consumption of processed meat and red meat), an increase in obesity and an increase in inactivity. The following sections provide a sense of the global dynamics linked with these nutritional factors.

Global obesity

Not only the high prevalence, but also the quite rapid rate of change of overweight and obesity in many middle-income and low-income countries is of particular importance. The trends presented here are agreed to have an effect on breast, colorectal, endometrial, gallbladder, kidney, oesophageal and pancreatic cancers^{13,25}. Increases in cancer incidence and prevalence often occur 20–35 years after shifts in the key lifestyle and dietary factors noted in TABLE 1. In lower-income and moderate-income countries, the shift toward a nutrition stage linked with increasing cancer has started only in the past two decades; therefore, large increases in cancer incidence are expected in the next few decades. Nevertheless, increases in cancer incidence, particularly those related to lifestyle factors, have been noted in many transitional countries and even poorer ones such as

China²⁶. It is worth noting that the quality of cancer registry data varies widely across low-income and transitional economies. In many developing countries, cancer rates are based on partial data and a small number of cases; therefore, future research in these countries is expected to be more difficult than research in the West²⁷. Studies in Japan, and migrant studies in the United States, indicate that trends in meat intake and obesity have been linked with increased colon cancer; similar bodies of literature are yet to emerge from other countries that have or are observing a marked shift towards the consumption of more red meat and increasing rates of obesity^{28,29}.

This Perspective examines data from studies that are nationally representative, weighted and with direct measurements of weight and height. The most standard measure of adult obesity is body mass index (BMI) which is weight (kg) divided by height² (m²). A BMI greater than 30 kg m⁻² is considered obese and a BMI between 25 and 29.9 kg m⁻² is considered overweight^{30,31}. Age-gender standards equivalent to adult overweight and obesity standards exist and are used for children and adolescents^{32,33} (FIG. 1). At present, more than 1.3 billion people globally are overweight or obese. Energy

imbalance characterized by overweight has become an important nutritional and public health concern; urban and rural areas in all countries have more than 5–10% of their populations overweight. This is a globe where more than 25% of Chinese adults are now overweight or obese and about two-thirds of the adult populations are overweight or obese in countries as diverse as the lower-income countries of Egypt, Mexico and South Africa, and higher-income countries such as Australia, the United Kingdom and the United States.

Directly comparable annual absolute percentage changes in the prevalence of overweight or obesity in eight countries around the globe are shown in FIG. 2. For example, more than 1.2% of the Chinese adult male population has become overweight or obese each year over the past decade, whereas the annual rate of increase was slightly less among adult men from Australia, the United Kingdom and the United States. Elsewhere, we have shown that the shifts in becoming overweight for some other larger lower-income countries with populations over a hundred million are even greater³⁴. In the case of the United States, a new study shows the rates of increase in overweight and obesity status

for all adults accelerated from 0.7% per year from 1978–1991 to 1.0% from 1991–2002 (REF. 33). The lower rates of change for children in most of these countries³³ are also shown in FIGS 1, 2.

Diabetes increases are global

Obesity and inactivity are the two main causes of diabetes, so it is no surprise that all countries are observing the shifts (noted above and below) linked with rapid increases in diabetes³⁵. This Perspective will not address the diabetes increases except to note the very rapid increases and the lower age-specific incidences observed in low-income countries compared with higher-income countries³⁶. Furthermore, insulin resistance might also be important in the aetiology of many cancers^{1, 37–40}.

Global dietary patterns and shifts

The diets of the developing world are shifting rapidly, particularly with respect to key components linked to cancer directly or indirectly through obesity. These components are caloric sweeteners, animal-source foods and highly energy-dense foods and beverages^{34,41,42}. The consumption of these foods contributes directly to increased energy imbalance. TABLE 1 shows the few dietary behaviours that are convincing in their protective or causative relationships with any cancer. Excessive body fatness and central body fatness have been shown in other extensive literatures to be linked with the effects of increased sedentarism and energy density. Further, the increased intake of caloric beverages is not linked with a reduction in food intake, so the shift towards greater caloric beverage consumption is another potentially important behaviour^{43,44}.

