

# Nutrition Transition and Its Health Outcomes

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**Abstract** Advances in agriculture and food systems, consequent increases in food availability, and a shift in dietary consumption patterns with economic development and urbanization of developing societies leads to adverse health outcomes. The structure of the habitual diet is altered and is characterized by increasing consumption of fats, saturated fats largely from animal sources and sugars. Lifestyle changes in an increasingly urbanized environment which occurs concurrently contributes to a reduction in physical activity levels which promotes overweight and obesity. The essence of these changes is captured by the term ‘nutrition transition’ which accompanies the demographic and epidemiologic transition in these countries with economic development. The existing burden of undernutrition in developing countries is thus compounded by the adverse effects of the nutrition transition, notably the increasing prevalence of obesity and non-communicable diseases. This double burden of malnutrition adds to the health and economic burden of developing societies.

**Keywords** Nutrition transition · Double burden of malnutrition · Non-communicable diseases · Overweight and obesity · Attributable risk · Economic costs

## Introduction

In September this year, heads of state and government ministers gathered at the United Nations (UN) high-level meeting on the prevention and control of non-communicable diseases (NCDs) to put NCDs on the global agenda. The agreement by

UN member states to hold the summit on NCDs signalled recognition of a growing global emergency with 36 million people dying annually from NCDs *i.e.*, 63 % of all deaths globally [1]. At present, NCDs disproportionately affect more people in developing countries, accounting for 80 % of all NCD-related deaths. These include cancers, cardiovascular diseases, diabetes, and chronic respiratory diseases; most of them co-morbidities associated with obesity. They are largely preventable and share common risk factors, such as tobacco use, unhealthy diet, physical inactivity, and harmful use of alcohol. The World Economic Forum identified NCDs as a severe threat to economic development and put a price tag of \$ 47 trillion on the expected global economic burden of these diseases by the year 2030 [2].

Economic development has brought numerous benefits to countries in the third world but also generated enormous challenges. There is growing recognition of the emergence of a ‘double burden’ of malnutrition and disease with under and over nutrition occurring simultaneously among different population and demographic groups in these countries. This phenomenon is not limited to upper-income developing countries, but is occurring across the globe. It encompasses countries with very different cultures and dietary customs and practices. Accumulating evidence suggests that as economic conditions improve, obesity and diet-related NCDs may escalate alongside persisting high levels of undernutrition [3]. Many factors influence these processes, including the rapid urbanization and internal migration from rural hinterlands, demographic shifts in population, the acquisition of sedentary lifestyles and the wide range of contributions from the liberalization of markets with globalization and environmental degradation which include the food systems of societies and the diets of individuals [4, 5]. This review focuses on one important element *i.e.*, the nutrition transition that accompanies these developmental processes and evaluates its contribution to health outcomes in some of these countries.

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## Health Related Transitions in Developing Societies

Several transitions related to health precede and follow the process of a country's economic development on the trajectory from pre-industrialised state to a modern affluent industrialised economy, a shift that is characteristic of western industrialised societies. Many of the benefits accrued are related to the improvements in the environment like water and sanitation that contribute to better health while others include food adequacy and better nutrition. Some of these health related transitions need to be described before we focus on the main theme of this review.

Abdel Omran in 1971 [6] formulated the term '*epidemiological transition*', which focuses on the 'complex changes in patterns of health, disease and mortality that result from the demographic, economic and sociological changes that follow the economic advancement of nations'. This health and mortality transition entails substitution of NCDs for infectious and communicable diseases as the primary causes of morbidity and mortality. This transition from a 'cause of death pattern dominated by infectious diseases with very high mortality, especially at younger ages, to a pattern dominated by chronic diseases and injuries with lower mortality, mostly peaking in adulthood or at older ages, is responsible for the phenomenal increase in life expectancy'. The 'epidemiologic transition' theory, while describing and explaining the spectacular fall in mortality and the changes in patterns of morbidity and mortality in industrialised countries, now allows us to speculate that developing countries currently lagging behind the economically developed countries (which have already completed the epidemiologic transition) will demonstrate a fall in infectious disease mortality and a rise in chronic NCDs.