It is important to understand that the key dietary factors linked with cancer will probably occur through their effects on total caloric intake. Extensive research has been undertaken on the causes of overweight and obesity. Nutritional causes of overweight and obesity in early life, which frequently tracks into adult life, are now generally agreed to include formula feeding (or lack of breastfeeding), energy-dense diets (or lack of nutrient-high energy-low foods), beverages that use caloric sweeteners and physical inactivity (or lack of regular sustained physical activity)^{43–46} (TABLE 1). There is much confusion and a lack of consensus about the ways that diet composition relates to energy imbalance. There seems to be a growing consensus that the energy density of foods and beverages is a key con-

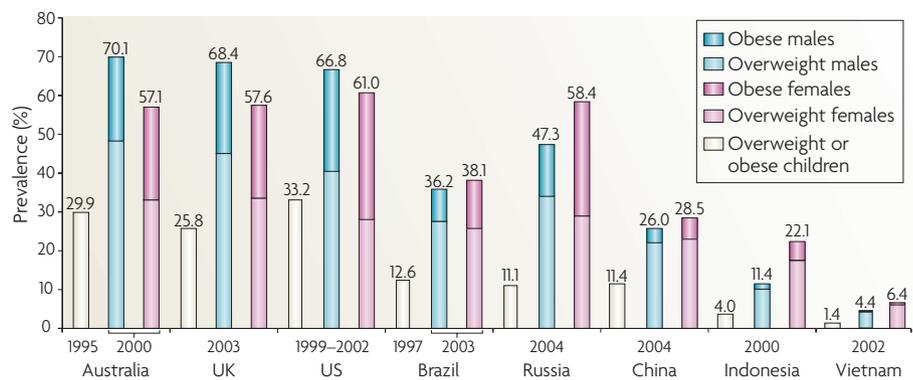


Figure 1 | The prevalence of overweight and obesity in selected countries. Data shown for children aged 6–17.9 years include overweight and obese together (the body mass index (BMI) age-gender standards for children are equivalent to adult overweight and obesity standards). Data shown for male and female adults aged ≥ 18 years separate overweight (BMI 25–29.9 kg m⁻²) and obesity (BMI >30 kg m⁻²). The years of data collection for each country are shown below the x axis. Data are from unpublished data of the author and from the following sources: **Australian Diabetes, Obesity and Lifestyle Study** (for adults) and **The National Nutrition Survey 1995** (for Australian children); **Pesquisa de Orçamentos Familiares** (for Brazilian adults and children); **The China Health and Nutrition Surveys** (for adults and children); **2000 Indonesia Family Life Surveys** (for adults and children); **the Russian Longitudinal Monitoring Survey** (for adults and children); **The Health Survey for England** (for adults and children); **National Health and Nutrition Examination Surveys** (for US adults and children); and the 2002 National Health Survey (for Vietnamese adults and children).

tributor to energy balance. There is reasonable consensus that reducing the energy density of a diet will cause a reduction in energy intake^{47–49}. Beyond that, there is limited evidence and controversy surrounding other options such as consuming a reduced glycaemic index diet, a low-carbohydrate high-protein diet, as well as a low-fat high complex-carbohydrate diet, although each have their proponents^{50–52}. Increased intake of edible oil and animal-source foods are two important ways that diets in many low-income and middle-income regions of the world are increasing the energy density of the food component of their diet. The beverage component, which can have an equally important affect on energy imbalance, is mainly shifting owing to the increased sweetening of beverages globally^{43,44,53}.

Edible oil. Edible oil has been an important source of dietary change in lower-income and middle-income countries, and is now the main global source of fat⁵⁴. The intake of edible oil has increased consistently over the past 15 years. In China, this increase has led to an average adult dietary intake of more than 300 calories per day from edible oil, which is about 15% of all consumed calories (S.W. Ng and B.M.P., unpublished data)³⁴. Large increases in the domestic production and imports of oilseeds and vegetable oils have dominated all lower-income countries. Principal vegetable oils include soybean,

sunflower, rapeseed, palm and groundnut oil. With the exception of groundnut oil, the global availability of each has approximately tripled between 1961 and 1990. Elsewhere, Williams, and also this author, have written in more depth about the technology behind this shift and the broader nature of these changes in both oil-seed extraction technology and the breeding of new oil-seed varieties that contain more oil^{55,56}. Globally, we have shown this to represent a significant source of calories and fats for most low-income and middle-income countries.