The usual backdrop to this health transition in developing economies is the preceding '*demographic transition*' seen when a largely pre-industrial country develops to an industrialized economy. Demographic transition is attributed to 'the changes in population structure following a shift from high fertility and high mortality to one of low fertility and low mortality' typical of economically advanced countries which include most of the industrialised nations of the world [7]. There is a dramatic reduction in infant and child mortality rates, which contributes to a marked increase in life expectancy of the population. An inevitable consequence of increasing life expectancy and decreasing birth rate is the alteration in the demographic profile of the population with a progressive change in the age structure characterised by ageing of the population now seen. Developing countries have also seen a demographic transition that has accompanied the rapid increase in population size and density and thus changed the age structure of the population. Life expectancy is increasing and birth rates are on the decline thus contributing to the share of population above the age of 60 growing at a rapid rate.

However, the changes in the population age pyramid demonstrating the demographic transition is highly variable between countries and also within the country and may differ from region to region. This is due to differences both in the period of onset of demographic transition and the result of differences in rate of transition.

The modernisation of societies with economic development seems to result in the population consuming a diet high in fats, sugars and refined and processed foods, which probably bear a causal relationship to the disease burden and mortality transition observed. This is referred to as the '*nutrition transition*', which is the main focus of this review and will be dealt with in greater detail later on.

All these important characteristics observed in the populations of nations during their transition as a consequence of economic development manifests as a '*health transition*'. Health transition is not merely the shift in disease profile from one dominated by mortality largely attributable to infectious diseases to one characterised by premature adult mortality due to NCDs but also encompasses the shifts in resource allocation, manpower development and the changes in the health systems that follow in its wake. It is generally believed that the disease burden associated with this health transition is characteristic of affluent populations in developed societies and the assumption is that chronic NCDs are not a health priority of poor individuals in developing nations. NCDs like cardiovascular disease initially affect the affluent classes and then this '*risk transition*' percolates through the social classes [8]. But in the long run it is the lower socio-economic classes that bear the brunt of NCDs and obesity [9].

## The Nature of Nutrition Transition in Developing Economies

We owe the promotion of the concept of '*nutrition transition*' and its important role as a determinant of the emerging epidemic of obesity and chronic NCDs in developing economies to Barry Popkin [10]. Nutrition transition refers to the changes in the composition and structure of the diet, usually accompanied by changes in physical activity levels. The diets of populations globally have undergone remarkable quantitative and qualitative changes and the pace of this change appears to have accelerated to varying degrees in different regions of the world. And with populations ageing and countries moving through epidemiological, demographic and nutrition transitions these in turn have contributed to changes in stature, body weight and body composition of these populations and increased their risk of obesity and NCDs. The convergence to the underlying dietary consumption pattern which is high in saturated fat, sugar and refined and processed foods and low in dietary fibre seems to be a common risk factor of the disease burden manifested.

Popkin [11] has characterized the nutrition transition into three stages: *i.e.*, '(i) receding famine, (ii) degenerative disease, and (iii) behavioral change'. In the first stage, diets are primarily derived from plant-based food sources, tend to be monotonous and are based more on home food production that requires high levels of physical activity related to planting, harvesting and processing. The second stage is characterized by dietary changes that generally include more animal source foods, higher intakes of fat—both vegetable oils and saturated fat from animal products—increased use of sugar and other sweeteners in the habitual diet and higher reliance on food produced and processed outside the home or the immediate community. Mandatory physical activity is also reduced and this reduction is noticed in spheres that include activity to produce food and procure water and fuel-wood, including agriculture-based labour and household labour. The final stage when achieved involves a shift to a diet with less fat and sugar as well as a decreasing reliance on processed foods. Typically, this stage encompasses increased intakes of whole grains, fruits and vegetables and decreased consumption of saturated fat, with a preference for animal source foods with lower saturated fat content like fish and white meat from poultry [11]. Intensive physical labour related to agricultural production is not reintroduced, but non-obligatory physical activity such as leisure time activity is increased. The final stage is what public health policy should aim towards which will involve not just the health sector but also agriculture, trade, transport, leisure and urban planning.

Table 1 summarizes some the changes observed over a 30-y period in 5 developing economies—China, Egypt, India, Mexico and The Philippines -compiled recently [3]. Based on the Food & Agriculture Organization's (FAO) Food Balance Sheet (FBS) data it provides levels of per capita availability of commodities and also expresses them as percent of energy in the diet per individual. It shows how in almost all countries the availability (as a proxy for consumption) per capita of cereals (grains including roots and tubers) has decreased and is contributing less energy while the consumption of fats and oils, animal source foods (ASF) and sugars has increased and contributes more to the energy in the daily diet. The redeeming factor appears to be the increase in consumption of fruits and vegetables, which is probably due to greater availability and possibly related to the economic growth in these countries. This trend seen in these developing countries mimics the trend observed in the British population over a 60-y period with carbohydrate consumption as a proportion of the dietary energy dropping with a reciprocal increase in the contribution of fat energy to the diet [12]. This dietary change over this period along with the reduction in the levels of habitual physical activity has probably contributed to an increase in the prevalence of obesity in the U.K and may be true of many other developed economies.

Household food consumption surveys in these developing countries while random and very often not representative, do however support the observations from FAO's FBS data and endorse the changing trends in dietary consumption and the structure of the diet in most of these countries [3]. Detailed comparisons of the trends in sources of energy intakes observed both in rural and urban populations in China (State Statistical Bureau for the years 1978–1997) and India (National Sample Survey Organization for the years 1973–1994) over two decades from crucial national household dietary consumption surveys [13] supports the trends noted from FAO's data in Table 1.

The data from national surveys in China and India [13] indicate that that there has been a shift from the 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 in India. Overall, diets of all income groups in both countries, has moved away from cereals to other food groups—these shifts are greater among the urban population and among the higher income groups. Fat intakes and the consumption of ASFs has increased for all income groups. However, while the population in China has increased its meat and edible oil intakes the consumption of dairy products and vegetable oils has increased among Indians. The consumption of sugar has also increased and is high among the Indians compared to the Chinese. In addition to the change in the structure of the diet, dietary diversity has also been enhanced over this period.

The important contribution of economic growth of a country to changes in the structure of the diets of its population was first made almost 40 y ago [14], and showed that there was a relationship between a country's per capita Gross National Product (GNP) and the percentage of total calories derived from fats and sugars in the diets of the population - greater the per capita GNP greater the contribution to the daily energy intake from fats, saturated fats and sugar and a reciprocal reduced contribution from complex carbohydrates. Thus, economic growth and rising incomes result in a reduction in the proportion of energy from complex carbohydrates and with an increase in the contribution from ASFs (main contributor of saturated fat in the diet) and fat to the diet—a characteristic feature of the nutrition transition.

More recently significant changes in the structure of this income-diet relationship of populations have been reported [15]. It appears that fat intake of populations in the 1990s (compared to the 1960s) is less dependent on income or GNP and that rapid urbanization seems to have a major influence on the nutrition transition. While the consumption of animal sources of fat showed a marked linear relationship with income in the 1960s (5 % of energy in low GNP countries compared to 38 % in high GNP countries), in the 1990s this relationship appeared to flatten out [15]. More significantly the contribution from vegetable fats seems to

**Table 1** Trends in supply or availability of food commodities (in kg/capita/year) with percent contribution to dietary energy supply in parenthesis over a 30 y period in 5 developing countries