Caloric sweeteners. Sucrose is the world's predominant sweetener; however, this is rapidly changing. There are many caloric sweeteners including glucose, fructose, sucrose and saccharose that exist either in a crystallized state as sugar or as syrups. Sweeteners also include maple sugar and syrups, golden syrup, artificial and natural honey, maltose, dextrose, isoglucose (high-fructose corn syrup) and lactose. High fructose corn syrup is the sweetener used in most soft drinks in the United States, and it is increasingly being used on a worldwide basis for sweetened beverages and many other foods⁴⁶. Some evidence suggests that fructose might pose an added risk to obesity⁵⁷. In the past few decades, increasing quantities of cereals (primarily maize) have been used to produce sweeteners derived from starch. Caloric sweetener consumption in beverages is linked with increased weight gain in both longitudinal association and

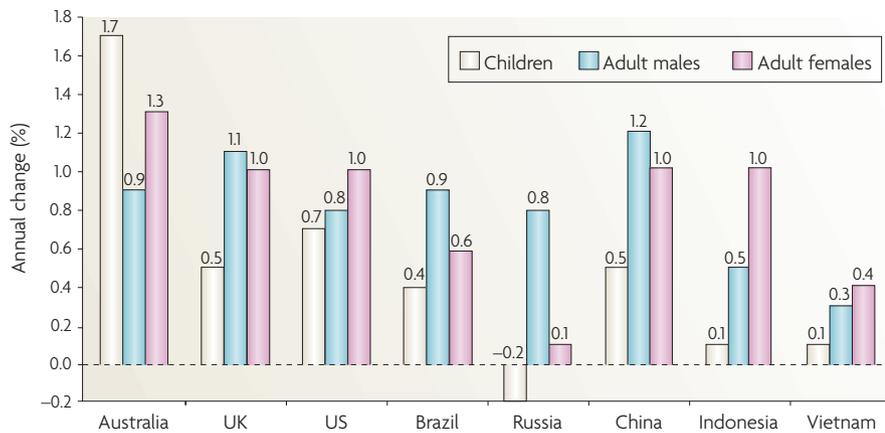


Figure 2 | Annual absolute changes in the prevalence of overweight and obesity in selected countries. Data shown are the annual percentage point increases in prevalence of overweight and obesity for countries with the initial year in the period from 1985 to 1995 and the final year in the period from 1995 to 2004. Overweight and obesity is classed as a body mass index (BMI) of ≥ 25.0 kg m⁻² for adults (for children, age-gender BMI standards equivalent to adult overweight and obesity standards were used). Data are from unpublished data of the author and from the following sources: [Australian Diabetes, Obesity and Lifestyle Study](#) (for adults) and [The National Nutrition Survey 1995](#) (for Australian children); [Pesquisa de Orçamentos Familiares](#) (for Brazilian adults and children); [The China Health and Nutrition Surveys](#) (for adults and children); [2000 Indonesia Family Life Surveys](#) (for adults and children); [the Russian Longitudinal Monitoring Survey](#) (for adults and children); [The Health Survey for England](#) (for adults and children); [National Health and Nutrition Examination Surveys](#) (for US adults and children); and the 2002 National Health Survey (for Vietnamese adults and children).

controlled trials⁴³, but controversy still exists over this relationship⁴⁴.

The overall trends show a large increase in caloric sweetener consumption in all countries of the world. In 2000, a worldwide analysis of food-availability data found that caloric sweetener consumption increased to 306 kcal per person per day, about a third more than in 1962 (REF. 53). Few countries have direct measures of all added caloric sweeteners in each food. However, such data exist for the United States, where more than a third of all carbohydrates and 16% of calories come from caloric sweeteners. In the United States, calorically-sweetened beverages — be they soft drinks, fruit drinks, water with caffeine and sugar added or any of hundreds of other options — represent more than half of the increase in calories consumed over the past 30 years⁵⁸. Many scholars think that caloric beverages are a significant factor, not only for causing obesity, but also for causing insulin resistance and type 2 diabetes^{43,44,58}.

Animal-source foods. Most of the world's growth in the production, importation and consumption of animal-source foods (consisting of meat, poultry, fish, eggs, cow's milk and other dairy products) has vastly increased in middle-income and even low-income countries⁵⁹. Therefore, by 2020 lower-income countries are projected to produce

63% of meat products and 50% of all cow's milk. A large proportion of this increased production, if not all, will be consumed by these same countries.