	China		Egypt		India		Mexico		Philippines	
	1970	2000	1970	2000	1970	2000	1970	2000	1970	2000
Cereals (incl. roots & tubers)	266 (82.1 %)	251 (57.7 %)	185 (66.6 %)	257 (64.8 %)	164 (67.6 %)	179 (60.8 %)	179 (54.9 %)	192 (46.8 %)	142 (59.0 %)	168 (56.1 %)
Fats & Oils	3 (2.9 %)	11 (8.7 %)	10 (9.4 %)	8 (5.9 %)	8 (5.8 %)	5 (11.6 %)	8 ((6.6 %)	13 (9.0 %)	5 (6.6 %)	7 (6.9 %)
Animal source foods	19 (5.4 %)	108 (18.4 %)	50 (4.6 %)	92 (6.2 %)	40.5 (4.2 %)	77 (5.8 %)	140 (11.7 %)	204 (17.1 %)	71 (12.6 %)	86 (13.3 %)
Fruits & Vegetables	50 (2.0 %)	291 (7.0 %)	168 (6.6 %)	275 (8.0 %)	69 (2.9 %)	107 (3.9 %)	114 (8.2 %)	173 (4.8 %)	144 (8.2 %)	162 (7.6 %)
Sugars & Sweeteners	3 (1.4 %)	7 (2.2 %)	48 (10.5 %)	75 (10.1 %)	29 (9.5 %)	38 (10.2 %)	37 (13.6 %)	49 (15.0 %)	22 (10.4 %)	30 (11.7 %)

Adapted from Kennedy, Nantel &amp; Shetty, 2006 (Ref. 3)

Based on FAO's Food Balance Sheet data

have increased over this period—from about 8–10 % in the 1960s to 15 % in the 1990s. What was most significant was not only that in the 1990s poor nations with low GNPs had relatively high fat intake but also that they achieved higher level of fat intake at a lower GNP in the 1990s compared to the 1960s. For instance, a diet with 20 % energy from fat required a GNP of US \$ 1900 in the 1960s while the same diet with 20 % fat energy could be reached with a GNP of only US \$ 900 in the 1990s (both in 1993 dollars) [15]. This was largely due to increased availability of vegetable fats due to increases in national and global production resulting from agricultural and technological investments and the consequent increase in consumption both in rich and poor nations. This is also reflected in the percentage of households with less than 10 % fat energy diets reducing while those with more than 30 % fat energy diets increasing in countries like China and Brazil over less than a decade. The universal availability of relatively cheap vegetable oils in most countries has made high fat diets accessible even to low income populations.

It has been suggested that the major brunt of the impact of nutritional transition will be borne by developing countries and that the progressive future trends in this transition are not encouraging [16]. The last three decades have seen a radical change in the nutritional situation of many developing countries. Energy supply increased swiftly, largely contributed by the success of the 'Green Revolution' and the shifts towards a more market-oriented agricultural sector and the prevalence of undernutrition has fallen in all major developing regions. However, populations in the more rapidly economically developing countries have begun to experience the consequences from oversupply of food energy and with increasing income inequalities, under and over nutrition now co-exist creating a 'double burden of malnutrition'. The longer-term outlook suggests that the number of similarly affected developing countries is likely to rise rapidly over the next 30 y. The speed of the nutrition and lifestyle transition of developing countries is driven by the rapid urbanization, high income growth, changes in the population structure as well as changes in the food systems (marketing, processing and distribution systems) including the changes in food retailing and the emergence of supermarkets.

Changes in habitual food consumption towards an increasingly energy dense diet that is high in saturated fats will further aggravate the burden of obesity and NCDs. The first step may be described as an 'expansion' effect. At low-income levels, the principal change is one towards higher energy supplies whereby the additional calories come largely from cheaper foodstuffs of vegetable origin. This has been an almost universal development and seems to take place regardless of cultural and religious factors, food traditions or agricultural production patterns [16]. The second step is largely a 'substitution' effect and reflects a shift from



carbohydrate rich staples (cereals, roots and tubers) to vegetable oils, sugar and ASFs. The substitution effect exhibits much more country-specificity and is often influenced by cultural or religious factors and food traditions (pork in China and milk and dairy products in India) [16]. These factors determine both the extent to which animal products substitute for vegetable products as well as the nature of animal products that enter the diet. Table 2 depicts the trends in the contribution of ASFs to energy intakes in different regions of the world. Both China's and India's growth in consumption of animal products are projected to continue over the next 30 y, albeit at a somewhat slower pace. But even at this slower pace, China will reach meat consumption levels by 2030 that will exceed those of many developed countries in the past (more than 65 kg and more than 500 kcal/d from ASFs). FAO's long term predictions indicate that consumption of ASFs in developing countries will continue to increase [17].

Any discussion of nutrition transition is incomplete without highlighting the role of the concurrent changes in habitual levels of physical activities of populations that has occurred over the same period of the observed nutrition transition. Reductions in occupational and leisure time activity and thus marked decrease in total daily energy expenditure with access to advancing technology and to labour saving devices has contributed to ease in attaining positive energy balance and thus to weight gain, resulting in an increase in overweight and obesity in these populations [18]. Obesity in turn is a major determinant of co-morbid conditions, which represent many of the NCDs and in particular, cardiovascular disease including hypertension, non-insulin dependent diabetes, and some cancers. Just as rapid urbanization has been shown to be a major driver of the nutrition transition, it is also a major determinant of the reduction in levels of physical activity. While the technological changes in industrial and agricultural

working environments have reduced the need for physical work, urbanization has created an environment which favours the use of mechanized transport and elevators to reduce the need for physical exertion in any form, all of which have contributed to the ease in attaining positive energy balance in the midst of surplus food energy [18].

## Nutrition Transition and Health Outcomes

Changing dietary patterns characterizing the *nutrition transition* combined with lifestyle changes that have resulted in a decline in energy expenditure have been identified as being significant causative agents of disability and premature deaths due to chronic NCDs which include obesity, diabetes mellitus, cardiovascular disease (CVD), hypertension and stroke, and some types of cancer [19]. Population-based epidemiological evidence has helped to clarify the role of diet in preventing and controlling morbidity and premature mortality resulting from NCDs. Some of the specific dietary components that increase the probability of occurrence of these diseases have also been identified [19].

In many countries, the rapid shift towards higher dietary energy intakes and increases in fat and saturated fat intakes with increase in ASF consumption and declining levels of physical activity has already been associated with a rapidly rising prevalence of overweight and obesity in their population. Available data from developing countries also supports the role of nutrition transition and reducing physical activity in driving this epidemic [20]. An examination of the attributable risks to the burden of NCDs globally [21], shows that overweight or obesity indicated by a high body mass index, low physical activity and low fruit and vegetable intakes consistently appear as important risk factors. Both hypertension (which is associated with high salt intake [19]—often consequent to increased consumption of processed ready to eat foods in largely urban settings) and high cholesterol levels (due to increase in saturated fats in the diet [19] mainly from ASFs) are also important risk factors [21]. Taking the example of cardiovascular diseases which accounts for nearly 30 % of deaths worldwide, eight risk factors—alcohol use, tobacco use, high blood pressure, high body mass index, high cholesterol, high blood glucose, low fruit and vegetable intake, and physical inactivity—account for 61 % of loss of healthy life years and 61 % of deaths [21]. The same risk factors together account for over three quarters of deaths from ischemic and hypertensive heart disease. Attempts have also been made to calculate the population attributable risk (PAR) of diet related NCDs to the elements of nutrition transition as well as to the economic costs associated with this health burden although they have been mainly focused on China and India with predictions for the year 2025 [13]. Similar analysis of nutritional risk of the 'diseases of affluence' (which are another

**Table 2** Calorie contribution from Animal Source Foods (meat, eggs, milk and dairy products) expressed as calories per person per day