Human consumption of red meat, pork, dairy products and poultry has shown a large increase in low-income and middle-income countries. There are different lower-income countries that dominate the consumption of different animal products. China is the dominant country in meat consumption, whereas India is the largest consumer of milk. In the mid-1990s India (representing about 17% of the world's population) consumed 13% of the world's total of milk, and 31% of milk consumed by all lower-income countries — representing a tripling of its milk consumption during the period from 1983 to 1997^{59,60}. Another more graphic way to view milk consumption patterns is that the growth in milk consumption per capita in India and China is double that of the rest of the world. Per capita milk consumption in India and China will be 105 kg and 16 kg per capita, respectively, in 2020 — close to half the consumption in all developing countries — an increase from much less than 10% of that level in 1970 (REFS 60,61).

An example of the rapid increase in the intake of animal-source foods is China. Along with edible oils, most of the shift

in China is towards great increases in the production, importation and consumption of animal-source foods⁶². Today, about two-thirds of the Chinese population obtain more than 15% of their energy from saturated fats — mainly from meat, dairy and egg products — but also some from lard. This is a doubling over the past two decades and is expected to increase even further to about 80% of the Chinese population by 2025. FIG. 3 shows the rapid shifts in elements of the Chinese diet (pork and grain consumption), physical activity and overweight status. Cancer incidence and mortality data are not included here, but there is concern that cancer mortality has and will continue to increase markedly in China⁶³.

Low energy-dense foods and beverages. As noted above, research suggests that increased energy density of the diet is linked with greater total energy intake^{47,64,65}. The most interesting work has involved increased intake of water — both as a proportion of all beverages and in absolute terms — linking it with significantly reduced weight, per cent body fat and waist circumference, as well as reduced total energy intake (J.D. Stookey, F. Constant, C. Gardner and B.M.P., unpublished data). Much more research needs to be undertaken on this topic and other noncaloric beverages such as tea, coffee and diet beverages. The food area is much more studied but few large-scale trials have been undertaken; however, it is important to note that many popular diets, as well as food plans (for example, the DASH (Dietary Approaches to Stop Hypertension) diet, Weight Watchers, the DPT (Diabetes Prevention Trial) diet and others), promote reduced energy density as a key dimension of their overall strategy⁶⁶.

Heterogeneity across countries. Limited comparative studies on dietary change exist across countries where identical data have been used. A comparison of patterns and trends between the dietary intake of children in China, Russia, the Philippines and the United States found extensive differences in the proportion of energy consumed away from home (for example, United States and Filipino children consumed 40% or more of their caloric intake from away-from-home foods compared with less than 5% in China and Russia). Similar patterns existed in the consumption of modern foods (for example, soft drinks and hamburgers) and snacks between the United States and Filipino children when compared with Chinese and Russian children⁶⁷.

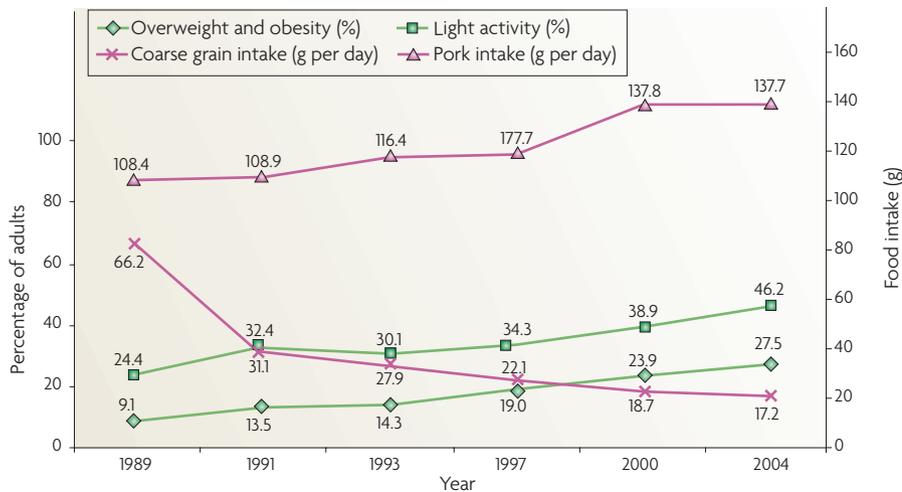


Figure 3 | Trends in diet, activity and obesity in China. Data shown are from 1989 to 2004 in Chinese adults aged 20 years and older. Coarse grain intake has decreased and pork intake increased. At the same time, the percentage of Chinese adults that are overweight or obese has increased. The percentage of adults engaged in light activity has gone up because heavier activity has gone down. Diet, cancer incidence and mortality data are not included but there is concern that cancer mortality has and will continue to increase markedly in China⁶⁴. Data are from the China Health and Nutrition Survey 1989–2004 and prepared by the author.