	1970	1980	1990	1998	2030
Industrialized countries	725	759	779	786	847
Developing countries	133	165	214	284	393
Sub-Saharan Africa	112	125	115	108	138
Latin America	333	394	391	468	633
Near East/North Africa	220	278	264	261	362
East Asia	88	124	218	360	527
South Asia	106	118	158	185	314

Adapted from Schmidhuber & Shetty, 2005. (Ref. 16)

The data for the years 1970, 1980, 1990 and 1998 are based on 3 y averages centred on the year indicated and based on FAO's Food Balance Sheets

term for the western pattern of disease burden associated with nutrition transition) has been reported with relation to rising national income, food share of household expenditure and urbanization from a cross-country analysis [22].

In developing countries, the adverse health outcomes of the nutrition transition are likely to be compounded by a number of other factors that are specific to the country. There is little doubt that the nutrition transition is proceeding much faster in developing countries, but also that its adverse health and economic impacts are likely to be felt more strongly there [16]. The simple fact that many developing countries lack adequate health promotion and health-care systems that would help prevent and manage these adverse impacts, is itself a matter of concern. However, all health outcomes of nutrition transition are not adverse for developing countries. The shift towards higher consumption of ASFs reflects a desirable nutritional goal, increasing both the quantity and quality of protein and access to essential minerals and vitamins in the diet. It certainly benefits infants and children by promoting appropriate growth in the first years of life. It improves the dietary availability of micro-nutrients in general and of iron in particular, a particular advantage to women who are at increased risk of anemia in their reproductive years. But these benefits decline rapidly as intake levels rise further and high intakes are associated with considerable risk and detrimental health outcomes.

## Conclusions

Economic growth and development should reduce the burden of undernutrition, but the reduction is slow and many people continue to suffer needlessly. There is thus a need for well-conceived policies for sustainable economic growth and social development that will benefit the poor and the undernourished. Given the complexity of factors that determine malnutrition of all forms, it is important that appropriate food and agricultural policies are developed to ensure household food security and that nutritional objectives are incorporated into development policies and programmes at national and local levels in developing countries. The deleterious consequences of rapid growth and development need to be guarded against and policies need to be in place to prevent one problem of malnutrition replacing another in these societies.

A critical examination of the principal causes of mortality and morbidity worldwide indicates that malnutrition and infectious diseases continue to be significant contributors to the health burden in the developing world. Although reductions in the prevalence of undernutrition is evident in most parts of the developing world, the numbers of individuals affected remain much the same or have even increased, largely the result of increases in the population in these countries. What is striking, however, is that the health

burden due to non-communicable diseases (NCDs) such as heart disease and cancer is dramatically increasing in some of these developing countries with modest per capita GNPs, particularly among those that are in some stage of rapid developmental transition. Even the modest increases in prosperity that accompany economic development seem to be associated with marked increases in the mortality and morbidity attributable to these diet related NCDs. These transitions in the disease burden of the population are mediated by changes in the dietary patterns and lifestyles which typify the acquisition of urbanized lifestyles.

Most developing countries, particularly those in rapid developmental transition, are in the midst of a demographic and epidemiologic transition. Economic development, industrialisation and globalisation are accompanied by rapid urbanisation. These developmental forces are bringing about changes in the social capital of these societies as well as increasing availability of food and changing lifestyles. The changes in food and nutrition are both quantitative and qualitative; there is not only access to more than adequate food among some sections of the population, but also a qualitative change in the habitual diet. Lifestyle changes contribute to a reduction in physical activity levels (occupational and leisure time) which promote obesity. The essence of these changes is captured by the term ‘nutrition transition’ [10] which accompanies the demographic and epidemiologic transition in these countries. The poor consumer resistance and inadequate regulation compromises food safety and increases contaminants in the food chain. In addition the deterioration of the physical environment, particularly the increase in levels of environmental pollution, contributes to the health burden. These developing societies suffer a ‘double burden’— an unfinished agenda of pre-existing widespread undernutrition superimposed by the emerging burden of obesity and chronic diseases.

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