The economic costs

These dietary shifts to energy-dense fatty, sugary foods and beverages and physical inactivity resulting in obesity are the causes that underlie the increases in diabetes and some common cancers among other chronic diseases³¹. The total economic costs from these problems are estimated for China to be over 4% of gross national product (GNP) at present, and projected to be 8% of GNP by 2025 (REF. 42). For the few cancers for which health expenditure data were available (breast, colon, oesophagus, endometrial, lung, stomach and bladder), the cost today is about 13% of the total national health-care costs, or about 0.5% of the GNP, conservatively estimated to increase to about 17% of the total national health-care costs and 1.53% of China's total GNP in 2025 (REF. 42). Both China and India are already suffering greater economic costs from overweight than underweight²⁶.

Macroeconomic shifts

Globalization, in this context, refers to the increasingly deregulated movement of capital, technology, goods and services. This is having profound effects on how populations and communities conduct their lives, including purchasing and consumption patterns, levels of physical activity and, in turn, on the levels of obesity⁶⁸. Among the key factors are: a) the worldwide shifts in food trade and the transfer of technology innovations that affect energy expenditures during leisure, transportation and work; b) globalization of food processing,

marketing and distribution techniques (most frequently linked with Westernization of the world's food supplies and, therefore, diets); and c) vast expansion and penetration of the globalized mass media. A few of the more focused elements are discussed below. Others are discussed elsewhere^{34,68}.

Food pricing. Economic and trade policies that have been determined in North America and Europe have fuelled one very significant change. This change is a drop in the global prices of red meat, in particular beef, to less than 25% of prices 40 years earlier³⁴. This is driven by the policy of all higher-income countries to subsidize animal-source foods and the production and distribution of feeder grains. The main global model of agricultural development has focused on the goal of first creating overall self-sufficiency, or at least the high production of grains, and then on creating a large animal-source foods industry.

One of the central shifts that has occurred in the global food system is related to the marketing and sales of food. The fresh (open public) market is disappearing as the main source of food in Africa, Latin America and Asia. These markets are being replaced by multinational, regional and local large supermarkets that are usually part of larger chains, or by local domestic chains patterned to function and look like these global chains as seen in other countries such as South Africa and China^{69,70}. Increasingly, hypermarkets (very large megastores) are the main force driving

shifts in food pricing and therefore purchasing and consumption in a country or region. For example, in Latin America, the share of all retail food sales made in supermarket increased from 15% in 1990 to 60% in 2000 (REFS 70,71). This same process is also occurring at varying rates in Asia, Eastern Europe and Africa.

Extensive research has shown the power of price policy for promoting animal-source foods as basic components in the diet. The poor are far more sensitive to price shifts than the rich, and there are ways to differentially benefit the poor with these policies (REFS 72,73). Several examples from China point out the great potential for taxing selective sets of foods and/or subsidizing others as a way to reduce the energy density and increase the health benefits of diets. By examining the overall effect of a food price change not only on the food itself, but also on the purchase and consumption of all other foods in the diet, we are able to understand the overall effect of the change in one food price on energy from fats, proteins and carbohydrates. Studying these factors over time in China, it is possible to see the potential power embedded in the vast array of subsidies, credit shifts and price shifts currently used in most countries. In each case, it has been shown that price shifts could improve the diet of the poor in terms of quality at the same time as reducing their total energy intake⁷⁴. One recent study of the effect of food price changes over 13 years on edible oil intake in China has shown that increased edible oil prices would be linked with a significant decrease in total energy intake for all income groups and an increase in the protein and carbohydrate intake of the poor.

The effect of price policies and many other regulations need much more careful exploration before we are able to undertake massive shifts of a healthy nature in the structure of food systems and food supplies. Other mechanisms available to the economic sector must be rigorously explored.

Aside from factors that affect the relative prices of goods, there are many ways to regulate food production, marketing and distribution systems. The example from the tobacco sector is most notable^{75–77}. Restrictions on advertising and other aspects of marketing, packaging, age limits for sales, mass-media campaigns to address health risks and many other strategies have been used. There is great potential in the taxation of selected foods as a way to change food-consumption patterns and caloric intake^{78,79}. For example, taxing sugar added to beverages and high-fat salty snacks and

other foods often termed junk food are frequently mentioned.

The anti-cigarette-smoking campaign showed that the linkage of both primary and secondary tobacco smoking with cancer and death was important in educating both children and adults about the dangers of smoking⁷⁵. Lantz and colleagues note that, "Several types of strategies warrant additional attention and evaluation, including aggressive media campaigns, teen smoking cessation programmes, social environment changes, community interventions, and increasing cigarette prices"⁷⁵. There is some evidence that these same types of changes can improve diet and physical activity patterns. National efforts in South Korea, Norway, Finland and elsewhere have shown marked improvements in diet and often body weight. Measures taken in these countries included similar components as those found in the quotation above for youth tobacco control^{80–83}. However, most of the increases in education efforts during the past decade at the national level in Europe and the United States do not seem to be effective in arresting changes in obesity, at least as seen by the increased rates of obesity and continued shifts towards poorer diets and reduced physical activity^{34,44,84,85}.

Other macroeconomic changes. One of the least studied and least understood areas of change as it relates to diets in low-income and middle-income countries is the role of the modern mass media³⁴. There has been a profound increase in the ownership of television sets and the penetration of international television programming. This has been accompanied by a proliferation of modern magazines and ready access to DVDs of movies from the United States. Similarly, other modes of communication — the internet, print media and music — have contributed to these shifts. The health implications of this phenomenon are not yet well understood. Extensive research in higher-income countries has shown that both television viewing, as well as the type of direct marketing of food on television, have had a large effect on children⁸⁵. Minimal research, none of a causal nature, has been undertaken on this relationship in developing countries.

For example, television set ownership and modern television programming are a recent phenomena in China. In China, less than two-thirds (63%) of households owned a television in 1989. Today, more than 95% own a television and many own more than one. Programming and advertisements have been rapidly shifting toward more modern

and Western content. For instance, the first television advertisements in China began with one advertisement in 1979 on a Shanghai television station, and only began in earnest with a large increase in the 1990s⁸⁶, and China is now considered the world's fastest growing advertising market⁸⁷. Similar increases in television ownership and viewership are noted throughout the developing world.

Challenges and opportunities

The transitions in diet, physical activity and energy imbalance seen across the world are a clear continuance of a shift seen since Paleolithic man. From that time forward, as we have moved through the agricultural revolution toward more modern stages linked with reduced famine and increased noncommunicable diseases, increased sweetness, fattiness and overall tastiness of our diet, and reduced energy expenditure in work and travel have been cornerstones of our changing world.

The global changes noted above are striking because of the speed with which they have occurred. There are many gaps in our understanding, particularly related to the underlying factors that cause these trends and the programmatic and policy issues that can address them effectively. Further, little is understood about whether the cancer risk from obesity will depend on the type of diet that gave rise to the obesity (for example, diets in the United States versus diets in China or India). All available data seem to indicate a shift in dietary and activity patterns towards a pattern dominated by caloric beverages, more highly-processed grains and other foods, greater energy density and inadequate amounts of fiber. Much more research needs to be undertaken on the effects of the two broader trends towards a higher consumption of processed sugars and energy-dense diets in large populations. These broader trends are certain to continue to increase obesity and have a marked effect on cancers in the future.

The crucial challenge is for health scientists to join with others to push for broader scale changes. We need to follow the tobacco control example and think big and act big. Price changes, social environment changes, other large-scale regulations and education efforts are all needed.

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Competing interests statement

The author declares no competing financial interests.

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The following terms in this article are linked online to:
 Entrez Gene: <http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=gene>
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FURTHER INFORMATION

The Nutrition Transition Program: <http://www.nutrans.org>
 Australian Diabetes, Obesity and Lifestyle Study: <http://www.diabetes.com.au/index.php>
 The National Nutrition Survey 1995: <http://www.abs.gov.au/Ausstats/>
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